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# Appearance of a dynamic arm support

Bachelor Assignment Industrial Design

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August 23th 2016

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# Preface

This report is written for my bachelor assignment of the Industrial Design program at the University of Twente. This report will describe the research on product acceptance an product appearance and will show the design process of the appearance of a dynamic arm support.

This assignment is executed in collaboration with Focal Meditech, located in Tilburg. I would like to thank all employees of Focal Meditech for the great opportunities and a pleasant working environment. Special thanks is going to Paul Verstegen for the good accompaniment and Ralf de Jong for the close collaboration.

Also I would like to thank all participants of my evaluations, both the questionnaires and the group discussions.

Last person that I would like to thank is Maaike Mulder- Nijkamp for the great accompaniment at the University of Twente.

I hope you all enjoy reading this report as much as I enjoyed writing it.

Emily Bohan
July 2016

# Summary

This report is written as a part of the bachelor assignment for the Industrial Design program at the University of Twente. The assignment is executed for Focal Meditech, a company located in Tilburg that designs, produces and supplies different assistive devices. At this moment Focal Meditech is working on the McArm, a Motion Controlled ARM support. The McArm is a dynamic arm support that is placed on a wheelchair and provides independence to perform activities of daily living for users with limited muscle strength.

Within the company many specialties are present. All specialties are focusing of the functioning of the product. For this assignment the design and appearance of the outer parts of the McArm are investigated and a final design is accomplished throughout this assignment.

The product acceptance and influence on the emotional well-being of the user are two focus points for the research part of this assignment, that is done to answer the following research question: How should the McArm look, for it to be appealing and create acceptance and satisfaction for the user? To answer the research question five phases are passed: the pre-phase, the analysis phase, the ideation phase, the detailing phase and the evaluation phase.

For the pre-phase some extra inside information about the product is collected, mostly about the functioning of the product and the interaction with the user. Also the degrees of freedom are show in this phase.

During the analysis phase, the problem, the stakeholders, the competition products, the context and the production methods are analyzed. Product related stigma is defined and analyzed as the main problem in product appearance and acceptance. The analysis of the other aspects resulted in a list of requirements that are used to define a possible solution to the answer of the research question.

The definition of the possible solution and a design of the McArm is obtained firstly through the ideation phase. This phase contains six different iterations, starting with examining the placement points and numbers of nodes within the product. After the sixth iteration the final shape is defined.

With this final shape, four different concept based on the personas from the analysis phase are constructed. These concepts differ from each other in appearance by material, colour and texture choices.

These four concepts and the basic shape are evaluated according to the requirements set in the analysis phase. The evaluation consists of some measurements, a questionnaire and a group discussion. This phase results in a concept choice and recommendations for research for improvement of this concept. This final concept is shown in the figure at the bottom of this page and is along with guidelines for designing an appealing and acceptable assistive device the conclusion of this assignment.

# Samenvatting

Dit verslag is geschreven als onderdeel voor de bachelor opdracht voor Industrieel Ontwerpen aan de Universiteit Twente. De opdracht is uitgevoerd voor Focal Meditech, een bedrijf gevestigd in Tilburg dat verschillende hulpmiddelen ontwerpt, ontwikkelt, produceert en levert. Op dit moment is het bedrijf bezig met het ontwikkelen van de McArm, dat staat voor Motion Controlled ARM support. De McArm is een dynamische arm ondersteuning die wordt geplaatst op een rolstoel en helpt bij het terugwinnen van de onafhankelijkheid tijdens het uitvoeren van dagelijkse taken voor mensen met minimale spierkracht.

Binnen het bedrijf zijn verschillende specialisten aanwezig die voornamelijk focussen op het functioneren van het product. Voor deze opdracht is het design en de uitstraling van de buitenkant van de McArm onderzocht en is er een eindontwerp gemaakt voor dit product. Voor het onderzoek heeft de product acceptatie en emotionele gezondheid als focus punt gediend om de volgende onderzoeksvraag te beantwoorden: Hoe moet de McArm er uit zien, om als aantrekkelijk te worden ervaren en acceptatie en tevredenheid te genereren bij de gebruiker van het product? Om deze onderzoeksvraag te beantwoorden zijn de volgende fasen doorlopen: de voorfase, de onderzoeksfase, de ideefase, de detailleringsfase en de evaluatiefase.
In de voorfase is extra informatie gegeven over het product. Het grootste deel van deze informatie gaat over het functioneren van het product en de interactie tussen het product en de gebruiker. Ook zijn de vrijheidsgraden en bewegingen van het product in deze fase benoemd.

Tijdens de analyse fase zijn het probleem, de betrokkenen, de markt, de context en de productiemethoden van Focal Meditech geanalyseerd. Product gerelateerde stigma is hier gedefinieerd als het grootste probleem bij de aantrekkelijkheid en acceptatie van het product. De resultaten van de andere analyses zijn verwerkt in een eisenlijst die gebruikt is om een mogelijke oplossing en een ontwerp te genereren die de onderzoeksvraag beantwoord.

Het bepalen van een mogelijke oplossing en een ontwerp voor de McArm is als eerste verkregen door de ideefase. Deze fase bevat zes verschillende iteraties, startende met het bekijken van de plaatsingspunten op de rolstoel en het aantal knooppunten. De zesde iteratie eindigt met een definitieve vorm van het product.

Van deze definitieve vorm zijn in de detailleringsfase vier verschillende concepten gemaakt die hun uitstraling danken aan de persona's die zijn gemaakt tijdens de analyse fase. De uitstraling van deze concepten zijn bepaald door de materiaal, kleur en textuur keuzes.

Deze vier verschillende uitstralingen en de basis vorm zijn geëvalueerd op basis van de eisen die tijdens de analysefase zijn opgesteld. De evaluatie bestaat uit metingen, een online enquête en een groepsdiscussie. Het resultaat van deze fase bestaat uit een conceptkeuze en advies voor verder onderzoek naar de verbetering van dit gekozen concept. Het eindconcept is onderaan deze pagina te zien en samen met een aantal richtlijnen voor het ontwerpen van een acceptabel en aantrekkelijk hulpmiddel vormt dit eindontwerp de conclusie van deze opdracht en het antwoord op de onderzoeksvraag.

# Table of content

# 1 INTRODUCTION

This report is written for a bachelor assingment of the Idustrial Design programm at the University of Twente. This report will describe the research on product acceptance an product appearance. Also included in this report is the design and development process of the appearance of the McArm, a dynamic arm support provided by Focal Meditech (Tilburg).

In this chapter, the company will be described along with the inducement en goals of the assignment. At the end of this chapter the structure of the rest of the report is introduced.

# 1.1 The Company

This bachelor assignment is commissioned by Focal Meditech, located in Tilburg. Focal Meditech is a company that designs, produces and supplies assistive devices in different categories in Tilburg.

All products provided by the company should help solve complex healthcare issues in a feasible and affordable manner and are designed with the same overarching goal: creating more independence for the user. To achieve this goal, 'listening, creating, improving' is used as a motto and strategy where the demands of the users are a central point of focus. After the first product is created by the research and development department, the product will be improved according to the users wishes until their demands are fully possessed. (Focal Meditech, 2016)

### 1.1.1 PRODUCTS

All products provided by Focal Meditech can be categorized into the following product-types: augmentative and alternative communication, headrest supports, wheelchair control, meal supports, dynamic arm supports, personal robotics, social robotics and therapy aids. Besides these products also integration of multiple assistive devices and integration with ventilators is a main point of focus. Most of the products that are provided by the company are placed on an existing wheelchair. (Focal Meditech, 2016)

**AUGMENTATIVE AND ALTERNATIVE COMMUNICATION**
This product type contains products that provide environmental control systems and communication devices based on tablet technology and advanced word prediction.

**HEADREST SUPPORTS**
Headrest supports are meant for users that in need of supporting the head while sitting, for maintaining a good posture. An example of a headrest support is the PAPILLON headrest(figure 1C).

**WHEELCHAIR CONTROL**
Wheelchair control focuses on a customized solution for use who cannot operate with the standard wheelchair control systems. This individual control can be integrated with computer, robot and communicational device control.

**MEAL SUPPORTS**
This type of assistive devices focuses on providing assistance when eating. Main function of this product type is controlling uncoordinated movement.

**DYNAMIC ARM SUPPORTS**
Dynamic arm supports are intended to assist users with a limited arm functioning, but a good hand functioning, when performing tasks of daily living. An example of a dynamic arm support is the TOP/HELP(figure 1A).

**PERSONAL ROBOTICS**
Personal robotics are robotic aids designed for the support of situation in every day life, for users with a very limited to no arm/hand functioning. Figure 1B shows JACO, an example of a personal robot.

**SOCIAL ROBOTICS**
PARO is the name of the social robot provided by the company and aims at engaging communication and interaction with the user. This product is an interactive and robotic seal toy and is mostly used by elderly in a therapeutic way. PARO can be seen in figure 1D.

**THERAPY AIDS**
Besides assistive devices for daily living, Focal also provides products for therapeutic practice of the arm and hand function. Not only physical exercise, but also exercise in virtual environments is provided.

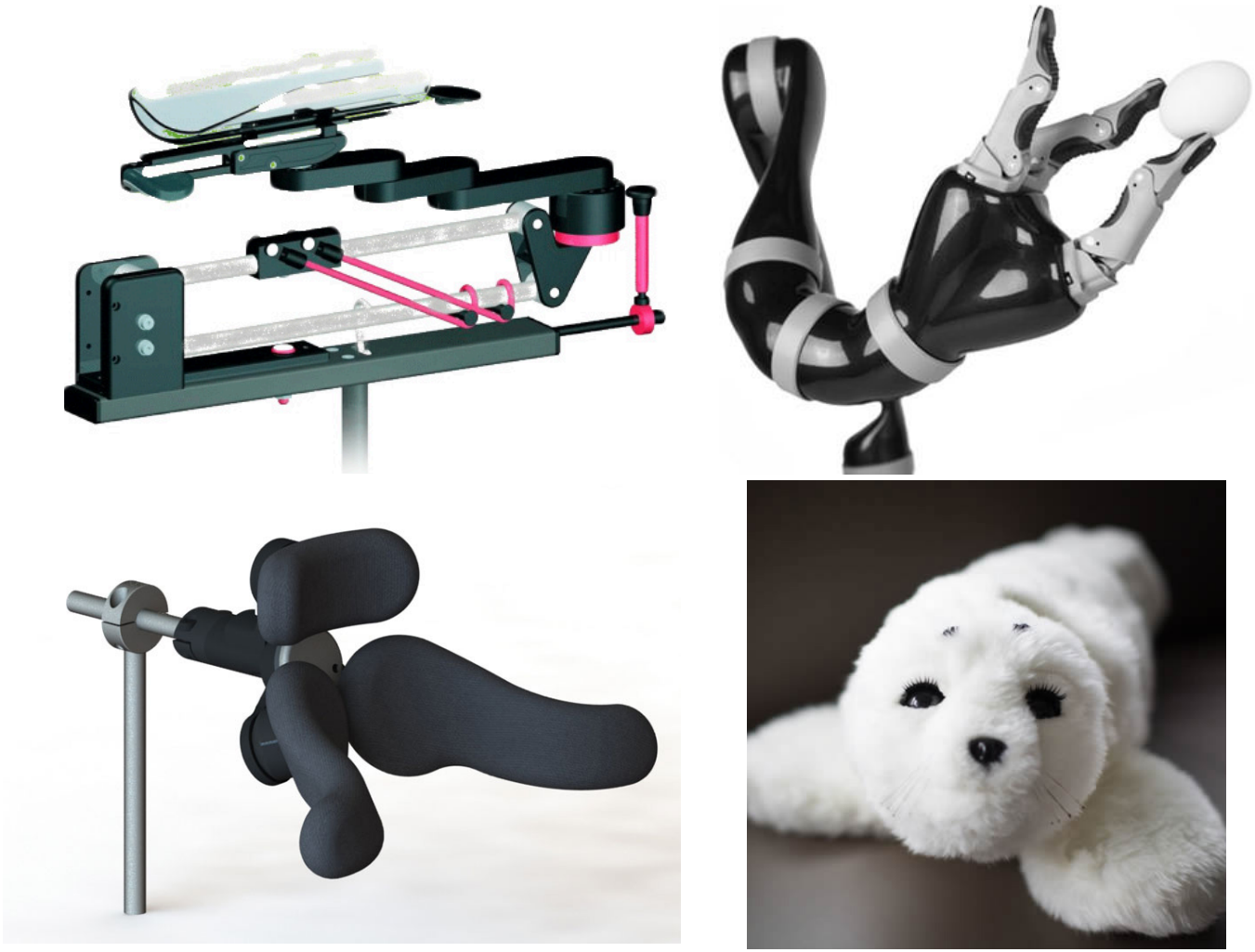


Figure 1: A) TOP/HELP B) JACO C) PAPILLON D) PARO (from left to right) (Focal Meditech, 2016)

**INTEGRATION**

Product integration is done in two ways within the company. First type is the integration of ventilators and other respiratory supports on the wheelchair, with certified building. The other type is integration of multiple assistive devices, for preventing users to need lots of devices on their wheelchair.

# 1.2 Inducement and Goal

### 1.2.1 INDUCEMENT

Focal Meditech is one of the leading companies on supports for restoring the arm and hand function. Dynamic arm supports differ a lot in simplicity. The most simple dynamic arm support is based on counterweight balancing. A more advanced arm support provides actuated assistance. When almost no arm and hand function is left, a complete robotic arm is used to perform tasks of daily living.

At this moment, the company is working on the McArm, a Motion Controlled Arm support. This arm support should form the bridge between an advanced arm support and a complete robotic arm and makes it possible for users to use their own arm longer, even if functioning is very limited. The McArm is going to be part of the wing-family. A group of more advanced dynamic arm supports. The products of the wing-family can be seen in figure2 in chapter 2.

The design and appearance of the products provided by Focal Meditech is always function based, since empowering the users to perform tasks of daily living, such as eating or scratching your head, all by them self, is the most important aspect of the products. For some dynamic arm supports the design and appearance of the products is taken into account, but in the last development phase and always based on the functional parts. Only the size of the product is taken into account during the whole development. This is applies to all products of the wing-family (figure 2). Other arm supports provided by Focal Meditech do not include the design at all.

With the design of an assistive device, not only functional effects are important, but also psychological impact of the product need to be taken into account. Part of the psychological impact is caused by the appearance of the assistive device. (Johnson, 2008)

With the insight that design and appearance is also important for acceptance, satisfaction and quality of the product, this bachelor assignment came through. This bachelor assignment is about the design and appearance of the McArm.

The McArm is not the only dynamic arm support provided by Focal Meditech. All products are divided into different product families based on their functional characteristics. The McArm will be part of the wing-family and besides the design and appearance of the McArm, this bachelor assignment will also provide an advice to integrate this design and appearance with the other products of the wing-family.

### 1.2.1 GOAL

The design and appearance of the McArm will be established by answering the following research question: How should the McArm look, for it to be appealing and create acceptance and satisfaction for the user?

# 1.3 Problem Definition

The insight that design is not only about functionality but also about appearance, formed a base for this bachelor assignment.

The reason for design and appearance to be accepted as a function is product acceptance. Now people are willing to use a dynamic arm support of Focal Meditech because of the qualitative functioning. For the McArm not only qualitative functioning, but also acceptance and desirability because of its appearance is desired.

As Vaes (2014) stated in his research on product-related stigma: “Many well-meaning inventions fail – not because they aren’t helpful, but because they aren’t appealing. To improve day-to-day hardship, designers must do what cold, clinical solutions do not: treat those in need as regular customers, whose emotions drive decisions.”

The acceptance of a assistive device depends on a lot of factors such as functioning, perception of the disability, personality and education, route of obtension, first impression and perception of the product. (Johnson, 2008). The last two factors, first impression and perception of the product are two factors that involve the design and appearance of the product and are the focus points of this assignment.

A big reoccurring problem that is involved in these factors is product-related stigma (Vaes, 2014). For example a often seen product-related stigmatizing reaction to a wheelchair user is: “What a huge wheelchair, that person must be very disabled”

Within the company, size is seen as a major influencer of first impression and product perception and is therefore seen as a great problem in the product appearance. Reducing the size of the product therefore is a major goal and focus point when constructing and designing a new product and is also a possible solutiuon for this defined problem.

In chapter 3 product-related stigma will be analyzed in depth as the main problem for the design and appearance of a dynamic arm support. The influence of size will be taken into account during this analyses.

# 1.4 Structure of the Report

For writing this report, the assignment was separated in four different phases. First phase contains all analysis on the different aspects of the project. Second phase consist of all ideation parts. Third phase is about detailing and integration with the construction. The last phase contains an evaluation of te designed appearance. Prior to these phases the product, provided by Focal Meditech was completely analysed to provide an extensive explanation of the McArm.

This report is not written in chronological order. Analyzing the product and the problem and the ideation phase are executed simultaneously.

### 1.4.1 THE PRODUCT (CHAPTER 2)

In chapter 2, all background information on the product is included. Main focus points of this chapter are the type of assistive device and the functionning of the product. Most information is not highly relevant for the appearance of the product, but this information gives an extensive explanation of the product.

The pre-phase contains the detailed description of the product and the corresponding product family. Also in this phase the problem is defined more specific and the scope of the assignment is emphasized.

### 1.4.2 THE PROBLEM (CHAPTER 3)

In the third chapter the problem, as stated in paragraph 1.3, is further examined. This includes the reason and origin of product-related stigma, the context in which stigma occurs and some dillemas that occur when the design and appearance is included from the beginning of the design process.

### 1.4.3 ANALYSIS (CHAPTER 4)

During the analyses phase a different aspects that influence the appearance of the product are investigated, for example the end user and the market. Result of this phase is a list of requirements and guidelines that can be used to design the McArm.

### 1.4.4 IDEATION (CHAPTER 5)

During the ideation phase different shapes of arm supports are investigated during five different iterations. Prior to these iterations, theoretical ideation is presented. This phase results in a fully defined shape, made visible with a Solidworks model.

### 1.4.5 DETAILING (CHAPTER 6)

For the detailing of the McArm four different concepts based on texture, colour and material are determined. Each concept will fit another persona. This phase is ended with a recommendation for the implementation of these four concepts in the final design of the product.

### 1.4.6 EVALUATION (CHAPTER 7)

For the evaluation of the product, the requirements are evaluated according to the value that the requirement contributes to. For the evaluation of the acceptability requirements, a discussion and questionnaire are used.

In Appendix 0 a bookmaker can be found that shows the research question with the subquestions and the location of the answer of these question

### 1.4.7 HEADING STRUCTURE

# CHAPTER

## #.# Section

#### #.#.#. PARAGRAPH

**SUBPARAGRAPH**

### 1.4.8 IMPORTANT DEFINITIONS

Throughout the report a lot of terms are mentioned. The most important terms are listed in this paragraph. Also synonyms that are used through out this report are listed accordingly on the next page.

*Assistive Device*: Product that is used to support disabled users to perform activities of daily living.
*Synonyms:* Assistive Technology

*Dynamic Arm Support*: Product category that contains products that supports the functioning of the arm
*Synonyms*: arm support

*Wing-family*: Group of similar dynamic arm supports of Focal Meditech.

*McArm*: Motion controlled arm support. A new dynamic arm support that will be design for this assignment
*Synonyms*: the product

*Nature*: A not by humans created object. In case of speaking of a natural design, shape characteristics that are based on natural objects are intended. These shape characteristics contain organic shapes and lines and shapes based on the human body.

# 2

# THE PRODUCT

This chapter contains an extensive description of the product, a motion controlled arm support. First the type of assistive technology is determined and the product family that the MCARM is part of is descripeed. Subsequently the functionning of the product is described in more detail and the construction that formed a starting point for this assignment is stated.

# 2.1 Type of assistive technology

## 2.1.1 TYPE OF ORTHOSIS

The motion controlled arm support (the product) is a dynamical arm support to empower user to perform activities of daily living. A dynamic arm support is a type of orthosis: an externally applied device used to modify the structural and functional characteristics of the skeletal and neuromuscular system (Wikipedia, 2016).

Orthoses, and therefore dynamical arm supports, can be divided into three different categories (Dunning and Herder, 2013):

1. Robot Manipulators
2. Active Orthoses
3. Passive Orthoses

This categorization of orthoses can be based on a technical perspective and from user perspective. Orthoses can be both robotically, actively or passively powered. For example, an active orthoses from technical perspective is electrically powered/ Also the input of the user towards the product can be robotically, passive or active, which means that active orthoses require active user input (muscle movement), from user's perspective. Finally, the categorization can be interpreted as stated by Dunning and Herder (2013), which categorizes the orthoses based on their control of the user's movement. This last categorization is used to describe the type of orthoses of the McArm.

First category of orthoses, defined by Dunning and Herder (2013), contains the robot manipulators. An example of a robot manipulator is the JACO as shown in figure 1B. Second category contains the active orthoses. These active orthoses are electrically powered and control the user's movements. Passive orthoses, the third category of orthoses, can be both electrically powered (with a motor) or passively powered (for example by a spring), but do not control the user's movement. The difference between passive and active orthoses is that the for passive orthoses the user determines the movement of the product and the product gains this movement. With active orthoses the movement is not determined by the user, but by the product itself.

According to this categorization, the McArm is an actively powered, but passive orthoses that requires active user input. The functioning of the product is based on electrical motors, the user determines the movement that the product makes and the user needs at least some muscle strength to use the product.

## 2.1.2 APPLICATION AREAS OF A DYNAMIC ARM SUPPORT

Dynamic arm supports as provided by Focal Meditech and other providing companies cover three different application areas. These different application areas applie to all types of dynamic arm supports (robitcal, active, or passive). (Focal Meditech, 2016)

First area covers assistance during movement against gravity. This area is the main scope of a dynamic arm support. Movement against gravity can be obtained by lifting the users arm completely or by assisting when needed. This application is most used by persons with muscle weakness.

Second area covers conduction of uncoordinated movements. The conduction is needed for critical activities like eating and drinking, that require precise movement and placement of the arm. This application is specifically useful for persons with multiple scleroses or cerebral palsy

Third, and last, application area covers the fixation of joints. The shoulder joint is fixated most often within this application. This orthotic function is an addition to the other application areas and is most beneficial for stroke victims or persons with spinal cord injuries. This application might even result in functioning with less pain and restoration of subluxation.

Figure 2: A) Dowing B) Darwing C) Gowing (from left to right) (Focal Meditech, 2016)

### 2.1.3 WING FAMILY

The McArm will be part of the wing-family, along with three other, already existing, dynamic arm supports: Dowing, Darwing and Gowing(figure 2). The main goal for each of these products is the same: create indepence to perform activities of daily living. For reaching this goal, all products of the wing-family provide assistance as needed for all three application areas mentioned in paragraph 2.1.2.

Despite that the goals and application areas of all three products are the same, the products are different and therefore fit different users. These differences can be found in the detailing of the function fulfillments and can be found in the properties table in appendix A.7.

Looking at the appearance of the products of the wing-family, circular shapes are used as a repetetive shape. Though the design and appearance of these product is included in the development process, the design is established only at the end of the development process. This resulted in three products that look mostly functional, but with some attention for detailling .A more detailed analyses of the appearance of these wing-family products can be found in chapter 4.

# 2.2 Goal

As stated before, the main goal of the McArm is the same for every other product of the wing-family: creating more independence for the user by empowering them to perform activities of daily living.

Another goal that was set specifically for the McArm is the goal to form a bridge between advanced dynamic arm supports as the products of the wing-family(figure 2) and thee robot manipulators such as the JACO (figure 1b), This goal was set to fit more different users and provide these users with a solution for their disability that enables them to use their own arm for performing activities of daily living, for a longer period of time. The visualization of this 'bridge can be seen in figure 3.

Beside functional goals, there is also a more commercial goal to create a unique selling-point. Focal Meditech wants to be the first to provides a commercially available exoskeleton for the arms and aims on reaching this goal with the McArm.

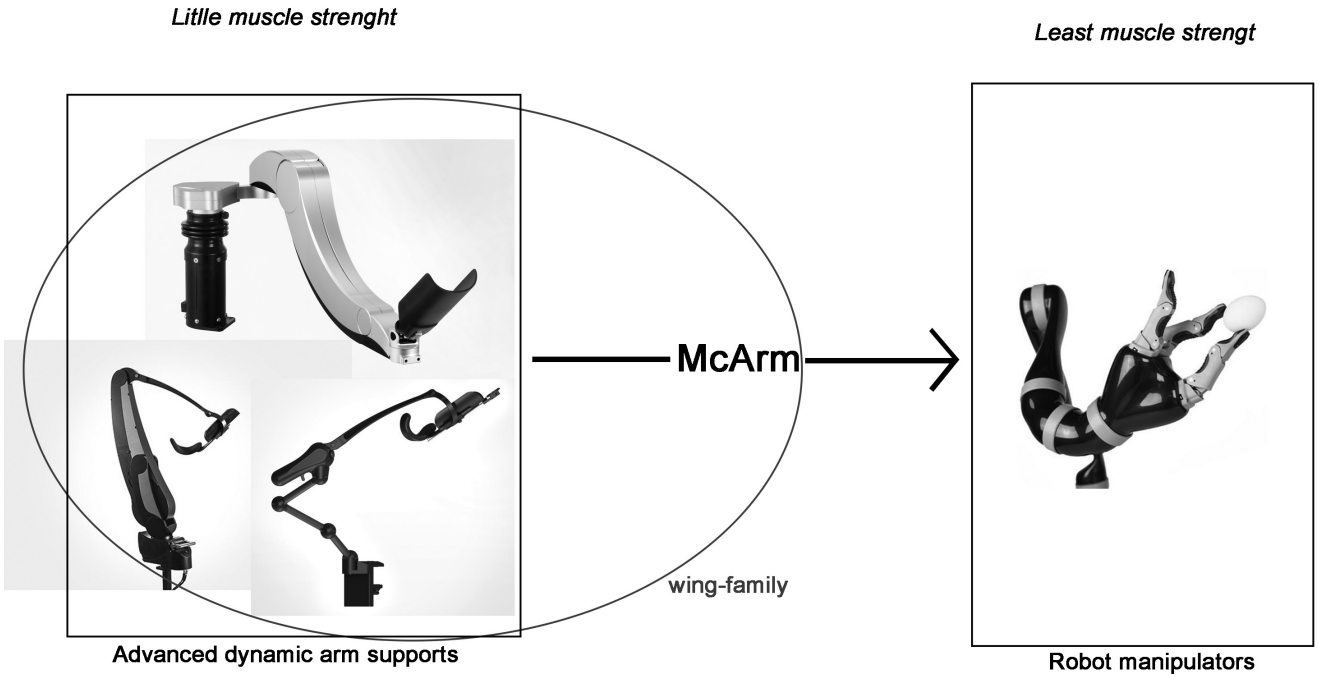



Figure3: Goal of the McArm

## 2.2.2 TARGET GROUP

One of the goals results in a more broad target group. For the McArm the desired target group contains all people who have a low muscle strength, are wheelchair bounded, cannot be helped by an already existing arm support, but have to much muscle strength to use a robot manipulator. Often the characteristics of this group are caused by neuromuscular disorders, but can also be caused by a spinal cord injury or stroke.

A more detailed analysis of the target group and other stakeholders can be found in chapter 3.

# 2.3 Functions and Operations

### 2.4.1 FUNCTIONS

To reach the goal set for the McArm, the following three functions are executed in the product:

1. Measure desired movement
2. Compensate gravity
3. Support desired movement

These three main functions are the same for each product of the wing-family, but the completion of these functions are different. Below the completion of these functions for the McArm are explained.

The first function is fulfilled by the use of a force sensor, placed on the back of the armscale, at the elbow joint. This sensor measures the forces and the direction of the forces. The input of this sensor is used for the execution of the other two functions.

The second and third function, gravity compensation and supporting the desired movement, are both fulfilled by the use of five actuators. These actuators are placed at the elements where they are needed for an even distribution of volume and a low energy transmission. Since the chosen actuators are strong enough for the desired performance and are not back-drivable, a spring is not needed for the balancing and gravity compensation.

For this bachelor assignment, the design and appearance of the product are acknowledged as a fourth function. This function does not determines the operational success of the product, but it partly determines the psychological success of the product.

This completion of the different function should also help reach the goal of the broader target group (paragraph 2.2.1) by enabling the user to use the product both as a Gowing and as a Darwing.

### 2.4.2 DEGREES OF FREEDOM

The product supports movement of the upper arm and forearm independently. It supports adduction and abduction of the shoulder, retroflexion and anteflexion of the shoulder, endorotation and exorotation of the shoulder, and flexion and extension of the elbow. Pronation and suppination of the elbow is not supported and also the wrist movements are not supported by the McArm.

To provide the support of these movements the product has five degrees of freedom.

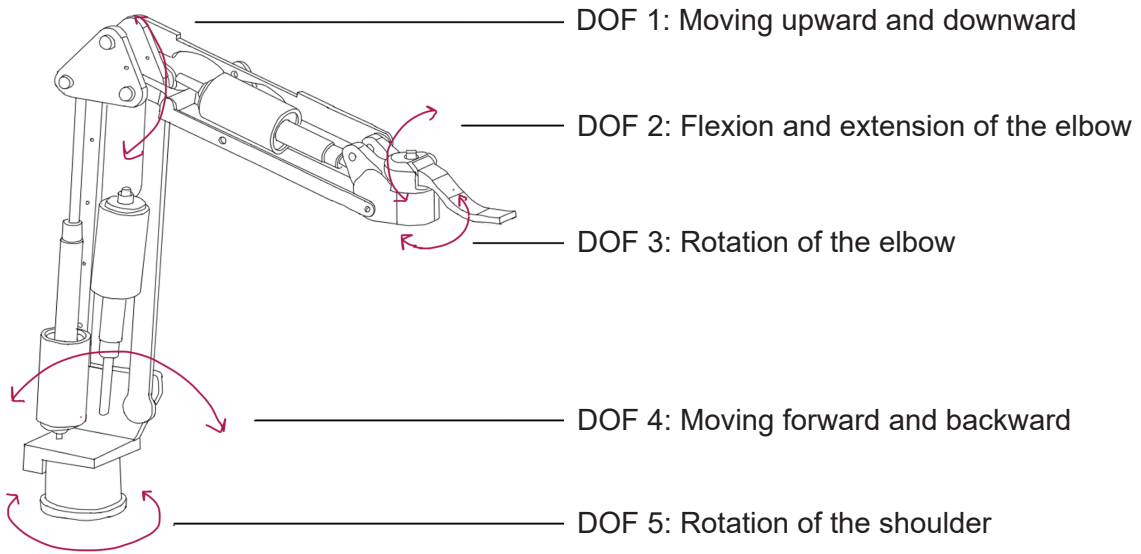



Figure 4: Degrees of freedom

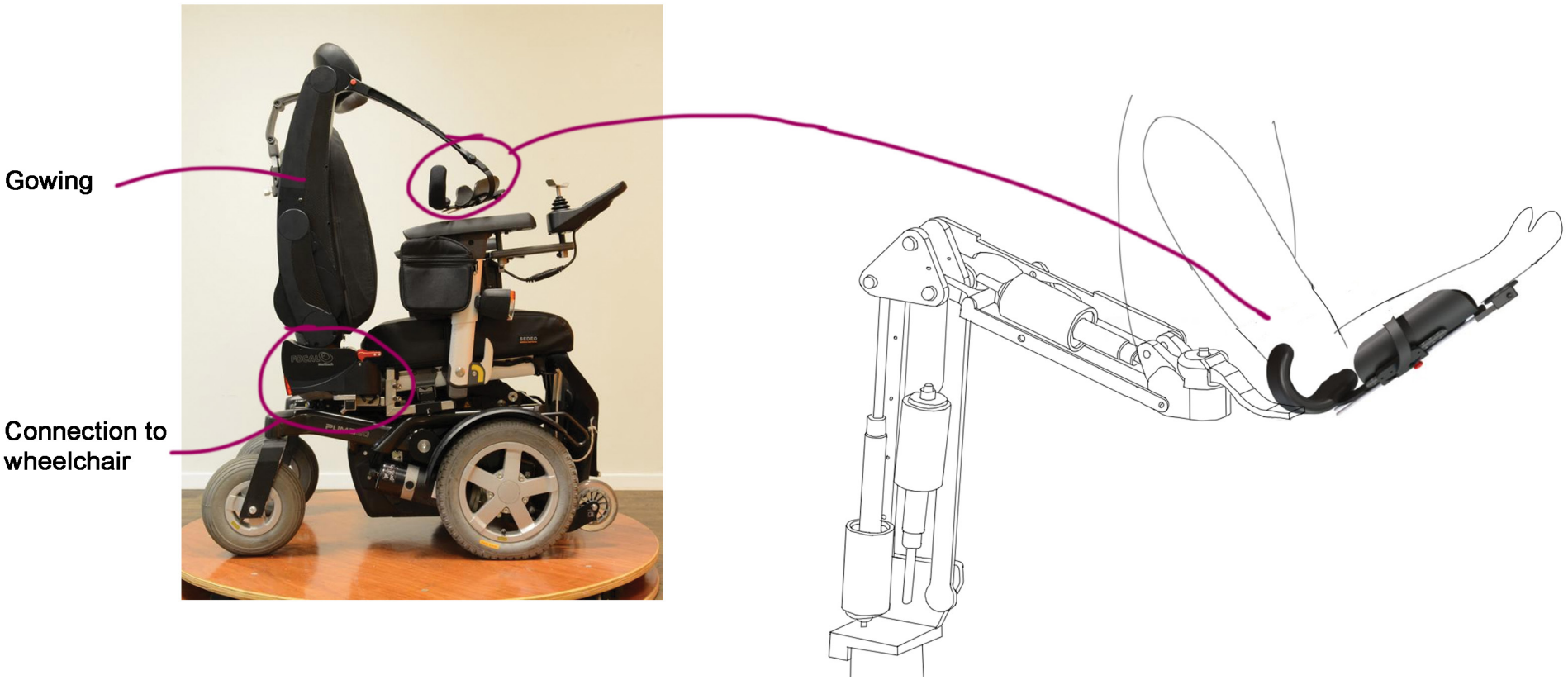



Figure 5: Gowing placed on a wheelchair / the McArm connected to a user

Each node of the product has one degree of freedom (DOF), but the startpoint of the armscale has two. The degrees of freedom of the different nodes can be found in figure 4.

The construction that is used to show the degrees of freedom in figure 4, is the starting point of the development of the construction at the beginning of this assignment.

## 2.4.3 INTERFACES

### CONNECTION TO THE WHEELCHAIR

The product is connected to the base of the wheelchair, to provide a more stable unity. The type of connection is the same as the connection of the Gowing (Figure 5). This connection consist of two parts. A detachable base is placed on the wheelchair and the arm support is detachably placed in the base part. The fixation of the base is done with an handle.

### CONNECTION TO THE USER

The body parts connected to the product is defined as the body interface(Dunning and Herder, 2013). For the McArm, the arm scale is the only part of the product that is part of the body interface.

The armscale is the same type of armscale as used for Darwing. There is a passive connection between the armscale and the arm of the user, which means that no

straps or other fixation is used for holding the arm in the right place. This passive connection provides freedom for pronation and suppination of the elbow, a degree of freedom that is not supported by the product itself.

Different sizes of the armscale are available and the armscale can be adjusted a little to the user by heating the armscale, that is made of plastic, and adjusting the shape before it cools down.

For the McArm a standard armscale with elbow support and the possibility to add a wrist support will; be used as can be seen in figure 5. The design of this arm scale will not be in the scope of  this assignment. Also the placement of the force sensor will be on this armscale, but the exact location is not yet determined. Determination of the location of this sensor will also not be in the scope of this assignment.

**CONTROL OF THE PRODUCT**

Although the product measures the desired movements, adjustments can be made when using the product.

The product can be turned on and off, for saving accu capacity when the product is not is not being used.

Also the detachability of the product is an control point. For detaching the product, a handle is used. This is the same handle as used for the Gowing.

Besides these basic control points, many parameters are presented that influence functioning of the product. These parameters are mostly software settings of the product.

In other arm supports or products, this type of parameters and modes are controlled by a joystick with screen, a keyboard/ buttons or a touchscreen. For the McArm it is desired by the company that the control of these parameters is more intuitive and adjustments can be made without the use of extra screens and buttons and by actions that are in the natural scope of the movement of the arm, such as the trigger for the degree of gravity compensation.

# 3

# THE PROBLEM

For this bachelor assignment, the appearance of the McArm is investigated with improved product acceptance as a goal. For this investigation, product-related stigma is defined as the main problem for the appearance of the McArm. In this chapter the definition of this product-related stigma will be determined along with some research on product signification and product acceptance. This chapter will finish with dilemmas and leads when appearance is included in the development of the product. This problem analysis results in some product requirements that need to be included for defining a shape and appearance of the McArm.

In the introduction of this report, product-related stigma is defined as the main problem in product acceptance and likability. Within literature the following definitions for stigma are found:

“Stigma = a person’s social identity or membership in some social category calls into question his or her humanity. The person is devaluated, spoiled or flawed in the eyes of others.” (Crocker, Major and Steele, 1998)

“Stigma is a mark that is attributed to a person while in interaction with a specific social context” (Vaes, 2014)

“Stigma = A mark that links someone to undesirable characteristics causing damaged/low self-esteem” (Skogsrod, n.d.)

Beside this definition, Skogsrod (n.d.) also defined four different types of stigma: visible stigma (E.g. wheelchair), hidden stigma (E.g. HIV), achieved stigma (E.g. prisoner) and voluntary stigma (E.g. piercings).

From these definitions it can be concluded that a social context is always present when stigma occurs. The actual stigma itself is a negative and subjective characteristic that is present in that social context and stigma influences the emotional well-being of the stigmatized person. (Figure 7) For example, when a wheelchair bounded person is going to the supermarket and needs a product from the top shelf. Since this person cannot reach for the product himself, the person has to ask a supermarket employee to get it for him (social context). The supermarket employee could feel pity over the person who cannot reach to the upper shelfs, or even keep distance from the person because they are unconsciously scared of the person (stigma). This might result in lower self-esteem of the person and in some cases it might restrain the person from buying products from the upper shelf (influenced emotional well-being).


Figure 7: Definition of stigma

The example mentioned above is an example of human to human stigma (Vaes, 20141) Which means that the stigmatizing reaction is about the user of an assistive device. Vaes (2014) also defined stigma from human to product. In this case the stigmatizing reaction is about the assistive device itself. For example, when first using a wheelchair, a human to product stigmatizing reaction can be: “That wheelchair is so ugly and has so many parts, would it make me look ugly and complicated as well? “. For the McArm, both types of stigma can occur. The human to human product-related stigma is presented when the product is used in a social context. The human to product product-related stigma mostly occurs when fitting the dynamic arm support for the first time.

The fitting of the product and the stigma that occurs when fitting the product for the first time will be explained in more detail in paragraph 3.1.2: signification of the assistive technology. In the design of the McArm, it is desired that this both types of stigma do not occur and the product only recalls positive, non-pity, reactions from bystanders and users.

### 3.1.1 REASON FOR PRODUCT-RELATED STIGMA

Stigma is caused because every person always judges, something conscious, sometimes unconscious, but always based on first impression and appearance. Thereby, using a quote from Paul Watszlawick: “One cannot not communicate”, products always communicate a certain appearance. For example, when seeing a cup of thee, everyone sees a cup of thee, because this cup is able to preserve the thee in it. On the other hand, the appearance of this cup determines what kind of cup is seen. Is it in old fashioned cup, or a personal cup or even an advertising cup. It is impossible for people to see, just a cup. So it is important to make sure that appearance is included in the design process, to create a positive judgments and therefore decrease stigmatizing reactions toward the product and its user (Skogsrod, n.d.).

The amount of stigma present when people react to objects, and assistive devices specific, depend on various aspects. The attitude toward a disabled person depends on the amount and nature of direct contact with the disabled person and the amount of information they have on the disability and person (Parette and Scherer, 2004). For example, a bystander who has a wheelchair bounded uncle, is less likely to have a stigmatizing reaction to a wheelchair user in a mall. For the user on the other hand, this aspect influences the attitude to him- or herself. When knowing other persons who use a wheelchair, they are less likely to feel embarrassed for using a wheelchair themselves.

Also a reaction to a product is determined to be positive or negative according to the similarity or difference between a disabled person and a not disabled person. On the same level, also the similarity or difference between socially accepted products and the assistive device influences this reaction (Parette and Scherer, 2004). For example, when using an umbrella as a waling aid, stigma is less likely to occur, because people who do not need a walking aid, also use an umbrella. In this example the disabled person looks the same as a non-disabled person on a rainy day and the umbrella is more socially accepted than a walking aid.

### 3.1.2 SIGNIFICATION OF THE ASSISTIVE TECHNOLOGY

Each user significates his or her product in a different, very personal, way. For example, when seeing a wheelchair, everyone thinks about a wheelchair. What this wheelchair means to someone differs for everyone. Although the significance of a product is specific for each user, the route to this product significance is equivalent for most users. Significance is partly determined by the expectations users have about their product. Family members, relatives and bystanders are important resources for forming these expectations, that can be of three different types (Vreeswijk, 2002):
- Expectations based on cultural knowledge
- Expectations based on own experiences
- Expectations without experiences

Expectations based on cultural knowledge are expectations of the community. For example, the image of the community on compression socks is that they belong to the elderly, so when wearing compression socks, you must be old and weak.

Expectations based on own experiences are expectations based on for example, the use of previous assistive device. Also experiences with family members or other relatives that use similar assistive devices lead to this type of expectations.

Finally, the expectations without experiences. These expectations are, contrasting to the other types, not based on experiences but on predictions of the user. For example, when needing a hearing aid, the degree of perceiving sound when using the hearing aid is very personal and expectations on this level are therefore only based on predictions.

For designing and developing the McArm, these different types of expectations should be kept in mind and experiences of users of similar product should be taken into account since meeting expectations determines the product acceptance greatly (Vreeswijk, 2002)

Product significance is a result of these expectations and how the product meets these expectations. This product significance can be divided into the central categories of signification (Vreeswijk, 2002). The following categories are distinguished:
- The visible outside
- The invisible inside
- The functioning of the product.

The visible outside is an aspect that becomes notable by external observation. Signification of this category is caused by comparable shapes and materials. The visible outside contains a universal basic shape and a time bound appearance. For example, a prosthesis. The universal basic shape is derived from the shape of the leg, so that the signification of the prosthesis is still a leg. The appearance of the prosthesis can be derived from everything in the world, such as a human leg for a realistic appearance

and signification, or the newest IPhone the create an appealing and trending gadget like appearance and signification. During the rest of the report, when speaking of the design of the product, the visible outside is meant.

The design signification is influenced the most by the appearance and the design of the McArm, therefore during defining this appearance and design, the universal basic shape and time-round appearance will be used as a starting point During the ideation phase the focus will be on the universal basic shape and during the detailing the focus will be on the time-bound appearance. Also the context of this type of signification will be examined further on in paragraph 3.1.3.

The invisible inside is the second category of signification. This type can be seen as “the staying inside the product”, the direct contact between human and product (Vreeswijk, 2002). With this the interaction between the product and the user is meant. For example, when using a cup, you hold the cup. The feel of the surface, the heat flow from the thee through the cup to your hand and the weight of the cup when carrying it, are all examples of the invisible inside of a cup. To be more clear, during the rest of the report the invisible inside will be explained as the user-product interaction.

In case of the McArm, the direct contact between human and product is part of the user-product interaction. An example for this interaction is the fitting of the arm in the armscale. Does the arm fit properly, does using the armscale result in any discomfort? Also the sensory feel when touching the other parts of the product is part of this user-product interaction. When the product comes in contact with the upper arm in a certain position, the sensory feel of the product should not be unpleasant or cold.

Last category of signification is the functioning of the product (Vreeswjk, 2002). Targeting and the effects on the behavior and functioning of the user are important aspects of this category. For the McArm, the targeting can be seen as an improved range of motion of the user and creating independence for the user. The difference in behavior can be that a user is confident enough to go eat in a restaurant because moving food from plate to mouth is easier when using the assistive device.

A visualization of the causes and types of product signification can be seen in figure 8.

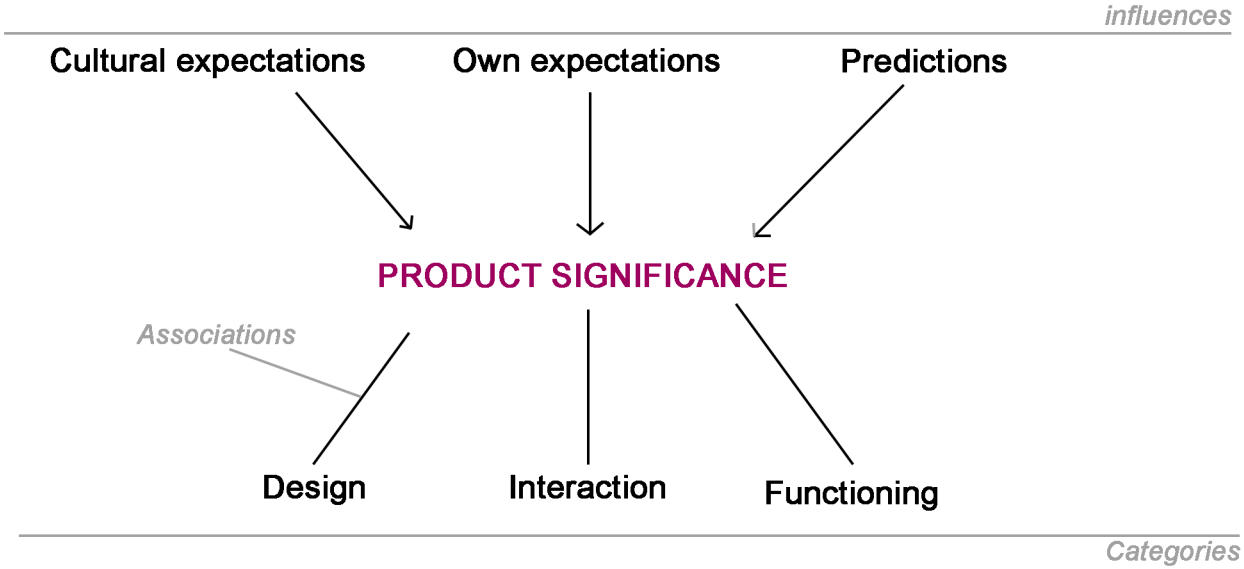



Figure 8: Visualization of product significance

### 3.1.3 CONTEXT OF THE DESIGN SIGNIFICATION

In the previous paragraph, it is stated that the design (visible outside) of the product greatly influences the product signification of the user. This influence occurs in both levels of product-related stigma (human to human, human to product) (Vaes, 2014).

For the human to product product-related stigma, the influence of the design (visible outside) takes an important place in the first phase of the provision of the product (Vreeswijk, 2002). For the McArm, this first phase is the fitting of the product. For the human to human product-related stigma, the influence of the design is present during the habituated use of the product. For the McArm, the goals of the user on the appearance are part of this habituation phase.

### HUMAN TO PRODUCT PRODUCT-RELATED STIGMA

A user of an assistive device does not go to a consumer store, but uses his or her insurance and introduction to the product only takes places at the moment of provision. An employee of Focal Meditech and the occupational therapist of the user will meet the user. The employee of Focal will bring all different types of dynamic arm supports and after a quick discussion about the needs, wishes and abilities of the user, some of the arm supports are tried out by the user. When/if a suitable arm support is found, the company will start the provision of the arm support.

At the time of this fitting of the product, the design forms a bridge between the living environment of the user and the medical environment of the assistive device (Vreeswijk. 2002). Most of the time the assistive device is a complicated product and when needing the assistive device, a lot of medical terms are used. The design is the first and sometimes only thing that a user understands when in first need of the product.

### HUMAN TO HUMAN PRODUCT-RELATED STIGMA

When the product is already in use, other contextual aspects are present for the design signification of the product. The signification of the product is directly linked to the personal identification and self-esteem of the user. The design of the product forms a base for the feeling of belonging and the social relations of the user (Vreeswijk, 2002). The design signification in this stage influences the visualization of the user's disability.

Most users doubt between using an assistive device and be stigmatized or not using a product and being dependent and disabled (Parette and Scherer, 2004). For other users the assistive device is a way of making bystanders aware of the situation the user is in. When defining the design of the McArm, the desires according to the visualization of the disability of the user need to be taken into account.

## 3.1.4 PRODUCT ASSOCIATIONS

The signification of a product is a long route based on different types of expectations within the three signification categories, but the design significance and meaning that a user finally gives to their product is different for each user (Veas, 2014). This difference occurs along with the associations people have with a product. Looking back at the example of the thee cup with a universal basic shape of a thee cup, but with the possibilities of different time-bound appearances, the same associations with this cup can lead to differences in the signification of the product. For example, an old fashioned thee cup. The universal basic shape is a thee cup, for some users of the cup this can be negatively significated, because the user does not like thee, for another user this could create a positive signification because this user likes the relaxation of drinking thee. Looking at the time-bound appearance the cup of this example is associated with old-fashioned. Some users would significate this with being old and being weak. Other users would significate this with happiness and family, because these users used to drink thee with their loved grandmother out of old-fashioned thee cups. The way associations lead to product design significance is visualized in figure 8.

The associations made with products are based on comparisons. Such a comparison takes a recognizable aspect of a something familiar as a reference for defining an association with something unfamiliar (Vreeswijk, 2002). For the design of an assistive device, association with medical products (white, industrial) are undesired, but association with nature (Organic shapes, friendly) are seen as positive and therefore are desired (Vreeswijk, 2002).

Taking into account the overall goal of the McArm as presented by Focal Meditech and all the research done using different readings, for example the ones by Vreeswijk (2002) and Vaes (2014, the following desired associations are assumed:

- Empowerment
- Strength
- Speeds/dynamics
- Friendliness

The first desired association is empowerment, this association relates to personal identification and self-esteem of the user as presented in the previous section. To associate the product with empowerment, the product should put the focus on the abilities of the user instead of the disabilities. This would result in a product appearance that draws attention to the hand of the user. This focus point shows the empowered users to still be able to use his/her own hand.

The second desired association is strength. Since the muscle strength of the average dynamic arm support user is very weak and the McArm gives them back their strength, the appearance should enhance this recovered ability. This also influences the personal identification and self-esteem of the user and therefore the human to human product-related stigma positively.

The third desired association is speed and dynamics. The McArm empowers the user to perform movement actions faster than without the use of the product and this goal should be visible in the design of the product, to not only physically create more strength, but also associate the product, and therefore the user, with more strength.

The last mentioned desired association is friendliness. This association is based on the contradiction with industrial and medical products. The associations with medical and industrial products are undesired (Vreeswijk, 2002), so the opposite associations are desired. Also friendlier associations could decrease the often occurring fear of assistive device users

How these assumed to be desired associations are included in the design process can be seen in the next chapter: ideation phase. The inclusion of these association is evaluated in the evaluation phase (chapter 6).

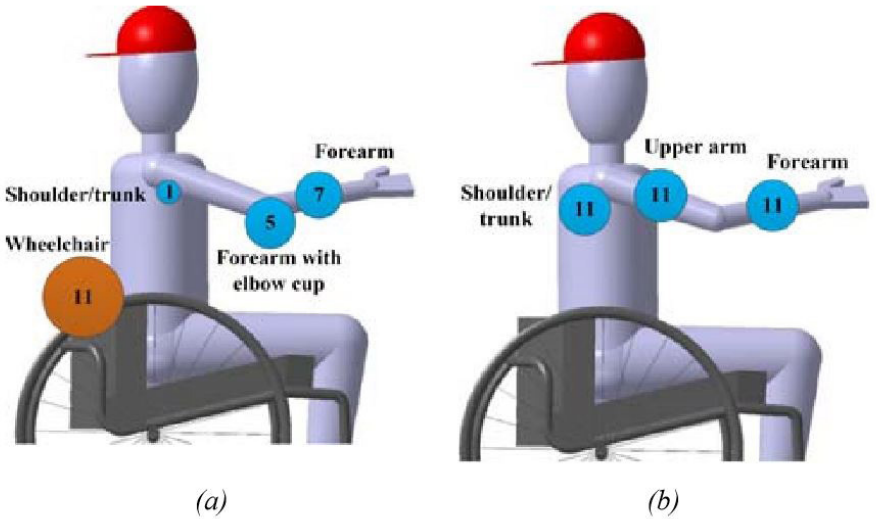



Figure 9: (a) serial construction (b) parallel construction (Dunning and Herder, 2013)

### 3.1.5 DILEMMAS WHEN APPEARANCE IS INCLUDED

The previous paragraphs show why the appearance is important for the product acceptance and likability. This paragraph will explore some dilemmas that occur when the appearance is included in the development of the product.

#### AESTHETIC PREFERENCES

The first problem that occurs is that different users have different aesthetic preferences. These differences are caused by the social context of the user, time boundaries, age, gender and the disability acceptance (Parette and Scherer, 2004). Also aesthetics and appearance are not a quantifiable value, but an emotional value that is hard to include

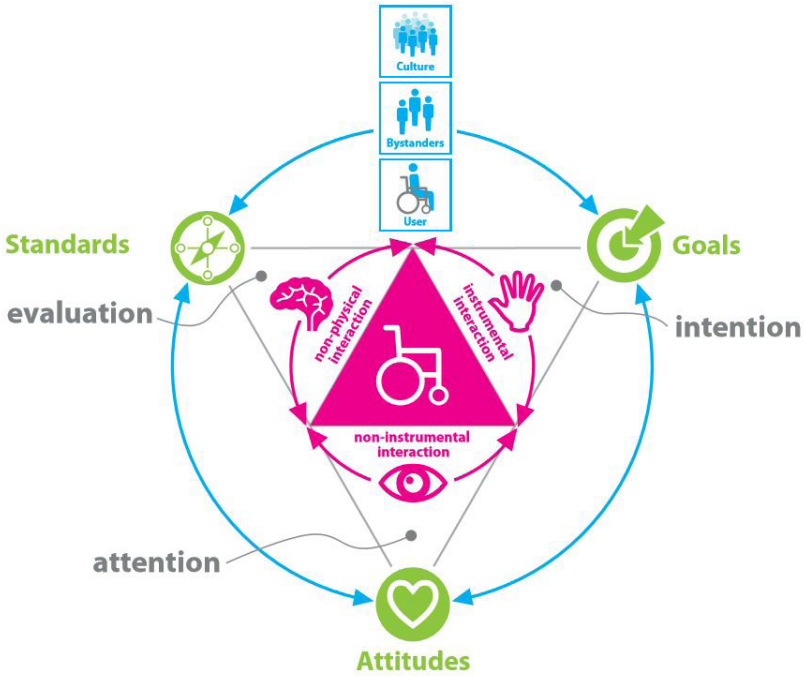



Figure 10: PAMS (Vaes, 2014)

and influence with the product (Ksogsrod, n.d.). With Focal Meditech wanting to fit the product to the majority of the users, also the appearance should be appealing to the majority of the users. How this goal can be reached will be further investigated in the beginning of chapter 3: theoretical ideation

**USER/WHEELCHAIR DILEMMA**

Another dilemma that occurs when designing the McArm (visible outside) is the user/wheelchair dilemma. As stated by Vreeswijk (2002) and mentioned earlier in paragraph 3.1.2, the appearance of the product should be true to nature, which means a resemblance with the human arm in case of the McArm. According to the same study done by Vreeswijk (2002), the product should also be true to its direct environment, in case of the McArm true to the wheelchair. A product that both mimics the user and the wheelchair is not feasible, so compromises should be made.

Along with this dilemma, the choice between a parallel or serial construction should be made. This choice is highly related to the user/wheelchair dilemma. During their review of assistive devices for arm balancing, Dunning and Herder (2013) divided constructions for arm balancing into parallel and serial constructions. Parallel constructions are connected to the body at all supported joints, while serial constructions are only connected to the human body at one point. The difference between a serial and parallel construction is shown in figure 9. The joint with number 11 are directly linked to the body/ wheelchair. The numbers 1, 5 and 7 are possible connection points with the human body for a serial construction.

Passive orthoses and devices for arm balancing are always serial to the body according to Dunning and Herder (2013), but they do not recall that it is not possible to differ from this. For the design of the McArm a serial construction is taken as a starting point, since this is the type of construction that is already used in the current state of the product as described in chapter 2, figure 4.

**CONSPICOUS/UNCONSPICOUS DILEMMA**

The last dilemma that occurs when including the design during the development of the product is the choice between a conspicuous or unconspicious product. As stated in the previous paragraph, some users use the product two show their disability and make bystanders aware of their situation. On the other hand, there are many user, who are highly influenced by the product-related stigma and therefore want to hide their assistive devices as much as possible. A compromise needs to be made between a conspicuous or unconspicious

### 3.1.6 THE PRODUCT APPRAISAL MODEL FOR STIGMA (PAMS)

Research on product-related stigma done by Vaes (2014) resulted in two applicable tools for designing assistive devices. First tool is the Appraisal Model for Stigma (PAMS). This tool explains context and appraisal factors that influence the occurrence of product-related stigma. Using this tools should provide more inside on the appraisal of a product and should ease the complexity of the context of the use of an assistive device.

The PAMS consist of two formats. First is a coherent graphic representation of the relevant factors involved in product-related stigma as can be seen in figure x. The second format is tangible design tool that consist three integrated matrix checklist. The model results in a list of stigma specific design challenges for the design of an assistive technology. It should be noted that this model takes into account the whole development process. In the following paragraphs both formats will be explained and will be only applied the design of the McArm, within the scope of this assignment.

## GRAPHIC REPRESENTATION OF PRODUCT-RELATED STIGMA

The model can be seen in figure 10. In the center of the product a wheelchair can be seen, that shows the product. It is surrounded by three different types of interaction with the product (in magenta). First is the non-instrumental interaction, which results in sensing and product perception (the eye in the figure). This type of interaction can be compared to invisible inside defined by Vreeswijk (2002). The second is the instrumental interaction, which is the acting and product use, comparable with the invisible inside combined with the functioning of Vreeswijk (2002). Last interaction type is non-physical interaction, these are the meanings and consequences of the use of the product. This interaction is the resulting product significance as defined by Vreeswijk (2002).

Surrounding the interaction types, in blue, different context levels are shown. First context level is the user context. This context contains the background, experiences, values and skills of the user. Second context type is the context of the bystander, which contains the social interaction with the bystanders and the reactions of the bystanders. Last and third context type is the cultural context. This context is the context of a group of people containing both the user and bystanders who commonly share values and norms.

Last ring in the model contains three human concerns that lead to three different types of appraisal.

First is attitudes appraisal resulting in attention. This is the tendency to like or dislike product, people and activities. Seconds is standards appraisal, resulting in an evaluation. This is the evaluation of what is perceived, such as the resemblance with other, more familiar, products. Third appraisal is the goals appraisal, resulting in intention, which is the behavior of the user and bystanders in a specific situation.

The graphic representation of product-related stigma does not involve all new insights, but gives another perspective on the previously obtained insights and is also used as a confirmation of these insights.

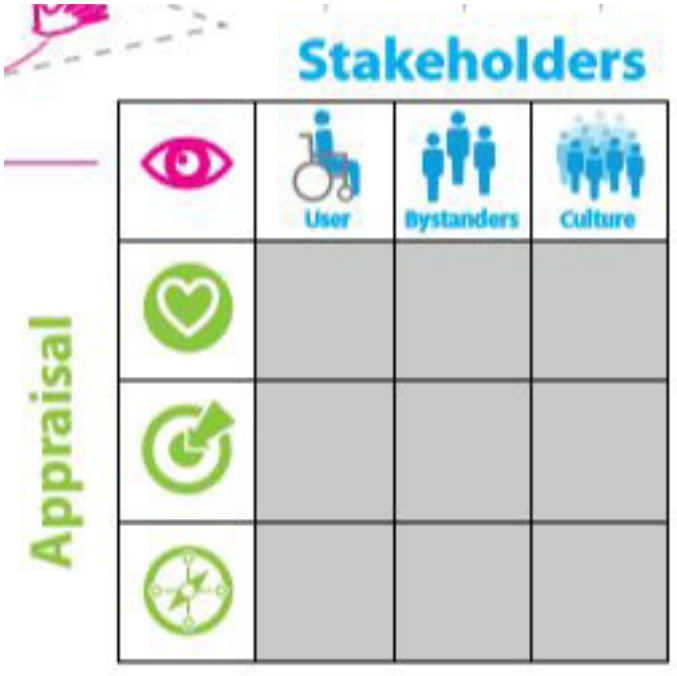



Figure 11: Example matrix PAMS (Vaes, 2017)

## THE DESIGN TOOL

Out of the graphical representation of product-related stigma, three different matrices can be constructed. Each type of interaction is represented in a different matrix. These matrices all include the stakeholders and the appraisal types, as can be seen in the example in figure 11. When filling in the matrices a challenge occurs that should be taken into account when designing an assistive device. The configurations and filled in matrices of an example product can be found in appendix A.1. Since little of the compartments of the matrices are within the scope of this assignmen, no filled in matrices of the McArm are shown. Below the

requirements that result of the challenges that are applicable to this assignment are listed:

- Product cannot exhibit discomforting or repelling features for its user. For the appearance of the McArm this means that the contact between user and product should feel comfortable. This should be included in both shape and surface material choice.

- Product cannot obstruct the user in obtaining his or her goals. The main goal of the product is supporting the user when performing activities of daily living, this main goal cannot suffer from the design of the product.

- Products significance and value is constant over time. For the McArm this means that the appearance is not time bounded and will be appealing over a longer period of time, without being a trend.

- Product cannot conflict with cultural habits, rules or laws. The design of the McArm cannot hinder the fulfilling of rules and laws. This also means that the product should still be reimbursed by the health insurance, despite the design of the product.

- Products look and feel matches with the personality and lifestyle of the user, bystander and culture.

- Product should be tolerated not only out of pure necessity. In case of this assignment, this means that the product should be accepted not only by its functioning but also by its appearance.

- Product matches the user's expectations and desires

### 3.1.5 REQUIREMENTS AND GUIDELINES

All different aspects of the problem analysis are discussed and examined and summarized in the following requirements and guidelines:

-Product does not create product-related stigma
-Product creates only positive reactions from bystanders(appraisal)
-Products appearance is appealing to the majority of the users
-Product resemble main stream products
-Product is conspicuous or inconspicuous.
-Product is serial to the body
-Product is not associated with medical product, or product used in the hospital
-Product should create the following associations: Empowerment, Strength, Friendliness, dynamics
-Product material should feel comfortable
-Product shape cannot hinder the use of the product.
-Product is reimbursed by the health insurances.
-Product matches user's personality and lifestyle
-Product is accepted by its appearance

### 3.1.6 CONCLUSION OF THE PROBLEM ANALYSIS

From this problem analysis firstly the definition of product-related stigma can be concluded as: A social context where negative and subjective characterizations are present that influence the emotional well-being of a person.

Also the signification of a product is examined. There are three types of influences of product signification:
- Expectations based on cultural knowledge
- Expectations based on own experiences
- Expectations without experiences

The product significance can occur within the following three categories:
-The visible outside (design)
-The invisible inside (interaction)
-The functioning of the product. (Functioning)

Another influencer of the signification are associations, the following associations are assumed to be desired:
-Empowerment
-Strength
-Speeds/dynamics
-Friendliness

At the end of this chapter some dilemma's when including the appearance in the development process are stated.

First dilemma is about the differences in aesthetic preferences. My vision on this dilemma is to have a generally appreciated appearances.

Second dilemma was the user/wheelchair dilemma. In my opinion the product should not mimic on of the two involved contexts, but the product should form the bridge between the wheelchair and the user. The part of the product connected to the wheelchair should mimic the wheelchair and the part of the product connected to the user should mimic the user. The difference between these two mimics should be merges to a smooth transition.

Last dilemma presented in this section is the choice between a conspicuous and unconspicious product. Since the vision of the company is to fit most of the users and I prefer to create a product appearance that is appealing to the majority of the users, I do not want to make a choice between a conspicious or unconspicious product. The appearance of the product should be designed in a way that the basic product(both universal shape and time-bound appearance included) should be unconspicious, but not hided. By personalizing the product users should be able to choose for a conspicious product.

# 4

# ANALYSES

During the analyses phase a different aspects that influence the appearance of the product are investigated, for example the end user and the market. Result of this phase is a list of requirements and guidelines that can be used to design the McArm and a vision that is used for the rest of the assignment.

# 4.1 Stakeholder Analysis

With the use of an assistive device, lots of different stakeholders are involved. These stakeholders are presented in a stakeholder diagram(figure 12). On the horizontal axis the interest of the stakeholder in the product is shown. On the vertical axis the influence that the stakeholder exerts is shown.

The stakeholders in the upper left corner of the diagram need to be satisfied, so they have to be taken into account without being the focus point of the design process. The stakeholders in the lower left corner of the diagram are not interested in the product and also do not influence the product, so these stakeholders will take minimum effort. The stakeholders in the lower right corner of the diagram need to be informed on regular base, so major issues can be prevented. The stakeholders in the upper right corner of the diagram are the most import stakeholders involved, so they need to be managed closely and if possible included in the design process. (Thompson, 2002)

Keeping in mind the duration of the assignment, and the importance of the stakeholders only the needs and wishes of the end user and the company will be included in the design process.

### 4.1.1 END USER

In short all wheelchair users with lacking strongly reduced arm functioning, but enough hand functioning are potential end users of the product. The degree of functioning and the stability of the shoulder determines whether the potential user is an actual end user. For this analysis all potential users are seen as an end user.

The reduced arm functioning can be caused by many different conditions, dividing from congenital diseases such as Duchenne or Multiple Sclerosis, but also during life obtained disorders such as spinal cord injury.

### 4.1.2 PERSONAS

What you think of the appearance of an assistive device is not very different from people's reaction to a specific piece of clothing. Everyone opinion is different, everyone has his or her own style, but it is possible to divide them into categories. Below four different personas are created with different generalized desires on the product. These personas will be used to create four different product versions that do not differ on the universal basic shape, but have their own time-bound appearance.

*Jeroen:*
Jeroen is the type of guy that does not get influenced by the appearance of his assistive devices. It does not have to be completely maneuvered away, but it also does not have to stand out. As long as it functions and it looks like a helpful and working product, Jeroen will be content with it.

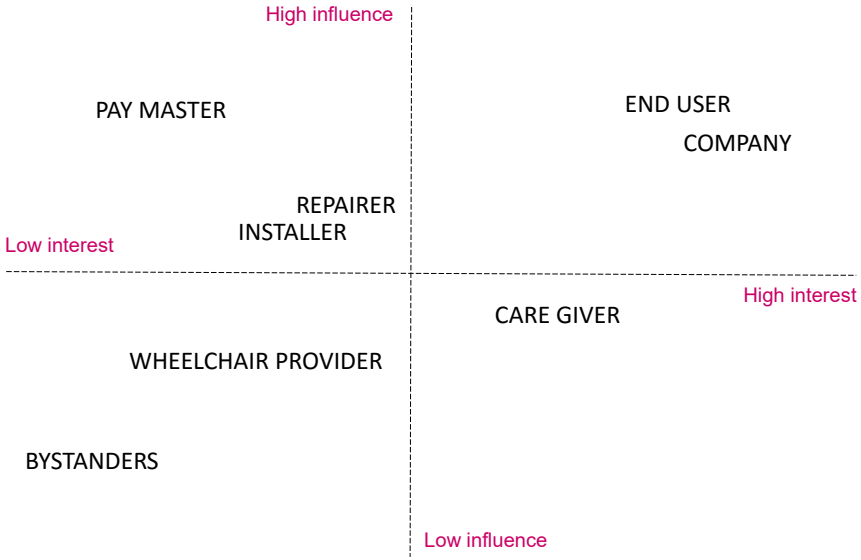



Figure 12: Stakeholders

*Jamilla:*
Jamilla is one of the stylish girls. Although she is in a wheelchair that is not appealing to her, she puts a lot of effort in the overall appearance to the world. Her clothing match perfectly. All the additional parts on her wheelchair are spray painted black so that it always matches her style and does not stand out.

*Jelle:*
Jelle likes gadgets a lot. He is always following the newest technologies and trends and has the newest phone. His own appearance is not as important as the appearance of the products he owns. His ideal arm support would fit the latest trends on product design and is a perfect show of, that makes his disability subordinate to his arm support.

Jacky:
Jacky is still in school and all her friends use assistive devices. Since everyone has lots of devices, that most of the time look alike, Jacky loves to make the newest device her own. She is very crafty and places stickers of the favorite cartoons all over the wheelchair. Her ideal arm support is completely personalizable.

In the problem analysis it is stated that the product should fit the majority of the users. To fit all four personas described above, personalizing the product might be the only solution. To do so a generally appreciated universal basic shape should be created and the time bound appearance should be personalizable.

### 4.1.3 REQUIREMENTS

During the stakeholder analysis some requirements and guidelines came up. Below all these requirements and guidelines are summed up:

-Product is personalizable
-Product had as generally appreciated basic shape

# 4.2 Market analysis

For the market analysis different assistive devices are analyzed according to their appearance. Firstly the appearance of the other products of the wing-family are examined, followed up by the competitional products of the wing-family. Also assistive devices in general are examined.

## 4.2.1 WING-FAMILY

The McArm will be part of the wing-family because of it's functioning, but if so, the product should also fit the appearance of this product-family. To make the McArm fit in the family and have the other products fit to the McArm at the end of the assignment, the shape characteristics of the products of the wing-family are listed. The shape characteristics can be seen in figure 13.

Aspects that come forward in each product of the wing-family is contrast in both colour and thickness of the product. The contrasting thickness makes the product look big and fragile at the same time. Also circular shapes at the rotational points(nodes) are repetitive aspects. At last, the visible mechanics and screws, result in a product that is not entirely united.

To fit the McArm to the product-family the circular shapes should be used. For improvement, the finishing of the product is important. Also the different thicknesses of the product should devolve neatly.

## 4.2.2 DYNAMIC ARM SUPPORTS AND EXOSKELETONS

Direct competition of the wing-family is the Armon product series by Micro Gravity Products. This company sells four different dynamic arm supports: Edero, Pura, Elemento and Ayura. First two are mechanical arm supports and the last two are electrical arm supports.

Based on the function the Armon Edero is comparable to Dowing, the Armon Pura to Gowing, the Armon Elemento to Darwing and

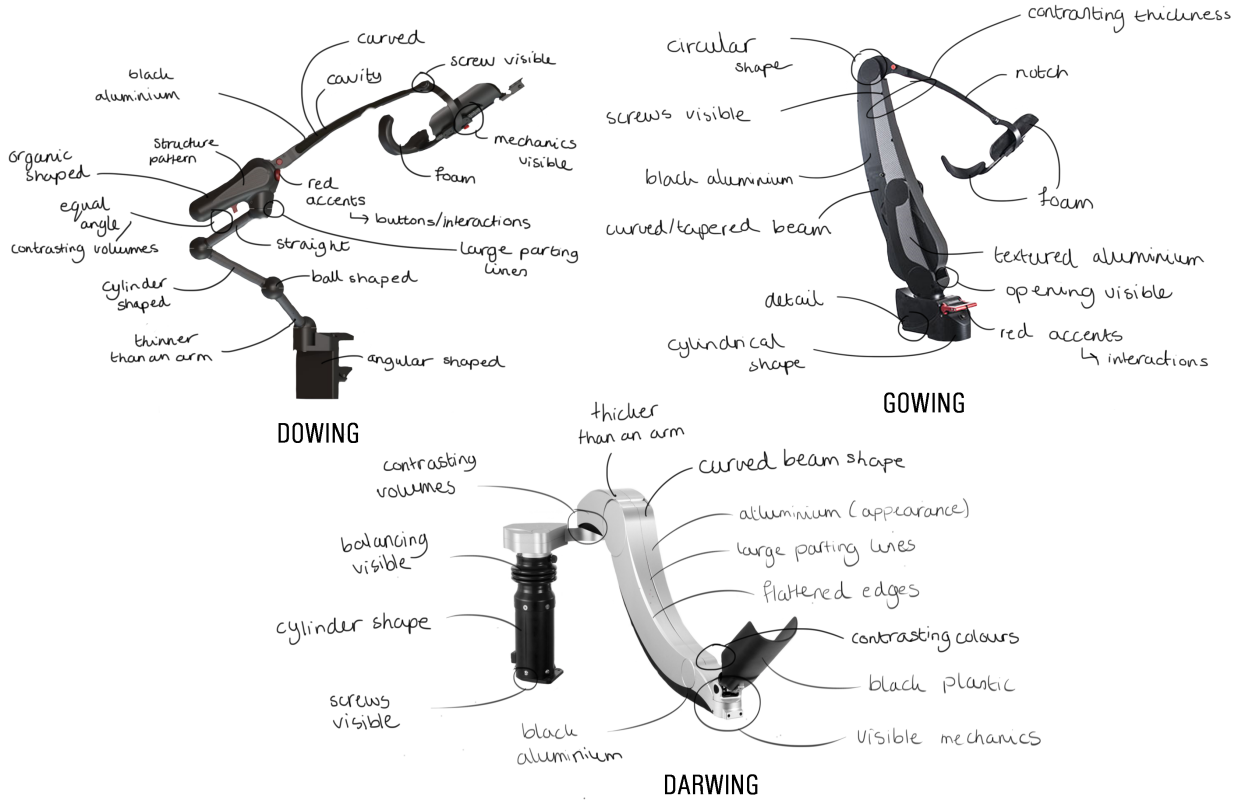



Figure 13: Shape characteristics Wing-family

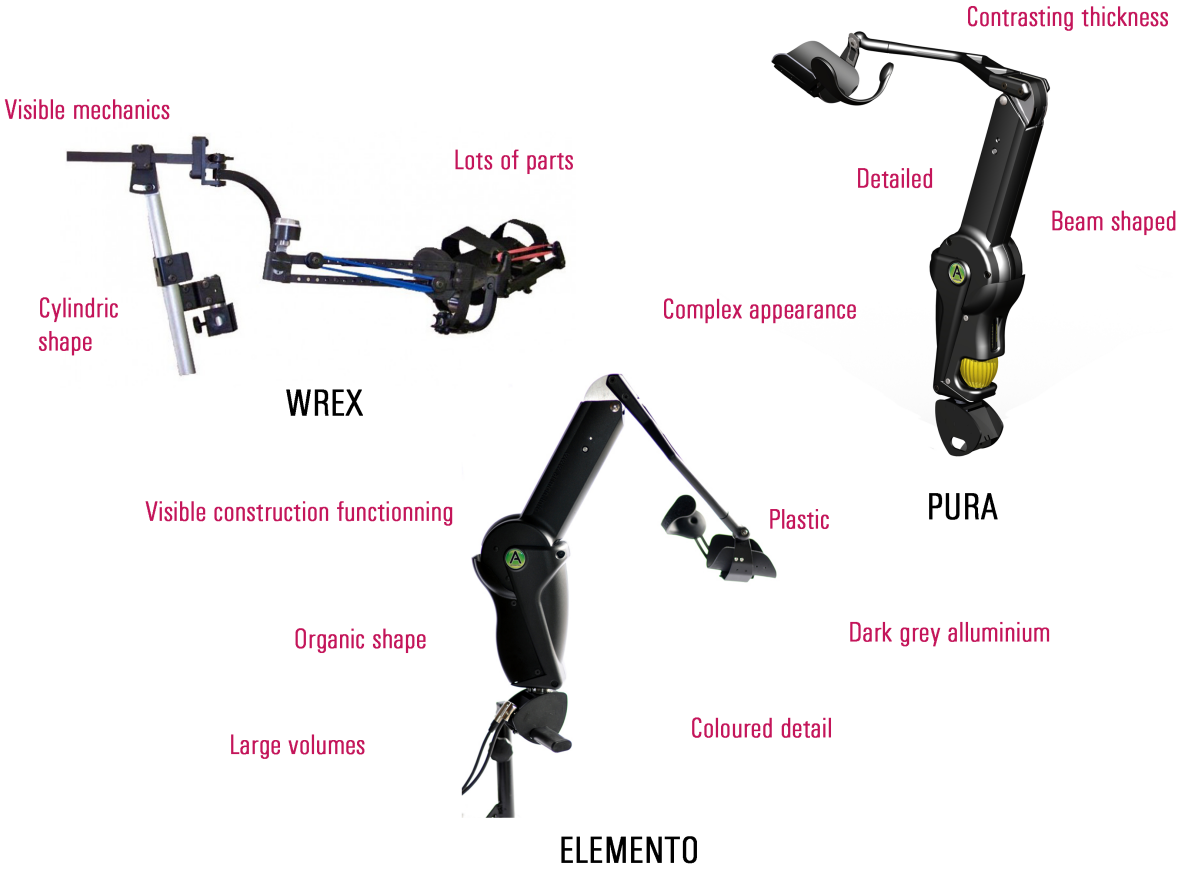



Figure 14: Shape characteristics competitional arm supports

the Armon Ayura to Darwing with added lifting function. (Armon Products, n.d.)

Another product that is direct competition of the McArm is Wrex, a exoskeleton for the upper limbs. The goal of this products is the same, being the first commercially available exoskeleton for the upper limbs (Jaeco Orthopedic, 2016).

Contradicting to the products of the wing-family, the product should not resemble the competitional dynamic arm supports. Therefore three other dynamic arm supports are analyzed by their shape characteristics. The Wrex, a mechanical Armon and an electrical Armon. These characteristics can be seen in figure 14.

The two Armon products are very resemblant. The Wrex seems very different, but all products shown are complex looking, because the may visible parts. The majority of the product looks like a unity, but the starting and end point are looking unfinished.

To have the McArm differ from the competition, onlay is a aspect that could distinguish the product and be unique. Also a the simple appearance that the wing-family products already exceed, could provide differentiation of the competition.

### 4.2.3 OTHER ASSISTIVE DEVICES

Arm supports are not the only assistive devices that cause product-related stigma. Therefore all different kinds of assistive technologies are placed in a coordinate system that can be seen in figure 15. This coordinate system will be used define a vision on the placement of the McArm on the function-design and notability scale. Also this coordinate system will be used to evaluate the defined shape of the McArm at the end of the assignment.

All products in this systems are ranked according to the desired notability of the product on the vertical axis and if they are design or function focused along the horizontal axis. Products that approximately belong on the place in the coordinate system, resulting in nine different product categories. For each category the overarching shape characteristics are annotated:

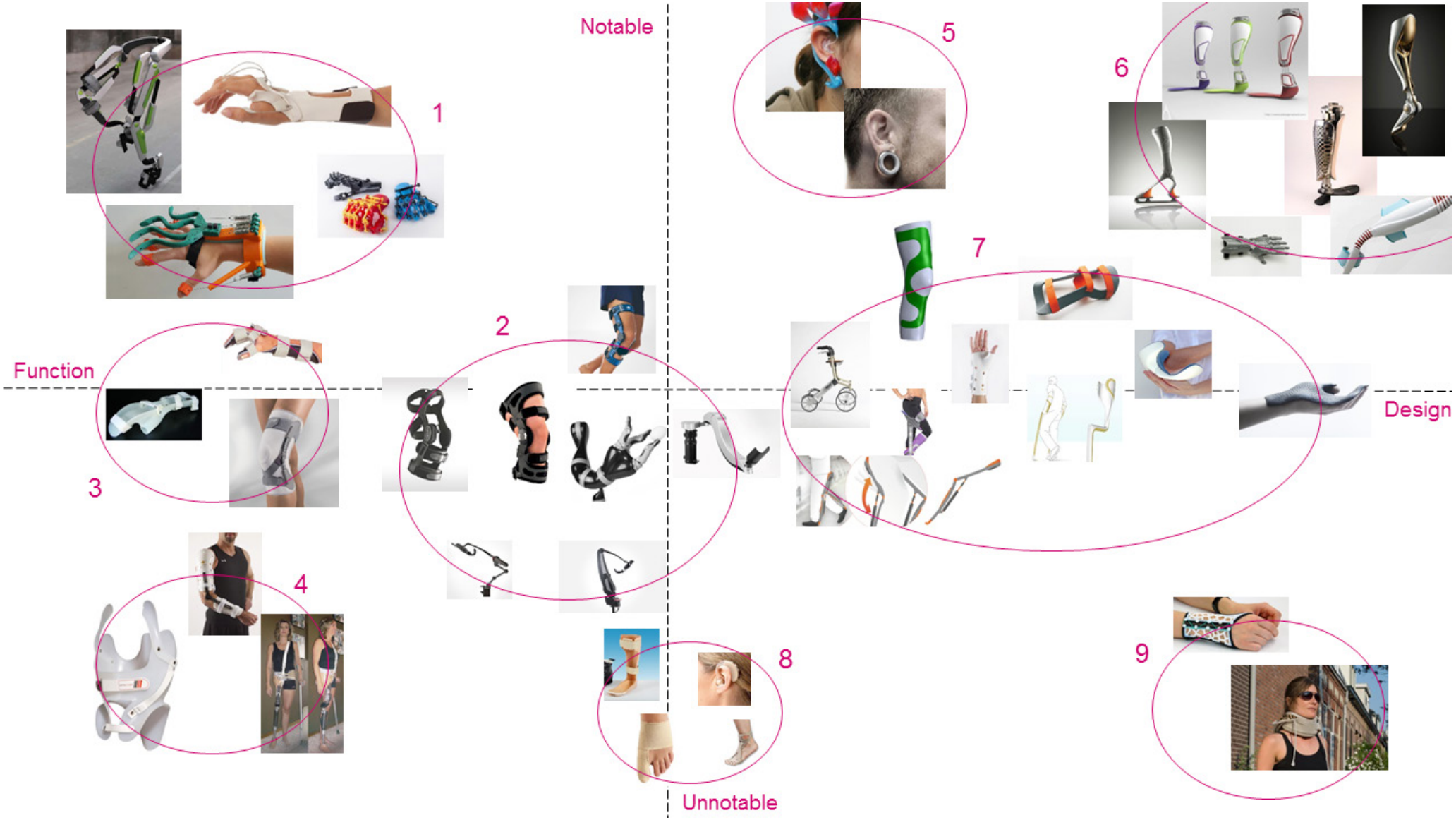



Figure 15: Appearance of assistive devices


Figure 16: Appearance of assistive devices

1. This category contains products where the design is fully defined by the function and where every function, part or movement is visible. It was not desired to hide the product, but to have it stand out by showing the desired outstanding function.

2. Second category contains products that are first fully functional designed, whereafter the appearance is improved within the functional boundaries.

3. Products that are part of this category are completely formed by function, do not intend to be noticed, but also are not desired to be hided. Also most of these products look uncomfortable to use.

4. Products in the fourth category have almost the same characteristics as the third category, but since these products are designed to fit the body more closely, they are desired to be hidden more. Most of these products are hidden under clothing.

5. Products in this fifth category are designed with a great importance for functioning, but combined with a very notable, personalized design

6. Category six focuses mainly on the design and appearance of the product. Most appearance are very notable and even a little futuristic. Some of the products in this category do not function.

7. This category's products included design as a function. The goal it should achieve is still the main function, but design is also important. Most of these products are not intended to be hided, but also not to be extremely striking.

8. Eight category contains products where the basic shape is fully defined by the function, but design is included in the colour of the product. All products are skin-coloured and intend to be inconspicuous.

9. Products in this last category have the same starting point as the products in category seven, but these products are intended not to be noticed. This is done

by integrating the functional product with accepted and regularly used products.

**DESIRED CATEGORY**

All products of the wing-family, and other competitive arm supports, are in the second category. Accepting design as a function and integrating the process of the functional design and the appearance, should improve the appearance of these products.

The third, fourth and eight category therefore are not desired. Either design and appearance is not taken into account at all, category three and four, or the appearance is used for trying to hide the product. Skin tone coloured product never exactly match and therefore will never exactly hide the product(Vaes, 2014).

Products in category one and six are designed for the individual. Since the product is a valuable product and products are used by a wide range of persons with different personalities, cultures and desires, this degree of personalization is not feasible for the product.

The remaining categories, category six, seven and nine, are possible desired categories, since all categories included design as a function. For category six applies, that this category is only desired if the products accomplish the functional goals of the product.

The choice of the eventual desired category depends on the degree of notability that is desired. For this project, category 7 is desired since this category would probably fit most of the users and this also fits the vision defined in paragraph 3.1.6 (a unconspicious, but not hided product, that can be conspicious by choice) This would result in the McArm having to be non-hided and non-striking.

### 4.2.4 MAINSTREAM PRODUCTS

In paragraph 3.1.1, it is stated that the McArm should resemble main stream products. Five mainstream products can be seen in figure 16, together with some appearance characteristics. This figure does not resemble all main stream products, but give an overview of the main stream products. When defining the shape characteristics in figure 16, the corresponding characteristics of the products are displayed.

Some of the products are trending products, which are appreciated at this specific moment, but the duration of this appreciation is unknown. For example the wooden sunglasses. At this specific moment wood is a material appearance that is found to be very attractive. The same applies to the pastel aluminum coloured IPhone.

A appealing aspect that is appreciated for a longer time is a simple design where the detailing is mostly determined by the material appearance. This is the case for the fitbit, that is all black but had contrasting structures, but also for the already mentioned IPhone and sunglasses.
The leather jacket and jeans that are presented in figure 14 are also found to be appealing products, but this acceptance and appreciation has been present for so long, that it is highly concludable that this appreciation will stay for the forthcoming times.

To include all these characteristics is not possible, but they can be used to create different detailed concepts or options for personalization. The simplicity in design and detailing that is a result of material appearance, that are present for all products shown is a desired shape characteristics of the McArm to have the product match with mainstream products.

### 4.2.5 REQUIREMENTS AND GUIDELINES

During the market analysis some requirements and guidelines came up. Below all these requirements and guidelines are summed up:

-No contrasting thickness
-Repetitive shape is circular
-No screws and other assembling parts visible
-Good onlay
-Simple appearance

# 4.3 Context analysis

### 4.3.1 WHEELCHAIRS

The product is placed on the base of the wheelchair, so the appearance of the product is influenced by the appearance of the wheelchair.

Most wheelchair whereon the product is used are electrical wheelchairs. Three types of electric wheelchairs are available. A front-wheel driven wheelchair, a back-wheel driven wheelchair and a mid-wheel driven wheelchair.

Figure 17: Wheelchair is use (Focal Meditech, 2016)

The three different types of wheelchairs can all be seen in figure 18. The difference is determined by the driving wheels of the wheelchair. For each chair, as seen in figure 15, the biggest wheels are driven and the smaller wheels are for support.

Different drivings results in different properties and different ideal use situations. For example a mid-wheeled driven wheelchair has a lower turning circle than a front or back driven wheelchair. All different properties are listed in table that can be seen in appendix A.2

Each use situation had an ideal wheelchair. For example a mid wheel driven wheelchair has a small turning radius and is therefore usable in small homes. Indoor used wheelchairs drive with a maximum speed of 6 km/h and outdoor used wheelchairs drive with a maximum speed of 12 km/h

Each situation is listed in table that can be found in appendix A.2, with the corresponding ideal wheelchair.

For each different wheelchair type many adjustments are available. For example a stand up function can be added and personal adjustments such as seating orthoses, seats and arm/head/leg rails. (hulpmiddelenwijzer, n.d.)

For the design of the McArm, this means that the design cannot limit the functioning of the wheelchair, but also should be able to handle situations that occur when the product is used on the wheelchair. It can occur that the user will drive against a jamb and the product should not break when this happens. Also the product can be used both inside and outside, so the product should be splash-water proof.

#### APPEARANCE OF WHEELCHAIRS

Beside the functional aspects of the wheelchair, also the shape characteristics are important and listed in figure 18.

From all these shape characteristics can be concluded that all wheelchairs present in figure 15 have a unfinished appearance, due to the visible mechanics and the many visible parts of different colours. This along with the different materials makes the wheelchairs appear not be an entirety. Since wheelchairs still cause

a lot of stigma and are seen as bulky and lacking aesthetic choices (Stenberg et al, 2016), these overarching appearances are not desired in the product.

In the problem analysis in chapter 3, it is stated that the product should match both user and environment. In contrast to this statement characteristics of the environment of the McArm are not desired, since wheelchairs still cause lots of stigmatizing reactions.

To create a product that does fit the environment, without taking over the stigmatizing reaction toward the environment, some shape characteristc should be included and some should not be included.

Conformity between product an environment should be obtained thourgh detailling characteristics such as colour, material and product finishing. Distiction should be made on the universal basic shape, such as the number of parts or highly constrasting sizes.


Figure 18: Three types of electric wheelchairs

### 4.3.2 REQUIREMENTS AND GUIDELINES

During the context anlysis some requirements and guidelines came up. Below all these requirements and guidelines are summed up:

-Product can handle driving against a wall with 12 km/h
-Product is splash-water proof
-Mechanics and construction of the product is not visible
-Product has a good onlay
-Product appearances matches the colouring and materials of the wheelchair
-Product is not hided
-Product is not striking
-Detailing is mainly determined by material appearance

# 4.4 Production analysis

Besides the appearance and usability, also the production and maintenance determine some specifications for designing the product. Since the production methods used within Focal Meditech, mostly machining, design for manufacturing would be a good design method to use for this project. This assignment is mostly about the appearance and therefore this design method will only be used to set some technical specifications and requirement that are needed to have a final design that is manufacturable and maintainable within the scope of the production methods used at Focal Meditech.

### 4.4.1 MACHINING

The material that is used to obtain most arm supports provided by Focal Meditech is aluminum. This material is strong and light and can be used for many different production operations.

Each production method has its own specific possibilities and restrictions, which are documented in design rules for each production method (Kals et al, 2012).

The production method that is used to create the stiff, complex and small series (around 30 products per batch) of products of Focal Meditech is machining. More specific it is a combination of milling and turning.

The design guidelines for these two production methods can be seen in appendix A.3. For this assignment the design will not be worked out in the amount of detail that is referred to in these guidelines. Therefore these guidelines are not taken into account for the requirements of the design, but are kept in mind when designing the product. These guidelines are provided by NPD solutions (2016).

Focal Meditech is now trying to reduce the production time and machine use by casting some of the aluminum parts and provide the needed surface finish by machining techniques. The basic design guidelines for this production method, provided by NPD solutions (2016) can also be found in appendix A.3

### 4.4.2 3D PRINTING

Since sales are going good and the production schedule of the company is busy , a 3D printer is purchased for the research and development department of the company. With this 3D printer some test parts can be printed without needing the machining equipment.

The 3D printer that they use is the Stratasys Fortus MC 250, shown in figure 19. It is a FDM (layer by layer) printer that uses ABSplus themoplastics that is available in many different colours. This product-machine combination makes it possible to not only create prototypes, but also to use this combination for production. This is the same 3D printer that will be used to create a visual representation of the final product. (Stratasys Ltd, 2016) The fact-sheet about the 3D printer and the ABSplus material can be found in appendix A.4.

### 4.4.3 SURFACE FINISH

After the desired shape is purchased by machining aluminum, the created parted should get a surface finish for the desired onlay and appearance. There are different types of surface finish.

**PRE-TREATMENT**

Before getting a surface finish on aluminum parts, the part needs a pre-treatment of cleaning and decreasing the surfaces. Also the natural oxidation layer should be removed by staining the part.

Through some surface finishes the structure of the aluminum is still visible. A desired structure can be obtained by: glazing, blasting and brushing. The appearance of these differently created structures can be seen in figure 20. (Aluminium coach, 2010)

**ANODIZING**

By a electrochemical treatment, an artificial oxidation layer is added to the part, when using anodization as a surface finish. After the

pre-treatment the part is rinsed, anodized, rinsed again and finally sealed.

This process can provide a clear surface finish where the colour of the aluminum is still visible. It is also possible to colour the part after anodizing and before sealing it. An example of a coloured anodized product is the apple IPod. (Aluminium Coach, 2010)

**VARNISH TREATMENT AND POWDER COATING**

Another surface finish of aluminum is a varnish treatment. These are multiple coloured layers adjusted to the aluminum. First a ground-layer of epoxy varnish is applied , whereafter the coloured layers are added through electrostatic spray painting. This can be done with liquid paint, or with a powder coating.

With power coatings, the powder is applied by electrostatic praying. Than the part is baked in an oven and the powder becomes liquid and covers the whole part. After baking the liquid particles will dry and turn into solid state again. The structure of the aluminum will not be visible after a couple of layers of varnish treatment. (Aluminium Coach, 2010)

**WRAPPING FOIL**

Besides all the surface treatments described for Aluminum, raping foil is also a surface finish option. This option allows every possible appearance needed.

The wrapping foil is adherent and available in many different appearances. A couple of examples can be seen in figure 21. When applying the wrapping foil, the protective foil is removed from the adherent side of the foil , whereafter it is placed on the part. Recovering mistakes or difficult areas can be wrapped by heating the foil over the desired area. (wrapfolie.nl, 2016)

All these options for the surface finish of the product will be taken into account when designing the final appearance of the product.

### 4.4.4 ASSEMBLY/MAINTENANCE

Besides design for manufacturing, design for assembly is also a design strategy that could be useful to use when designing the McArm. Design for assembly aims at the reduction of parts. Reducing the number of parts, makes production, assembly and logistics much easier.

There are three main question to ask, when determining if a part can be excluded. First question: Should the part move relatively to an other part? Second question: Should the part be made out of a different material? Third question: Should the part be releasable relatively to other parts for assembling or maintaining the product?

If the answer to all these questions is ‘no’, than it should be reconsidered if the part could be integrated with one or multiple other parts of the product.
Besides the number of parts, standardization is also an important aspect of design for assembly. For the standardization of a product, it is necessary to keep in mind that a larger number of simple parts is easier and cheaper than a lower number of complex parts, in most cases. This is especially the case for small series production, as is the case for Focal Meditech. (Kals et al, 2012)

Figure 19: Stratasys Fortus MC 250 (Stratasys Ltd, 2016)

When the product is in use, all kinds of problems can occur. With the mechanics all covered up as desired according the previous sections of this report, is needed to be able to reach the inner parts.

Reduction and standardization of the parts, along with the reachability of the inner parts will be taken into account in the detailing and evaluation of the design.

Figure 20: Pre-treatments of aluminium: blasted, glazed, brushed ( from left to right) (alumnium coach, 2010)

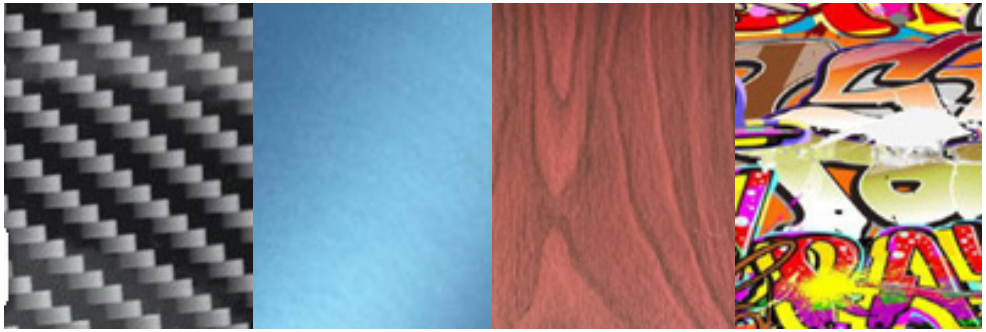


Figure 21: Appearances of wrapping foil (wrapfolie.nl, 2016)

### 4.4.5 REQUIREMENTS

During the production analysis some requirements and guidelines came up. Below all these requirements and guidelines are summed up:

-Product contains as few parts as possible
-Assembling product parts is as standardized as possible.
-Product can be obtained by using Focal Meditech's currently available production methods
-Product is producible according to the guidelines presented in appendix A.3
-Product contains only the minimum number of required parts
-Standardization of the product is kept in mind when designing the product
-Product parts are easily releasable so rapid maintenance is possible

# 4.5 Requirments

All requirements and guidelines conducted in the previous sections are collected and organized according the desired product value that they contribute to. The values used for this categorization are: functionality/usability. producability, acceptability and other.

Besides this categorization, all listed requirements and guidelines are linked to each other and divided into requirements/ characteristic and specification that suit with these requirements and characteristics.

Within the scope of this assignment, the requirements and characteristics that belong the acceptability value are the most important requirements and are shown in table 22 on the next page. All requirements can be found in appendix A.5.

| VALUE | REQUIREMENTS/CHARACTERISTICS | SPECIFICATION |
|---|---|---|
| *Acceptability* | Product does not create stigma | |
| | Product creates possitive reaction from bystanders | Desirede associations: Empowermenet, Strengt, Friendlyness, dynamical |
| | Product is appealing to the majority of the users | Product resembles mainstream products |
| | | Main shape does not contain very contrasting thicknesses |
| | | Circular shapes are repetetively present on the product |
| | | Product is simple |
| | | Detailling of the product is determined by material choices |
| | Product is not associated with medical products | Product is not white |
| | Product matches user's personality and lifestyle | Product personalizable |
| | Product is fully finished | No screws and other assembling parts visible |
| | | Construction is not unintended visibile |
| | Product is not inconspicious | Product is not hided |
| | | Product is not unchoicenly striking |
| | | Product matches the colouring of the wheelchair(mostly black) |

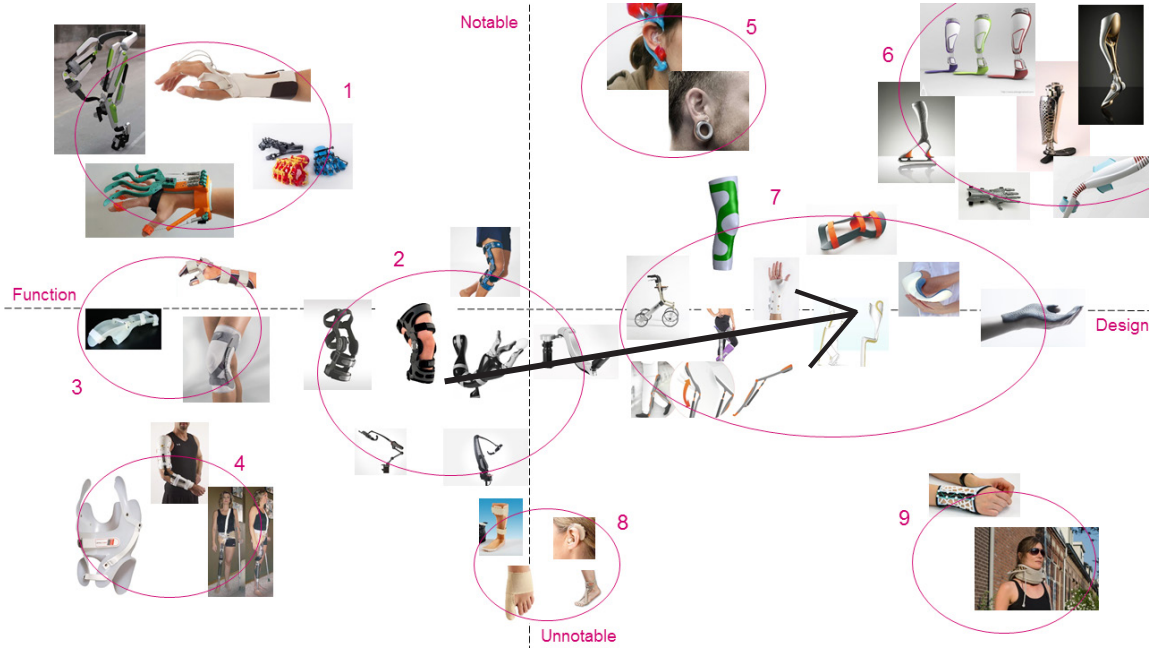
Table 22: Acceptabilty requirements

# 4.6 Conclusion of the Analysis

In this phase the problem, stakeholders, competition, context and production is analyzed with relevancy to the assignment.

From all these analyses a personal design vision for defining the appearance of the McArm is arised. in the coordinate system below the desired shift on the function/design and notability scale is shown.

The design of the McArm will be a design that is not hided, but unnotable. Notability of the product can be personally added by choice. This will be done for a product that still has all the required functionning, but with enough attention for the design of the product. All analyses done for this phase are transformed into requirements and guidelines that should provide a product that fits the set vision. The set of requirements can be found in appendix A.5



# 5 IDEATION

During the ideation phase different shapes of arm supports are investigated during five different iterations. Prior to these iterations, theoretical ideation is presented. This phase results in a fully defined shape, made visible with a Solidworks model.

# 5.1 Theories

Most of the requirements set during the analysis phase are subjective. By using both quantitative and qualitative evaluation methods it is possible to test these requirements, but using them do ideate on the subject is a hard task. Therefore in this paragraph some theoretical background information will be given that defines more practical requirements for the design and ideation of the McArm.

These guidelines are listed as possible solutions in the requirements table in appendix A.5.

For defining this guidelines practical design objectives will be given for the following categories: shape, texture and color.

### 5.1.1 PRODUCT CONCINNITY

The acceptance of an appearance is determined by many different aspects, The shape of a product is one of these aspects. To create an appealing design for the McArm the theory of product concinnity will be used as a starting point.

Concinnity, as defined by Sansoni et al (2014) is a harmonious and skillful arrangement of fitting together different parts of a product. It is an order and sense in which a product is perceived. More understandably, it is the way people see a product and it parts and how these parts come together.

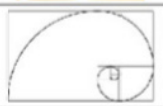
| Design Principles | Examples | Design Elements | Examples |
|---|---|---|---|
| Unity |  | Natural patterns |  |
| Grouping |  | Archetypes |  |
| Rhythm and Pattern |  | Colours |  |
| Contrast |  | Scultural properties |  |
| Balance |  | Fashion |  |
| Placement |  | Meaning |  |
| Proportion |  | | |

Figure 23:Parameters concinnity (sansoni et al, 2014)

In his research Crilly et al (2004) defined both subjective and objective concinnity.

Subjective concinnity is determined by the background of people that influences their aesthetic taste towards products, shapes and elements. (Design elements) Subjective concinnity determines whether a product appearance makes sense and is logical to a user.

Objective concinnity on the other hand can never be gained or lost in time. This is a framework, or the right recipy, for arranging the subjective elements and shapes. (Design principles) For example a product that is highly symmetrical an orthogonal appears to be more simple. (Crilly et al, 2004)

For an accepted and appealing design, both objective and subjective concinnity fit to the design (Sansoni et al, 2014). The parameters that influence the concinnity are shown in figure 20.

The theory of product concinnity makes a good distinguishment between objectively appreciated and subjectively appreciated shape characteristics, but this theory is still hard to apply for designing the McArm. Therefore in the next three paragraphs some additional theories are used to explore the application of the concinnity theory into the

design of the McArm. These theories are divided into three different levels: shape, texture and colour. The shape level contains applicable theory for the design principles of objective concinnity, the texture and colour level provide applicable theory on the design elements of subjective concinnity.

## 5.1.2 SHAPE

On the shape level of the product there are two aspects that are further investigated to provide more applicable guidelines for the objective concinnity theory. These aspects are symmetry/asymmetry and volume.

### SYMMETRY/ASYMMETRY

A symmetrical product has another appearance than an asymmetrical product. The effects of symmetry and asymmetry are listed in table 24. Since both balance (symmetry) and dynamics (asymmetry) are desired, the product should not be all symmetrical, but also not all asymmetrical.

Product symmetry can be obtained both horizontally and vertically, but these two types have different influences. Horizontal symmetry is almost not noted by people and often even needs correction to observe something as horizontally symmetrical.

Vertical symmetry on the other hand is highly noted. Therefore when working with symmetry in the design of the McArm, focus should be on the vertical symmetry.

| SYMMETRY | ASYMMETRY |
|---|---|
| Statical | Dynamical |
| Balance | inbalance |
| Without direction | directional |

Table 24: Effects of symmety and asymmetry (Eger et al, 2010)

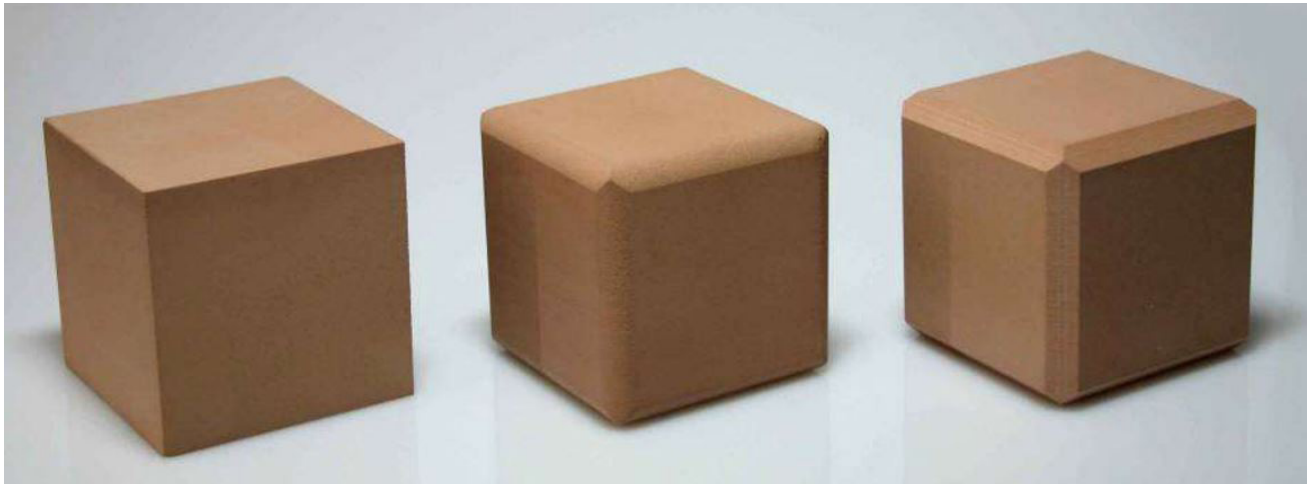


Table 25: Effects of filleds and chamfers (Eger et al, 2010)

### VOLUME

Another important aspect of the shape of a product is the products volume. This aspect is especially important for the McArm, since the main reaction when first seeing a dynamic arm support is: “what a big product!”, according to Focal Meditech.

The volume of the product is mostly determined by the inner construction of the product , but there are two ways to make the volume appear smaller than it actually is.

First way to create a product that appears to be smaller than it actually is, is by adding some fillets or chamfers to the product.
The filled or chamfered area of two connected surfaces will reflect light. The lighted area of this filled or chamfered edge will make the product appear smaller than a striped light reflection of a non-filled or non-chamfered surface. The results of this interventions are shown in figure 25.

An other way to influence the appearance of the volume of a product is the division of the product. A horizontal division appears to be more dynamical than a vertical devision of the product, since this is the same direction as the visual perspective. A dynamic product

appears to be smaller than a statical product and therefore a horizontal devision of the product is desired for the McArm. (Eger et al, 2010)

The horizontal deviation of the product should be done according to the rule of thirds or a ratio of 1:1.5 (Eger et al, 2010) (Sansoni et al, 2014).

### 5.1.3 TEXTURE

On the texture level of the product, the difference in the appearance of a glossy or mat product is investigated.

A high gloss product reflects more light and accentuates the shape more than a mat product. Therefore a high gloss product is more conspicious than a mat product. Since for the McArm it is desired that the product is not hided, but also not conspicious a mat product would fit better than a high gloss product. On top of that a mat product also appears to be softer and smaller and therefore be more friendly. (Eger et al, 2010)

### 5.1.4 COLOUR

On the colour level of the product, the signification and likability of a colour is discussed and also the appearance of size as a result of a colour is discussed.

Just as a mat or high gloss texture, colour also influence the appearance of the volume of a product. A light coloured product seems bigger than a dark coloured product.

The choice of a desired colour is very personal and influenced by a persons culture and background. Though if a recommendation for a colour other than black should be given to the company for a conspicious version, that the user can choose, of the McArm, blue is the colour that is recommended.

Blue is chosen as a favorite colour by 38% of all people. This seems odd, since blue is associated with coldness and chills. Less known, blue is also associated with trust, harmony, sportivity, emotional well-being and friendship. Also a blue sky creates endomorphism (happiness) for all people. Therefore if it is chosen to make a notable and conspicious version of the McArm, that has another colour than used for wheelchairs, blue would be the colour to choose. (Eger et al, 2010).

### 5.1.5 PIMS DESIGN INTERVENTIONS

In the problem analysis, the research done by Vaes (2014) was mentioned. There the Product Appraisal Model for Stigma (PAMS) was discussed, but his research led to another tangible model that is could be of great use for this assignment.

This second model is the Product Intervention Model for Stigma(PIMS). This model is tool that provides 17 different design interventions divided over three different main categories: product, culture and user. These categories are in turn divided into subcategories, which are divided into the 17 interventions. A web made of these interventions are shown in figure 22. (Veas, 2014)

The PIMS can be used for the entire development of the product. For this assignment the appearance is the focus point. Therefore the possible solution routes for the interventions that are applicable on the appearance of the product are also listed in the web in figure 26. The magenta coloured lines indicate such a solution route.

The main solution that can be concluded from investigating these interventions is that the product should be personalizable and that the user should be included in the design of the product. Another important solution is that attention is drawn to the hand of the user instead of to the assistive device. For example this can be done by having the user choose a specific colour or print and using dynamical lines on the shape that draw attention to the hand of the user.

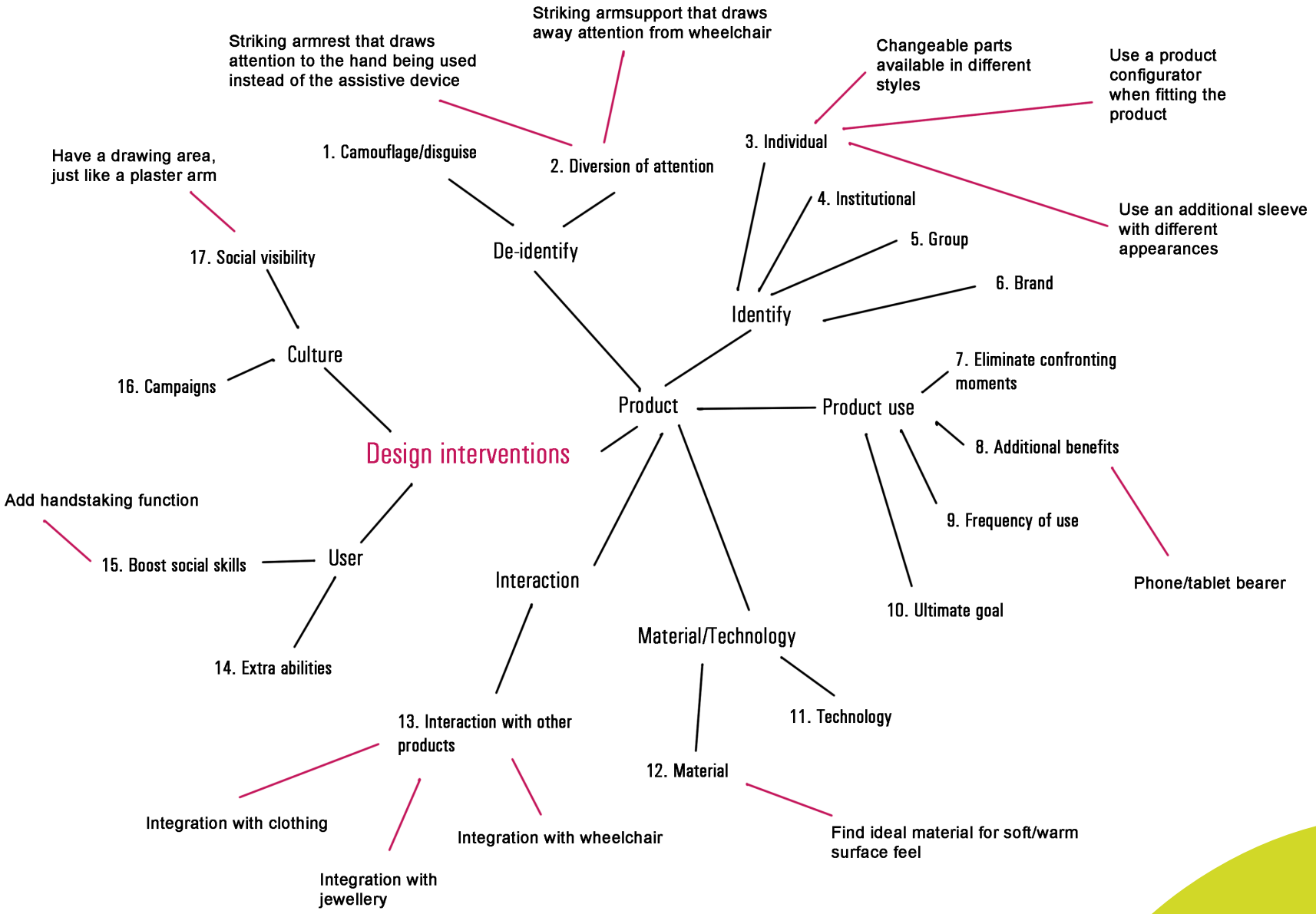



Figure 26: PIMS design interventions

# 5.2 Placements and nodes

For defining the shape of the McArm, the appearance of the most basic development desicions should be included. For a dynamic arm support, the most basic appearance is defined by the placement point on the wheelchair and the number of nodes that the product contains.

In figure 27, twelve different placement point and different numbers of nodes are shown. The wheelchair and the person sitting in the wheelchair are the same for each version.

As can be seen, the appearance for each version is very different. The version not only differ in placement points and nodes, but also in following the body or following the wheelchair.

The version in figure 27 that is circled in black is the version that would fit my personal vision the most. This version is the best bridge between mimicing the wheelchair and mimicing the user.

To evaluate the different versions and to eventually choose a starting point the different versions are discussed during a meeting with some employees of Focal Meditech of different departments. Also a questionaire was conducted in filled in by almost all employees of Focal Meditech.

For the questionaire, each participant was asked to chose a top three of versions that was most appealing to him/her, without taking the feasibility into consideration.

During the discussion, first the questionnaire was filled in by each participant, wereafter the reason for their choice was discussed in a group discussion.

The full preperation and unprocessed results can be found in appendix B.1.

As a result from the questionaire, three versions were chosen to be the three most appealing placement points and nodes. These version are shown in Figure 28. The main reason for these choices were the choise between folowing the body or folowing the wheelchair, the space that the product takes in on the wheelchair and trying to show the user over trying to show the product.

After this evaluation the three chosen versions are discussed within the research and development team. After this discussion, version nine (bordered version in figure 28) came through as the best version.

Version nine mimics a bith more of the wheelchair than desired in my personal vision, but still mimics both user and wheelchair. Also this version takes not to much space of the wheelchair, is feasible to fulfill kinematic requirements and also shows the user the most. This version will be used as a starting point for defining the shape and appearance of the McArm.

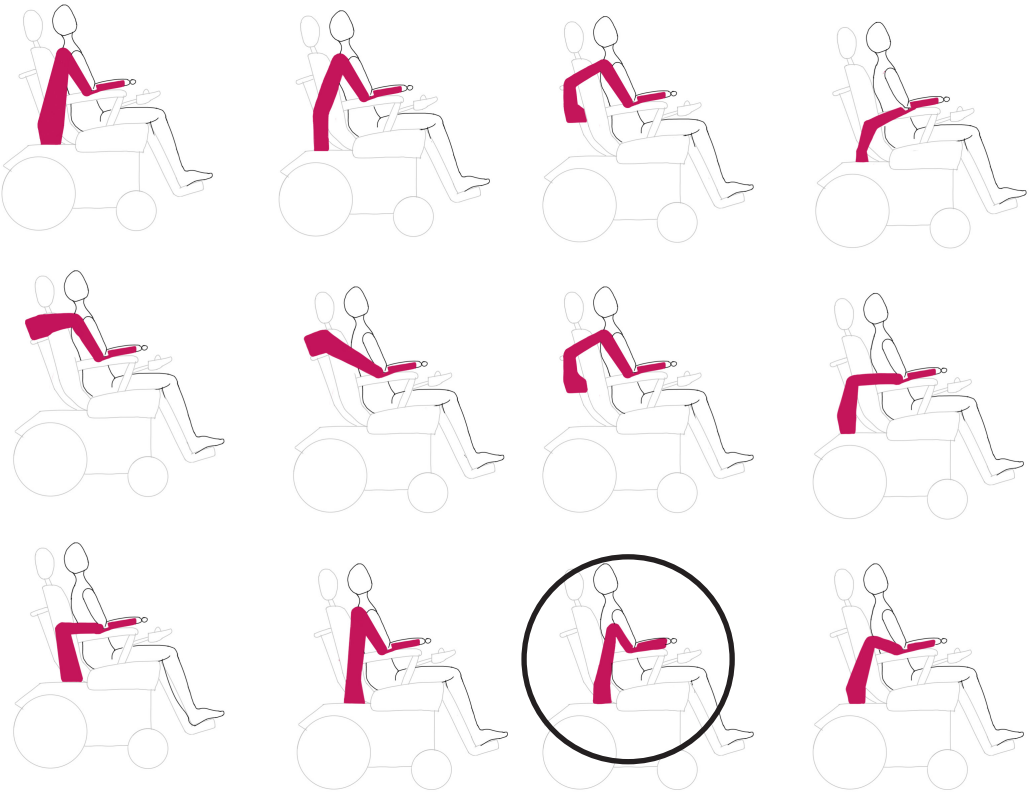


Figure 27: Different placements and nodes

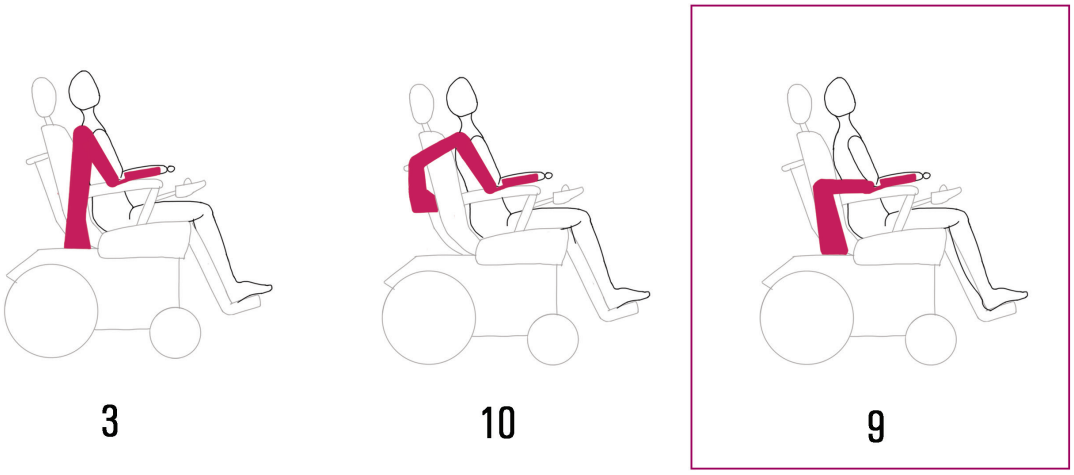



Figure 28: Results placement points and nodes

# 5.3 Rough shape

With version 9 of figure 28 as starting point, two iterations are done to define the rough shape of the product.

### 5.3.1 FIRST ITERATION

Curvatures are a returning shape characteristic is the products of the wing-family. Therefore the first iteration of the rough shape contains curvatures in different direction, starting from the placement point and nodes defined in the previous section. The versions made for this first iteration are shown in figure 29.

The direction of the curvature greatly influences the appeared posture of the user. For example the person in version 1 of figure 29 seems to be sitting more straight up than the person in version 2 of figure 29, although the person is exactly the same in both version.
This is probably due to the fact that the curvature of version 1 in figure 29 mimics the

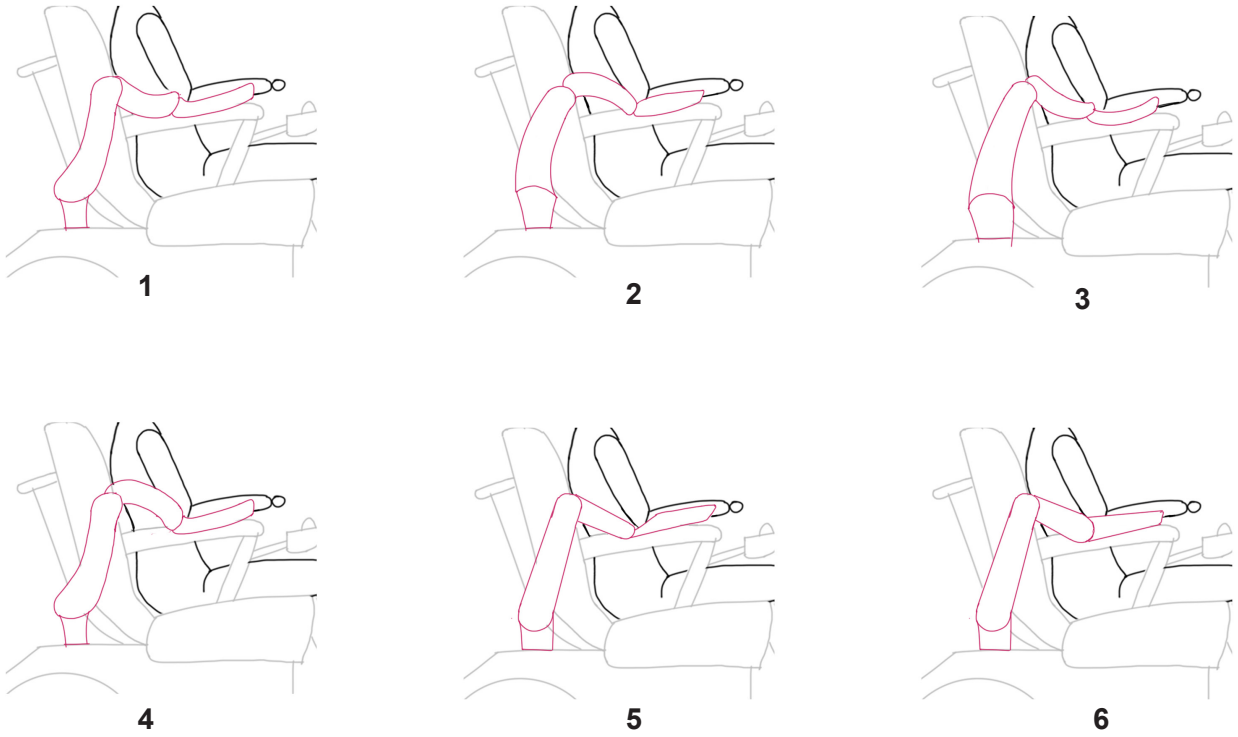



Figure 29: Different curvatures

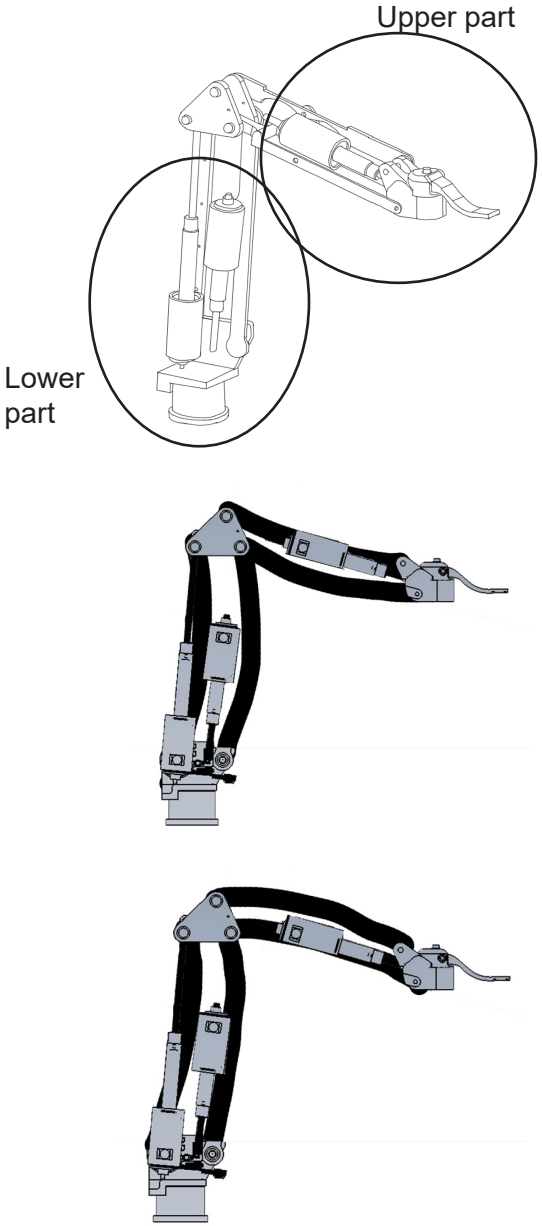



Figure 30: Curvatures of the axes

curvature of the users back when sitting upright and version 2 in figure 29 has the opposite curvature direction.

Do create more confidence for the user, an upright position is needed and therefore the curvature direction of version 1 in figure 29 is desired.

This desired curvature is adjusted to the construction of the McArm, at the time this iteration was done. The results of this adjustment are shown in figure 30. All outcomes of this first iteration are shown in appendix B.2.

### 5.3.2 SECOND ITERATION

The second iteration is the most broad iteration of all iterations done for this assignment. It contains many sketches with different curved axes and is based on the starting point defined in version 9 of figure 28. All sketches can be seen in appendix B.3 and a sections that shows the variety between the sketches is shown in figure 31, on the next page.

All sketches are drawn over the current construction of the product(as shown in figure 30), therefore the ratio between the upper part and the lower part are representative. The context of the product is not shown in this series of design since this would distract attention, that is need for proper evaluation, from the designs.

To converge all these sketches to first product idea, a discussion was held within the research and development department. The most striking designs, that came out of this discussion, are shown in figure 32 on the next page. The parts that made the designs the most striking are circled.

Version 1 in figure 32 was chosen, because of a functional aspect. The circled part in this version is curved, with a curvature direction inside the product. This result in more freedom for the upper part of the product to rotate towards the lower part of the product.

The second version shown in figure 32 is chosen because of the contrast between the basic constructed lower part, surrounded by two organic shaped covers. The covers make the product look more friendly and dynamical, while the construction is still simple. Also the use of these covers create some more depth in the product.

The third, and last, version chosen has two aspects that were striking enough to choose the design. First aspect is the rotation point between the upper and lower part of the product. The upper part rotating in the lower part creates a unity between the two parts and also a symmetrical product that has the same appearance when it used on the left or the right side of the wheelchair.

The second striking aspect of this third version (figure 32), is the cover over the connection between the upper part and the attachment point of arm scale, which results in a completely finished looking product.

The striking parts of these three versions of the product are combined in a first product idea. This idea is show in figure 33. On the left the new construction based on this first product idea is shown and on the right the desired appearance of this product idea is shown. The construction and design are developed separately from each other and at the same time with the same starting point(figure 32).

For this idea it is also taken into account that the bottom part that is drawn in all version of this iteration is not strictly necessary for the functioning of the product.

*Evaluation of the first product idea*
After conducting this first product idea, the results are discussed with the same persons from the research and development department. Out of this discussion it is concluded that the first product idea looks to big. Also the added surfaces seems to lack function and are just sticked on. Further more the production and assembling of the end of the upper part is very complex.

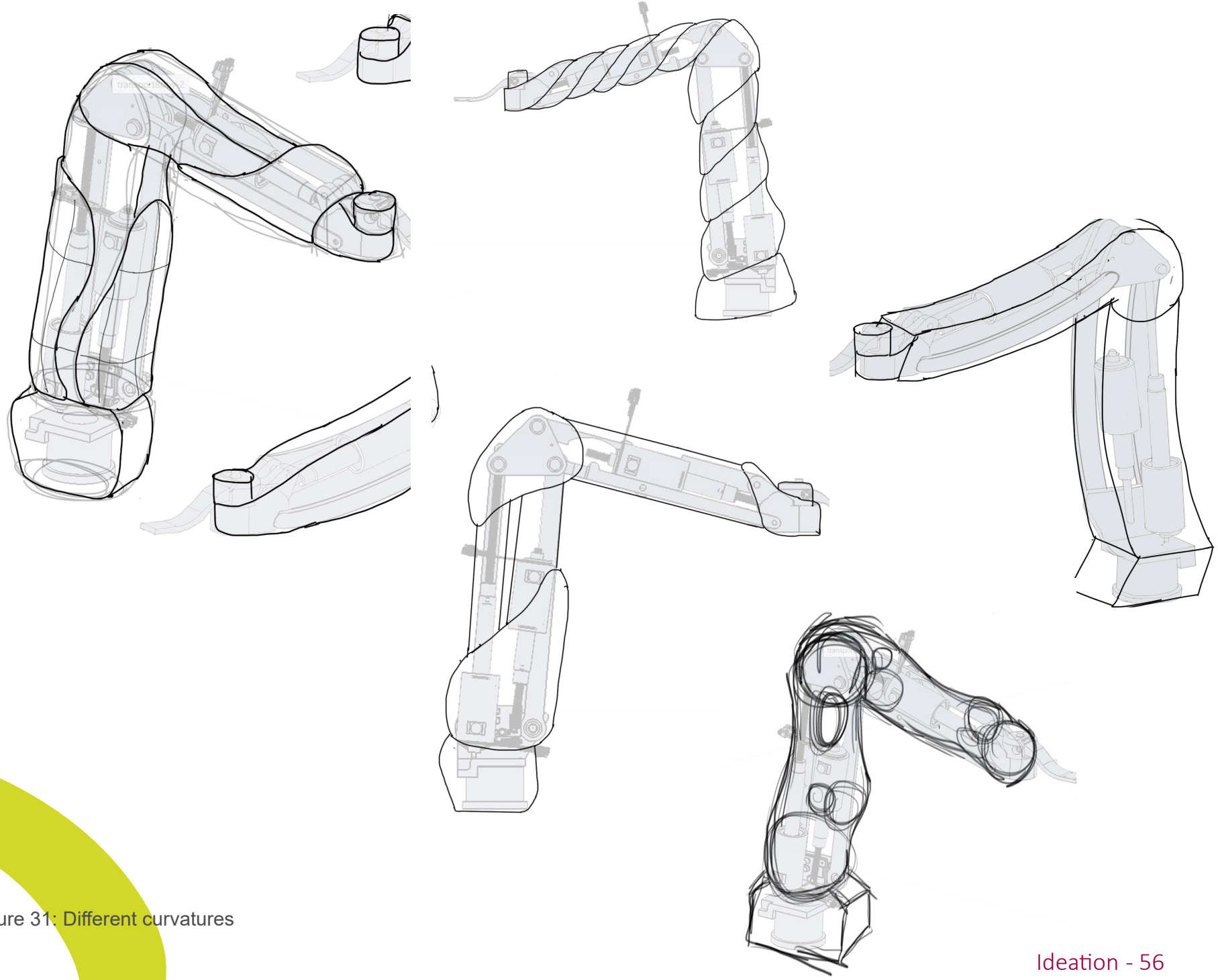


Figure 31: Different curvatures

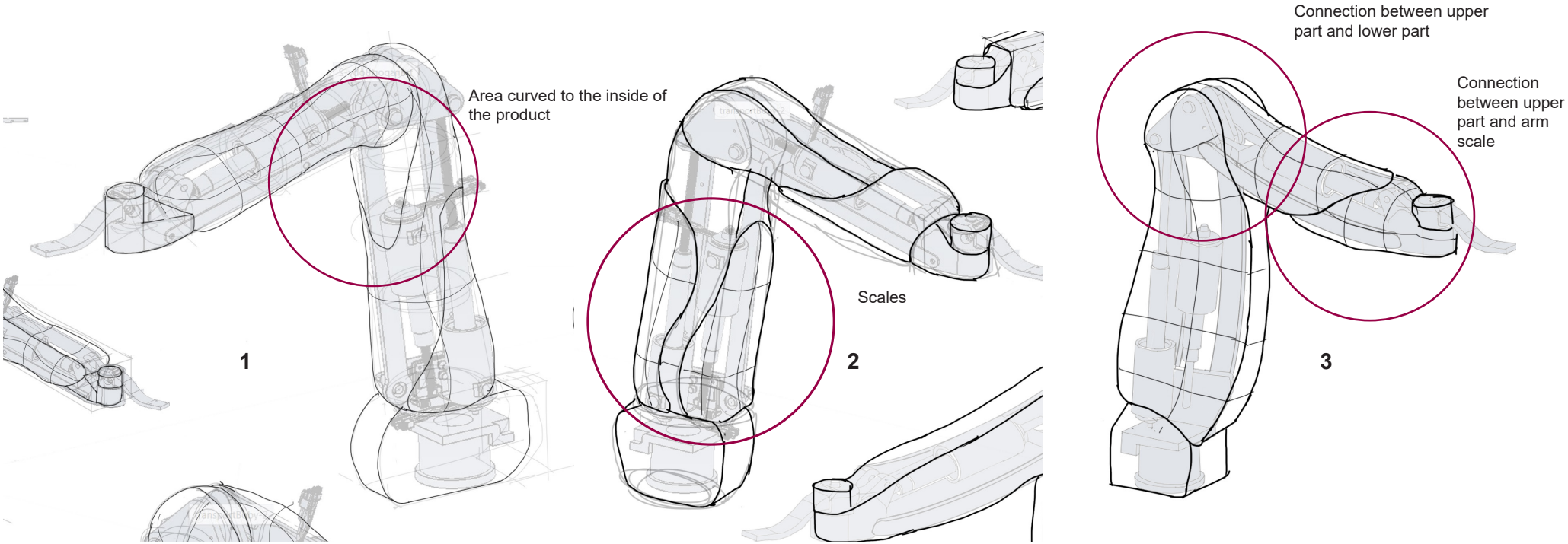
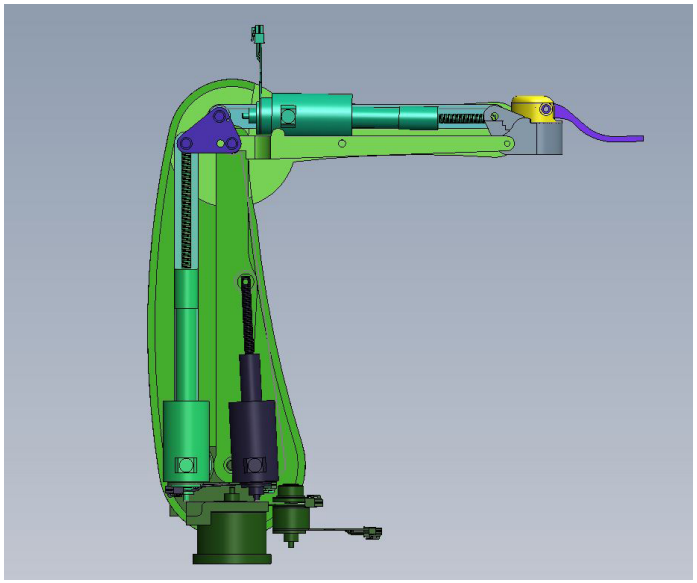



Figure 32: Three designs of iteration 2



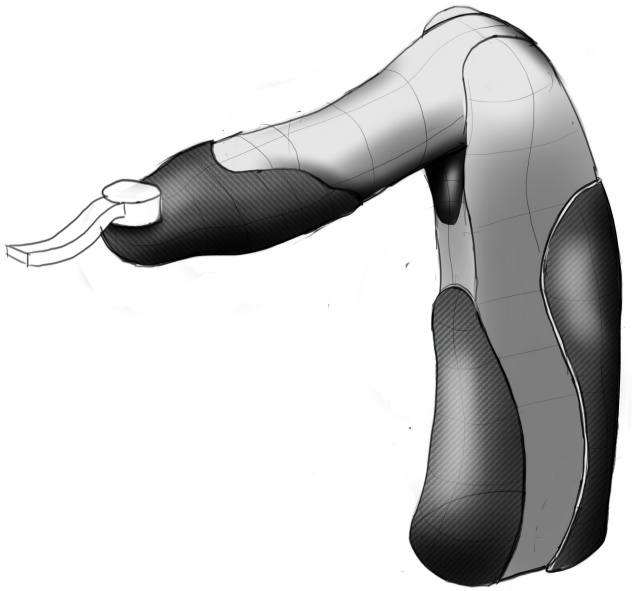


Figure 33: Result of iteration 2

# 5.4 Medium shape

### 5.4.1 THIRD ITERATION

The third iteration is based on evaluation of the second iteration and mostly on reducing the appeared size of the product. This is mostly done by creating a filled bottom of the lower part, and a added cylindrical part on the bottom of the product for the connection to the wheelchair. Also the right curvature of the lower part of the product (as defined in section 5.3.1) is added to the product.

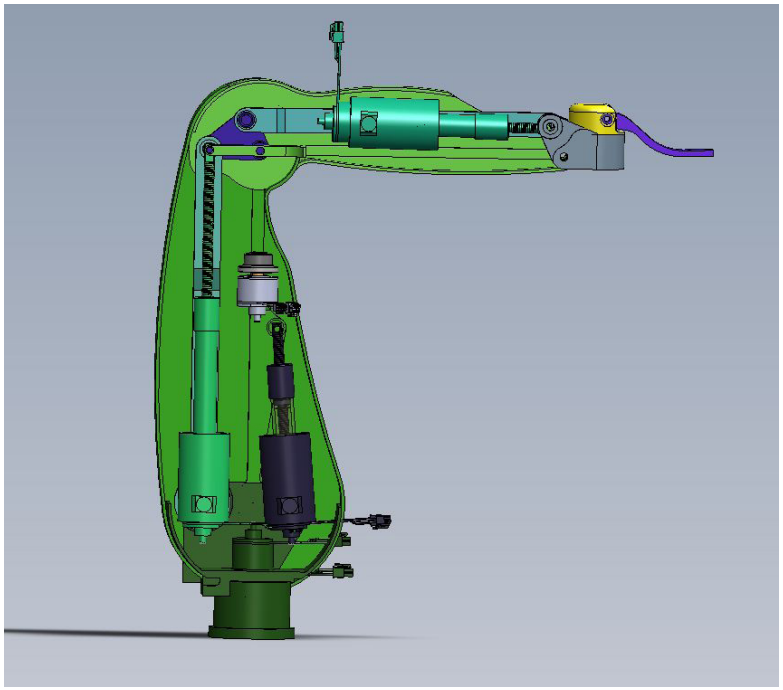
The result of this fourth iteration, both the design and construction are shown in figure 34. The process of this iteration can be seen in appendix B.4

*Evaluation of the second product idea*
In this result, the added surfaces still look sticked on and without function, but these surfaces do break the large surfaces of the upper and lower parts, which results in a smaller looking part. These feedback points are taken into account in the forthcoming iterations.

For the producability of the product, the bulge on the top of the lower part of the product should either be flattened, or solved with a 3D printed scale, since the bulge would increase the orbital period to much

### 5.4.2 FOURTH ITERATION

For improvement of the result from the third iteration, some extra inspiration is used in the form of biomimicry. In his research Sansoni et al (2014) not only defined the guidelines to create product concinnity, but also gave a practical



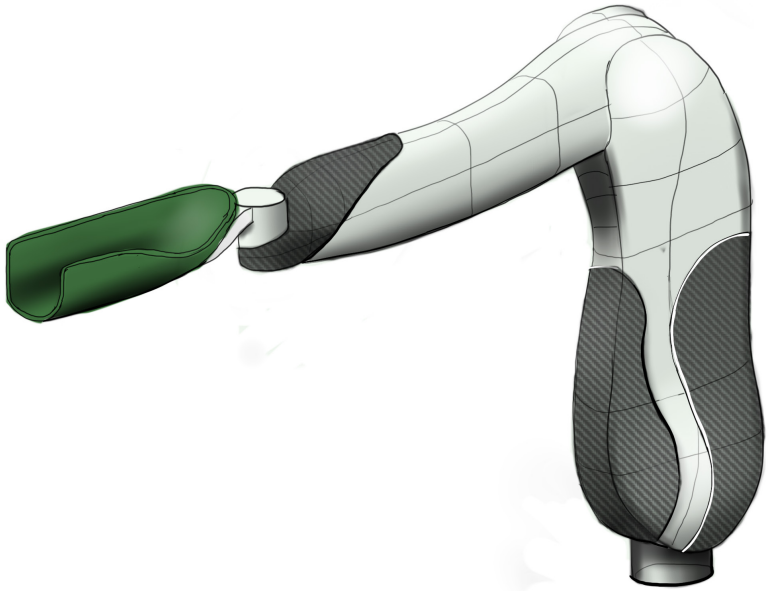


Figure 34: Results of iteration three

application for biomimicry. Biomimicri is a design tool that takes natural sources, such as flora and fauna as an inspiration for designing products. (Sansoni et al, 2014)

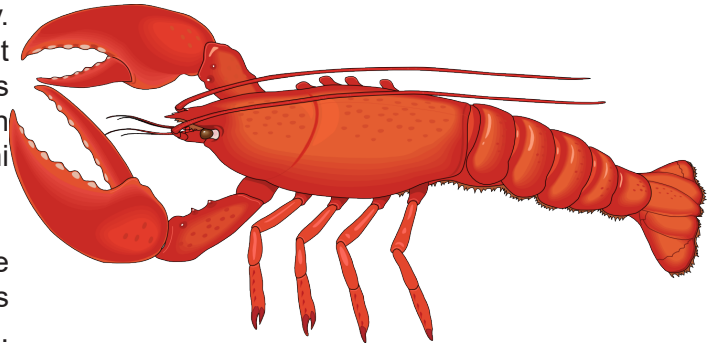


Figure 35 : Lobster

For the fourth iteration of the design of the McArm, a lobster is chosen as a inspirational source. The choice for this animal came forth out of the desired associations. A lobster, shown in figure 35, has a very soft inside but a very powerful shell. Despite this stiff shell, a lobster is still able to move smoothly and roll up its entire tail. These characteristics of a lobster are similar to the desired associations of the McArm, namely: strength and dynamics. The soft inside of the lobster can be seen as the sometimes vulnerable emotional well-being of the user.

Figure 36 : Dragon (http://www.efteling.com/nl)

This inspirational source resulted in not just added surfaces, but added scales that protect the product just like the scales of the lobster protect the animal.

Besides the lobster, another inspirational source was used. The dragon of the Efteling (a theme-park in Kaatsheuvel, the Netherlands) also has scales just like the lobster and this dragon protects the treasure of the theme-park. In case of the McArm, the product protects the user.

Besides these mental and design inspiration, the dragon can also be used as an inspiration for the functioning of the product. The scales of the dragon rotate into each other, whereby movement is possible.
This rotation of scales is also applicable to the outer cover of the McArm. This outer cover can be smaller if not all movements should take place inside the cover, but are part of the cover.

Figure 37 : First visual model of the product

The iteration process of this fourth iteration can be seen in appendix B.5. The sketches as a result of this iteration are also discussed within the research and development department of the company. Out of this discussion the first visual model was made to capture the result of iteration four.

*Evaluation of the third product idea*
The scales give the added surfaces more meaning, because they also have a function, but with this added function also some restrictions occur. The scales on the upper part of the product should be underneath

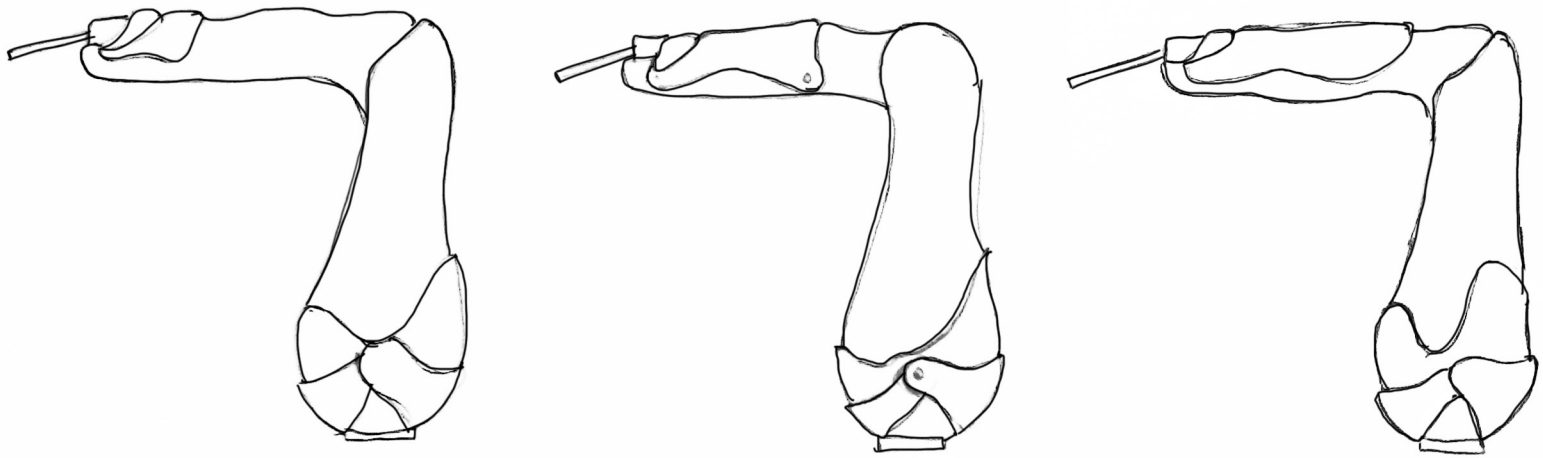


Figure 38: Top results of iteration 5

Figure 39: Final result of iteration 5

the big scale instead of on top of the big scale to provide the needed freedom of rotation.

On the lower part of the product, the scales should be placed on the back as well on the front of the part, to provide freedom for rotation both to the front and back.

Also the organic shaped bulges should be shaped differently, because rotation of a scale over another scale is not possible with the bulges as presented in figure 37.

### 5.4.3 FIFTH ITERATION

For the fifth iteration the result of iteration 4 is taken as a starting point. Variations are made according to the evaluated points of this design. All variations made can be seen in appendix B.6.

Again all these variations are evaluated within the research and development department and the found to be most striking versions are shown in figure 38.
The first version shown in figure 38 is chosen as one of the most striking versions because of the scales on the bottom part. These scales form a good balance between symmetrical (the two small scales) and a symmetrical (the big scale), which results in a dynamical but serene look.

The second version show in figure 38, has a very strong shaped scale on the upper part of the product. This is because of the good integration between the scale and the upper part. Also this scale represents a good 1:1.5 ratio, the scale cover 2/3 of the upper part.

The last version shown in figure 38 is chosen because of the repetitive direction in the upper part of the product. This repetitive direction draws the attention towards the armscale and therefore to the arm and hand of the user.

The strong points of these chosen versions are combined and a CAD model is made from this design idea. The visualization of this CAD model is shown in figure 39.

### 5.4.4 SIXTH ITERATION

The sixth and last iteration of the ideation phase is about the addition of an extra scale. At the rotation point between the upper part and the lower part of the product an extra scale is needed to provide the curvature with an inwards direction as discussed in iteration 2. For this extra scale some additional variations are made and presented in appendix B.7. The result of these variations and the discussion within the research and development department is shown in figure 40.

Figure 40 : Result of iteration 6

# 5.5 Conclusion of the ideation

Out of these six iterations, a final shape is determined. This final shape is the universal basic shape of the product. This shape combined with the construction provided by Focal Meditech can be seen in figure 41 till figure 43. Figure 41 shows the plain result, figure 42 shows final shape on a commonly used wheelchair and in figure 43 the main dimensions of the result are given.

During the whole ideation process, each iteration was communicated to the constructor of Focal Meditech and while defining the shape, lots of collaboration took place. This not only resulted in a whole iteration process of designs, but also in a whole iteration process of the construction. The evolution of the construction, placed on a wheelchair, can be seen in appendix B.8.

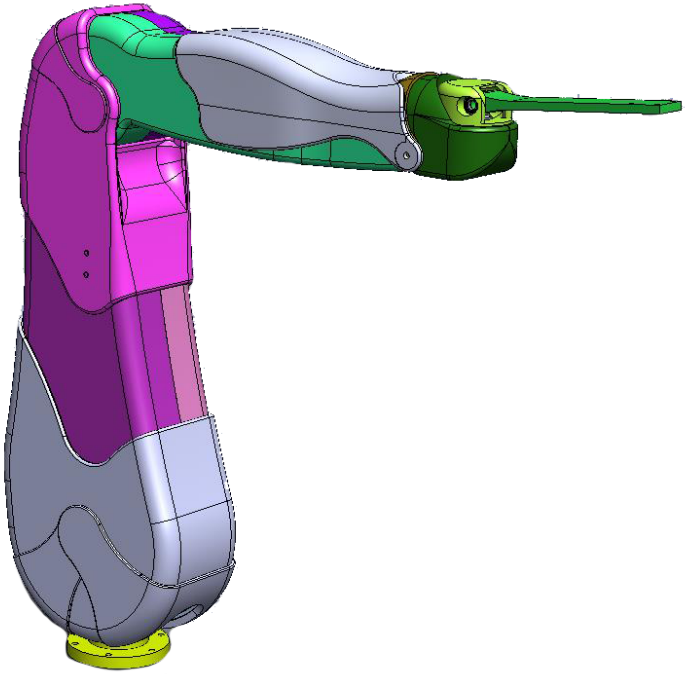


Figure 41 : Final result by Focal Meditech

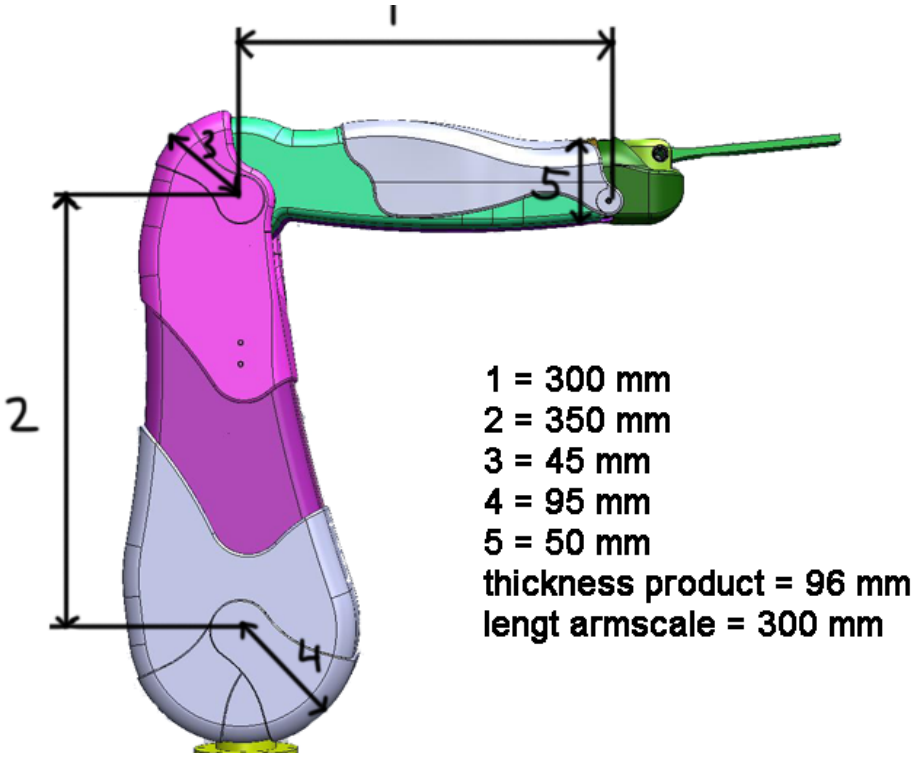



Figure 42: Size of the final product


Figure 43: Final shape placed on wheelchair

# 6

# DETAILING

The detailing of the final shape is done according to the personas defined during the analysis phase. As also stated in the analysis, most main stream product have a detailing based on colouring and material appearances. Therefore each of the four concepts will be detailed according to material, colour and texture, and therefore have a different time-bound appearance. Each concept is based on a different persona and a different placement in the function/design - notability coordinate system. The concept are made to evaluate the four different versions to define a basic appearance that can be used as a starting point for the personalization of the product.

# 6.1 Concept Blanc

First concept is concept blanc and is the most basic concept of all. This concept is all made of aluminum according to the commonly used production methods of Focal Meditech. The texture of the aluminum is not adjusted and the appearance of this material is mostly mat. This concept can be provided aluminum coloured, but for further personalization the annodization colour of the aluminum can be chosen by the user. This concept would fit Jacky the best, since she could choose her favorite colour and afterward further personalize it with every attribute she wants.

Jacky:
Jacky is still in school and all her friends use assistive devices. Since everyone has lots of devices, that most of the time look alike, Jacky loves to make her newest device her own. She is very crafty and places stickers of her favorite cartoons all over her wheelchair. Her ideal arm support is completely personalizable.

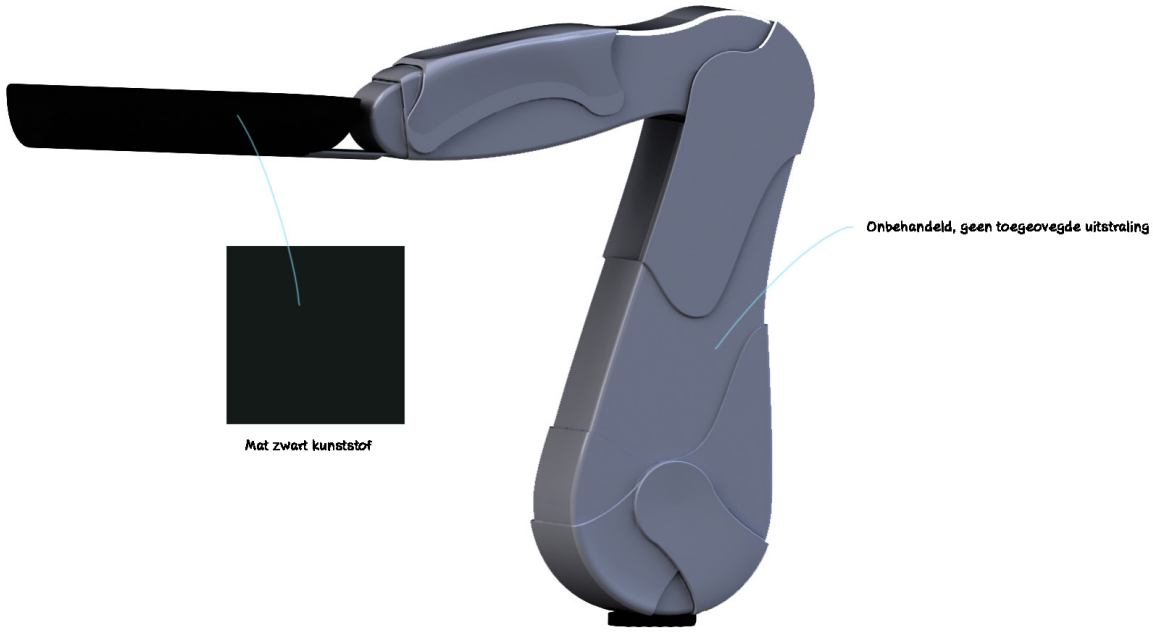



Figure 44 : Concept Blanc

# 6.2 Concept Carbon

Concept Carbon is the second concept. This concept's bases made of mat black anodized aluminum and the covers of this concept are 3D printed and finished with a carbon fiber wrapping foil. The colour black is used to match the wheelchair and the carbon fiber is used since this is already used in the other products of the wing-family. This concept would match properly with the wheelchair and therefore would not influence the overall appearance of the product in context to much. This concept would be a good choice for Jeroen.


Figure 45: Concept Carbon

*Jeroen:*
Jeroen is the type of guy that does not get influenced by the appearance of his assistive devices. It does not have to be completely maneuvered away, but it also does not have to stand out. As long as it functions and it looks like a helpful and working product, Jeroen will be content with it.

# 6.3 Concept Leather

The third concept is concept leather and is made of a mat black anodized aluminum. The scales are made of 3D printed ABS, but covered with leather wrapping foil. Stating point for this concept was timeless fashion. Black and leather are two fashion aspects that are very likely to be fashionable for a very long time. For this reason this concept would make a good fit for Jamilla.

*Jamilla:*
Jamilla is one of the stylish girls. Although she is in a wheelchair that is not appealing to her, she puts a lot of effort in her overall appearance to the world. Her clothing match perfectly. All the additional parts on her wheelchair are spray-painted black so that it always matches her style and does not stand out.


Figure 46 : Concept Leather

# 6.4 Concept Wood

The last concept is concept wood and designed especially for Jelle. This concept is made of brushed light blue anodized aluminum and the scales are made of 3D printed ABD, covered with a wooden foil.

The wooden foil is used since this is trend that is seen in all types of consumer products and the colour of the anodized aluminum is chosen to be blue since this colour fits the desired association the most. Also blue is the most striking colour for most of the people. This trendy concept would strongly stand out in the context with the wheelchair an would with draw attention from the mostly cumbersome and unfinished wheelchair.

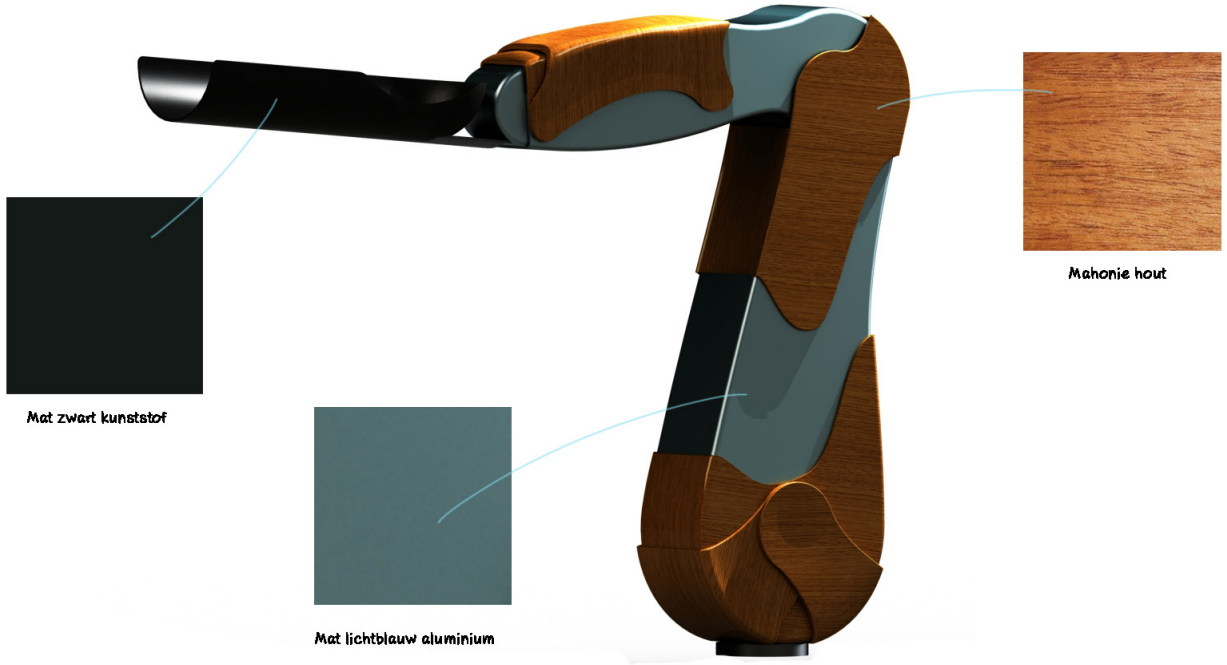



Figure 47 : Concept Wood

*Jelle:*
Jelle likes gadgets a lot. He is always following the newest technologies and trends and has the newest phone. His own appearance is not as important as the appearance of the products he owns. His ideal arm support would fit the latest trends on product design and is a perfect show of, that makes his disability subordinate to his arm support.

# 6.5 Dissemination of the concepts

Each concept used a persona as a starting point, but also is based on a specific place in the function/design - notability coordinate system.

For the universal basic shape the desired placement defined in the design vision in section 4.6 is used. The four concepts are all derived from this universal basic shape. The dissemination of the concept can be seen in figure 48.

Concept Blanc is placed in category 5 because of the colour personalization option and the freedom to create every desired appearance by pimping the product when in use.

Concept Carbon is placed between category 7 and category 8. Category 7 comes from the universal basic shape of the product. This concept shifts a bit to category 8 because it fits the wheelchair well and therefore is not very notable.

Concept Leather is placed between category 7 and category 9. Category 9 was used a starting point because the products in this category are all fashion item. This concept has shifted back partly to category 7 because of the universal basic shape that is not connected to the body in the way the fashion items of category 9 are connected to the body.

The last concept (concept wood) is based on the products in category 6, which resulted in the styled and very notable appearance of this concept.

This dissemination of the four concepts shows that the concept all cover another area of the function/design - notability diagram and all cover a different personality type. When thinking about the number of personalization options, all options should cover another category and personality for the McArm at

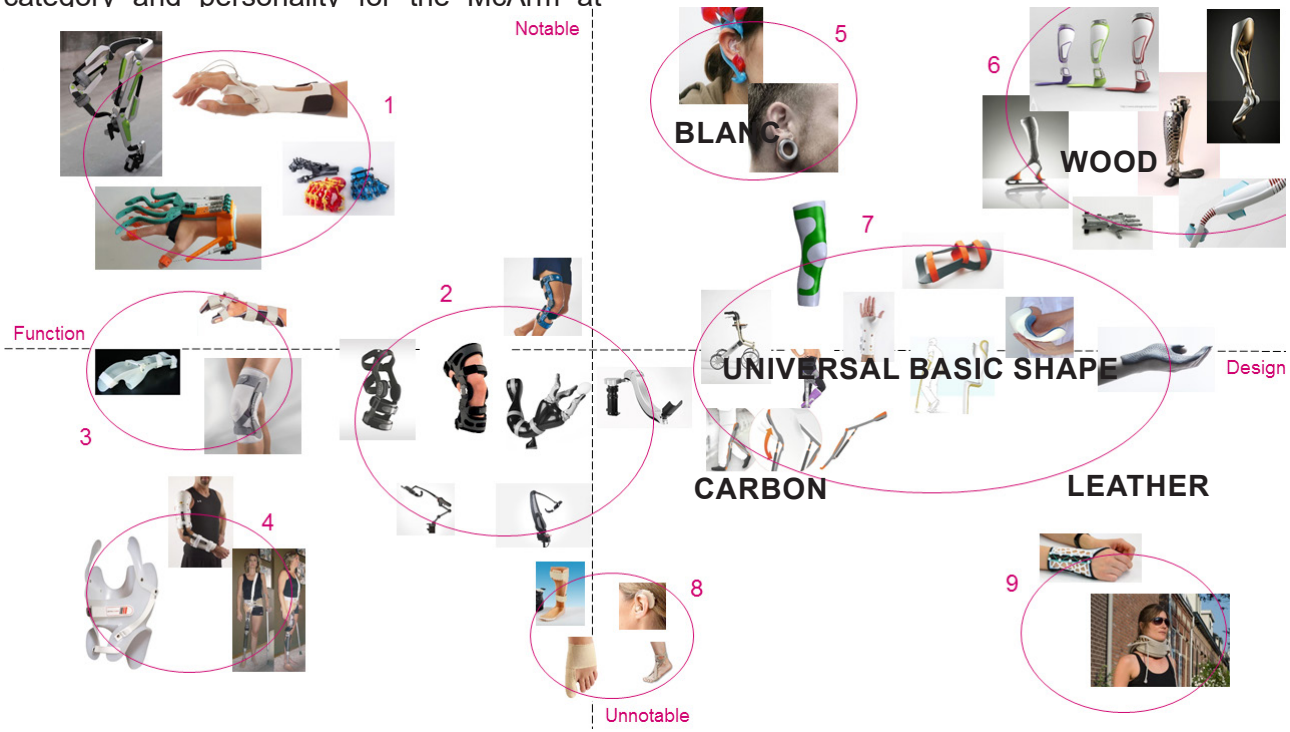



Figure 48 : Concept Leather

# 7

# EVALUATION

For the evaluation of the product, the requirements are evaluated according to the value that the requirement contributes to. For the evaluation of the acceptability requirements, a discussion and questionnaire are used.

# 7.1 Functional/production

### 7.1.1 EVALUATION OF THE FUNCTIONAL REQUIREMENTS

The functionality and usability requirements set for this assignment are not directly integrated in the final design, but are kept in mind during the process. Some requirements that influence this value can already be stated as fulfilled.

For example the product is serial to the body. The only part where the product is parallel to the body is at the body interface, the armscale. The rest of the product is a serial construction.

Also the product does not hinder the functionality of the product. This requirement is not tested, but this part is trusted to the constructor of Focal Meditech.

The external influences are not used or evaluated through the process. A good way of evaluating this requirement is by doing a finite element analyses of the different parts and the construction in total. This evaluation can be started easily since the Solidworks model, that is needed for a finite element analysis, is already finished by the constructor of Focal Meditech.

### 7.1.2 EVALUATION OF PRODUCABILITY REQUIREMENTS

Most of the production and maintenance requirements are to detailed to be evaluated within the scope of this assignment. Although it can be stated that the internal parts can be reached easily, because the scales will be blindly detachable. Because of the close collaboration with the constructor of the product, who on his turn collaborates with the production manages of Focal Meditech, it can be stated that the product can be produced with the available techniques and methods.

The product is standardized as much as possible is requirement that is to detailed to be in the scope of this bachelor assignment, but this can be given as a recommendation to the company to evaluate. The requirement about the minimum number of parts is taken into account for the design process. For example, the three scales on the bottom of the product do not move relative to each other and are therefore integrated into one scale for production. The scales at the endpoint of the upper part of the product do move relative to each other and therefore are still separate parts.

# 7.2 Acceptability requirements

The requirements that influence the acceptability value of the product are stated as the most important requirement set for the scope of this assignment and are therefore evaluated in more detail. Some of the requirements are easy to evaluate because it is clear if the requirement is fulfilled by the product or not. For each concept defined in chapter 5 these measurable requirements are stated in table 49.

### 7.2.1 OBJECTIVE PRODUCT CONCINNITY

Another requirement set for the design of the McArm was: the product should be designed according to de guidelines of objective concinnity that were set during the theoretical explanation of the ideation phase.

First guideline to objective concinnity is unity. Unity is processed in the final design by using a repetitive organically shapes line for the contours of the scales as represented in figure 50.

The second guideline is grouping. Grouping is processed in the design of the McArm by using the same appearance for parts that are grouped together. For example, the scales at the connection point between the upper base and the armscale are grouped together by the use of the same foil.

The third guideline is rhythm and pattern and this guideline is processed by the same shape characteristic as for the unity guideline. The lines represented in figure 50 are placed according to the 1:1.5 ratio, which forms a rhythm within the product.

| | BLANC | CARBON | LEATHER | WOOD |
|---|---|---|---|---|
| Product is blue or black coloured | X | √ | √ | √ |
| Product is filled or chamfered | √ | √ | √ | √ |
| Product is not all symmetrical (vertical) | √ | √ | √ | √ |
| Product is not all asymmetrical (vertical) | √ | √ | √ | √ |
| Product surfaces are divided horizontally | √ | √ | √ | √ |
| Product has a surface division according to a 1:1,5 ratio | √ | √ | √ | √ |
| Product does not contain very contrasting thicknesses | √ | √ | √ | √ |
| Circular shapes are repetitively present on the product | √ | √ | √ | √ |
| Product is not white | √ | √ | √ | √ |
| Product is personalizable | √ | √ | √ | √ |
| Product is fully finished | √ | √ | √ | √ |
| Product is not hided | √ | √ | √ | √ |
| Product matches the colour of the wheelchair (mostly black) | X | √ | √ | X |

Figure 49: Evaluation measurable acceptability requirements

The next guideline is contrast, this contrast is obtained by using two different types of materials and appearances for different types of parts within the product. These different types of product also form a balanced whole for the product, which is the next guideline. This balance is created by covering both bases for 2/3 by the scales. In this way, also the placement and proportion guidelines are processed in the design.

The proportion guideline is also processed through another dimension. Each base has two end points. Where of one of these endpoints is joint. The circles in figure 51 represent these endpoints. The ratio between the diameter of the circles that are used for basic shape of the product is 1:2 for the endpoints of both bases. This is illustrated in figure 51.

## 7.2.2 QUANTITATIVE EVALUATION

Besides the more measurable requirements, there also are a lot of requirements and guidelines that are not as directly measurable as the previous mentioned requirements. These requirements are mainly about the associations people have with the product. The association that were set as desired are: empowerment, strength, dynamics and friendliness. Also the appeared size and the type of product that it looks like (hospital product or consumer product) are not directly measurable. These requirements are evaluated based on a discussion and a questionnaire.

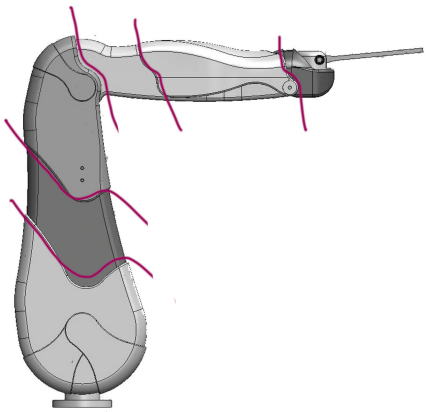


Figure 50 : Unity and rhythm

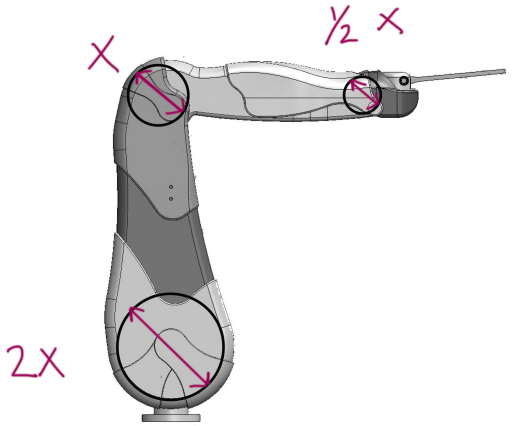
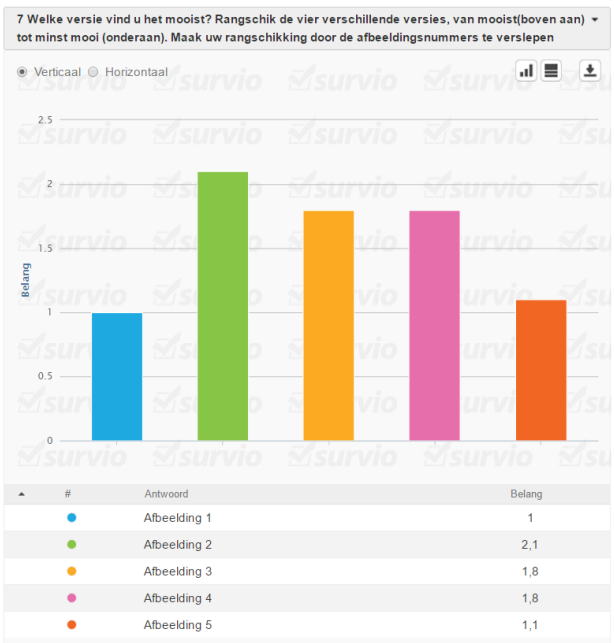



Figure 51 : Proportion



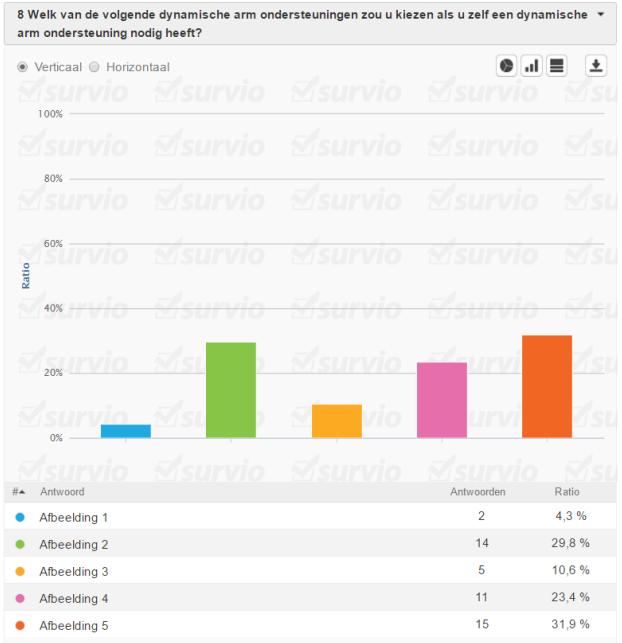




Figure 52 : Results of the quantitative analyses

The participants, of this evaluation are seen as the bystanders from the stakeholder diagram. Although this group of people was not included in the design process or analysis, the reaction of this group on the product influences the product acceptance of the user a lot. Therefore, their opinion on the product is tested in this evaluation.

When a bystander sees the product for the first time, the time that it takes to form an opinion is really short. Therefore, the product in context is shown only for a short time during the questionnaire. The questions about the associations with the different concepts are without context to be sure that the association is always about the product and not only about the wheelchair. Of course the context of the product is very important and for this reason the associations with or without context are compared during a group discussion.

Besides the associations with the product, also the preferences of the participants are evaluated to provide recommendations on the detailing choices for Focal Meditech.

The questionnaire contains 11 questions and is answered by 46 participants from different backgrounds. From the results of this evaluation it can be concluded that the product type is still to associated with industry or hospital products and that the product appears to be too big without the context. The dynamics, friendliness and the calmness of the product are present in the association of the participants, but could still be improved.

Also for the concept choices, concept carbon was rated the best according to the associations and this concept was also ranked high according to the preferences for own use of the participants.

The whole evaluation preparation, questionnaire, results and conclusions can be found in appendix C.2

### 7.2.3 QUALITATIVE EVALUATION

To get more insight in the reasons for the associations people have with the product a group discussion was organized with four design students, who are trained to explain why they think a product is appealing or not.

This qualitative evaluation consists of three parts. The first part starts with judging the associations for each version with minimum knowledge and without context. After judging the results are discussed. For the second part the participants are giving more information about the product, where after they judged again, this time for the products with a context. This second part ended with a discussion about their judgments and the differences with or without context. It is important to evaluate the product also without context, since the first time a user sees their new arm support, the product does not yet have a context and at that time the first impression determines a great part of the product acceptance.
The last part of this evaluation is about the placement of the final design in the notability – function/design graph as presented in figure 13 on page 27. Below the most striking conclusion are discussed.

First thing that can be concluded from this evaluation is that the product is seen a hospital product, based on its function and the disability of the user. On the other hand, the wheelchair is seen as a daily used, consumer product. Although the product is associated with hospitals, the appearance of the product contributes to a more consumer like association.

Concept carbon is determined as the most appealing concept. The main reason for this the combination of the dynamical surfaces/ scales, lines and structures on one hand and the unity and calmness that comes across when looking at the whole context on the other hand.

Without context, the desired associations of the shape are highly positive. The shape is dynamical but not hysterical and the product looks united. The associated product type and size are still points of improvement for the product without context. Despite the decline in size that already made during the development, the product should still be smaller. The material, colour and texture choices influences these associations positively.

With context, it differs per version if the desired associations are influenced positively or negatively by the context. For concept carbon and concept leather the dynamics, calmness, size, and strength are influenced positively. For concept blanc and concept wood, this is the other way around. All concepts are appearing to resemble a hospital product even more with the context, because the disability of the user now is visible, according to the participants.

The whole preparation, questions, discussion topics, results and conclusions of this qualitative evaluation can be found in appendix C.1.

Overall it can be stated that concept carbon can be recommended to choose as a base version for the further development of the product. This product scored the best based on the associations with or without context by the discussion group, but also by the participants of the questionnaire. The main reason for this recommendation is that concept carbon positively influences the whole picture and the context positively influences the appearances of the product. The context makes the product look more serene and small, while the product makes the context, in this case the user, appear more strong and dynamical.

This product appearance is finally also chosen by the company, because it also fits the appearance of the other products of the wing-family the best. Therefore, the placement of concept carbon in the

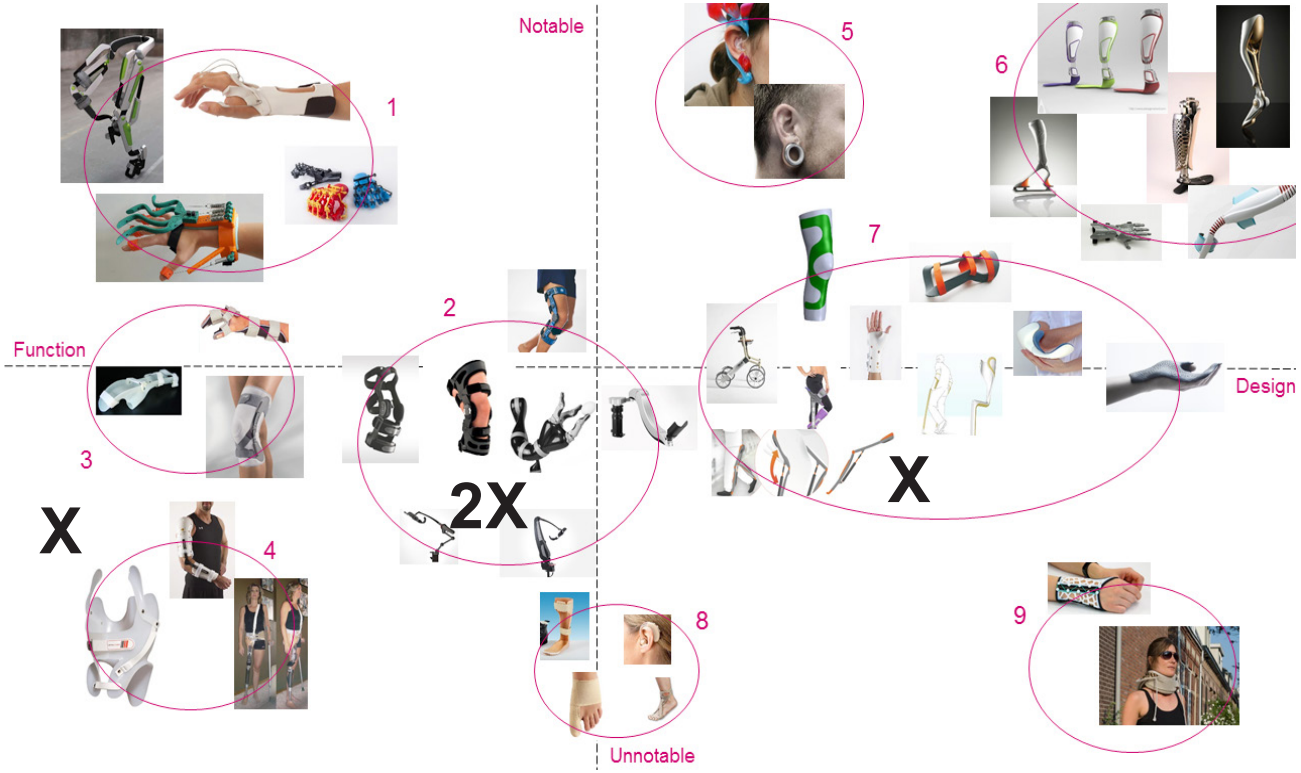



Figure 53: Notability - function/design graph

notability – function/design graph is also discussed during the qualitative evaluation. The placements chosen by the participants of the discussion can be seen in figure 46.

Two out of three placements are not as stated desired during the analysis phase. The reason behind these placements of the participants are based on the functioning of the product that still was the main requirement for the development of the product.

One of the participants stated that the notability was very low, since it looks the same as the wheelchair and you don't want to see the product or the disability of the user using the product. Therefore, this participant placed the product in category four.

The other participant chose to place the product neutrally on the notability axes, because the dynamic shape stand out from the wheelchair and therefore the product is notable, but the colouring matches the wheelchair and therefore the product is not notable.

# 7.3 Conclusion of the evaluation

From all evaluations it can be concluded that most of the directly measurable requirements that are evaluated are fulfilled by the product. Some directly measurable requirements should be evaluated in the future.

The not directly measurable requirements can also be stated as mostly fulfilled according to both a quantitative and qualitative evaluation, but lots of improvements can be made.

Finally concept carbon is determined as the best concept, because it scored best on both evaluations and therefore would fit the most user compared to the other versions and also because it fits the other products of the wing-family the best. To the company it would be recommended to use concept carbon as a basic version, but still provide personalization options for the wrapping foil used to cover the scales.

77- Conclusion

# 1

# CONCLUSION

For this bachelor assignment the design and appearance of a new dynamic arm support, called the McArm, of Focal Meditech is investigated and established by answering the research question: How should the McArm look, for it to be appealing and create product acceptance and satisfaction for the user?

The answer to this research question is obtained by firstly analyzing the problem, the stakeholders, the competitional products, the context of the product and the production methods of Focal Meditech. Out of all these analyses the following vision was set for defining the design of the McArm:

*The design of the McArm will be divided into a universal basic shape and a time-bound appearance. The universal basic shape should be appealing to the majority of the users and form the bridge between the wheelchair and the user. The time-bound appearance is a design that is not hided, but unnotable. Notability of the product can be personally added by choice. This will be done for a product that still has all the required functioning, but with enough attention for the design of the product.*

Along with this vision a set of requirements and guidelines was conducted from the analyses. These requirements and guidelines are used to define the universal basic shape of the product by executing six iterations.

After defining the shape, four different concepts based on their material appearances were constructed. With a questionnaire and a discussion group the associations with these four concepts are evaluated.

This evaluation also dealt with the other requirements and guidelines set during the analysis phase and resulted in a recommendation for Focal Meditech. This recommendation reads the choice for concept carbon as a starting point for the further development of the product but making the appearance of the scales personalizable by having the user choose from a set of different wrapping foils to cover the scales. Taking the personalization option into account. This final product idea can be seen in figure 54.

To answer the research question shortly, the McArm should look, powerful, friendly, calm, dynamical, united with the wheelchair and

user for it to be appealing and create product acceptance, an example to accomplish this appearance within the set vision is the final product idea in figure 54.

The final product idea forms the bridge between the wheelchair and the user because the lower part follows the back-support of the wheelchair and the upper part and armscale follow arm, while the product still smoothly transform between mimicking the wheelchair and user. With the inclusion of the concinnity guidelines, the universal basic shape should be appealing to the majority of the users.

The resemblance with the wheelchair, but finished look along with the personalization options provides a product that should improve product acceptance and likability.

Figure 54: The final product idea

**TOPICS FOR FURTHER RESEARCH**

- Evaluate the product with multiple users, with the real product instead of with pictures
- Investigate the ergonomics of the product
- Investigate how the final product idea can be improved according to the results of the evaluation
- Evaluate more broadly, with a real product instead of with pictures
-Try out different appearances of the scales with only mat black aluminum base to check how personalization would work out
-Investigate how to create a less massive appearing product, without handing in on function
- Identify the expectations of potential users and evaluate this expectations for the final product idea
- The implementation of the final product idea and the set vision on to the other products of the wing-family
- Research on the control of the product without the use of extra buttons or screens
- More detailed research on the production methods used for

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# Appendix 0

## 0.1 BOOKMAKER

# 0.1 BOOKMAKER

1. How does the product work? **Ch. 2**
    - 1.1 Which interactions are there between the product and the stakeholders?
    - 1.2 On which principles is the functioning of the product based?
    - 1.3 What is the main function of the product?
    - 1.4 Where and how is the product placed on the wheelchair?
    - 1.5 In what context is the product used?
    - 1.6 What actions does the user perform with the product?
    - 1.7 What are the similarities with the other products of the wing-family?
    - 1.8 What are the differences with the other products of the wing-family?

2. What is required for the design of the cover? **Ch. 4**
    - 2.1 What are the wishes and needs of the users concerning the cover of the product?
        - 2.1.1 What are their wishes and needs related to the look and feel?
        - 2.1.2 What are their wishes and needs concerning the usability of the product?
        - 2.1.3 Who use the product?
    - 2.2 What are the wishes and needs of the company concerning the cover of the product?
        - 2.2.1 What are their wishes and needs related to the look and feel?
        - 2.2.2 What are the requirements based on the technical solution?
    - 2.3 What requirements are set by insurance companies for the allowance of the product?
    - 2.4 What are the wishes and needs of the care giver of the end user concerning the cover of the product?
        - 2.4.1 What are their wishes and needs about the look and feel?
        - 2.4.2 What are their wishes and needs concerning the usability of the product?
        - 2.4.3 Who are the caretakers of the user?
    - 2.5 What are the wishes and needs of the producer/installer/repairer concerning the cover of the product?
        - 2.5.1 What are their wishes and needs concerning the reachability of the inner parts?
        - 2.5.2 What are their wishes and needs concerning the assembly of the product?
    - 2.6 What are the needs and wishes of the other stakeholders?
        - 2.6.1 Which other stakeholders are involved?
    - 2.7 What external influences are present on the cover?
        - 2.7.1 What forces are present on the cover?
        - 2.7.1 What environmental influences (such as water and temperature) are present?

3. Which designs already exist? **Ch.4**
    - 3.1 How do the other products of the wing-family look?
    - 3.2 How do other arm rest look?
    - 3.3 How do wheelchairs look?

4. How can the requirements be fulfilled? **Ch. 4 / Ch. 5**
    - 4.1 What shape characteristics can be used to fulfil the requirements?
    - 4.2 What material should be used?
        - 4.2.1 What materials are already available within the company?
        - 4.2.2 What are the properties of these materials?
        - 4.2.3 Which material properties are needed to fit the design requirements?

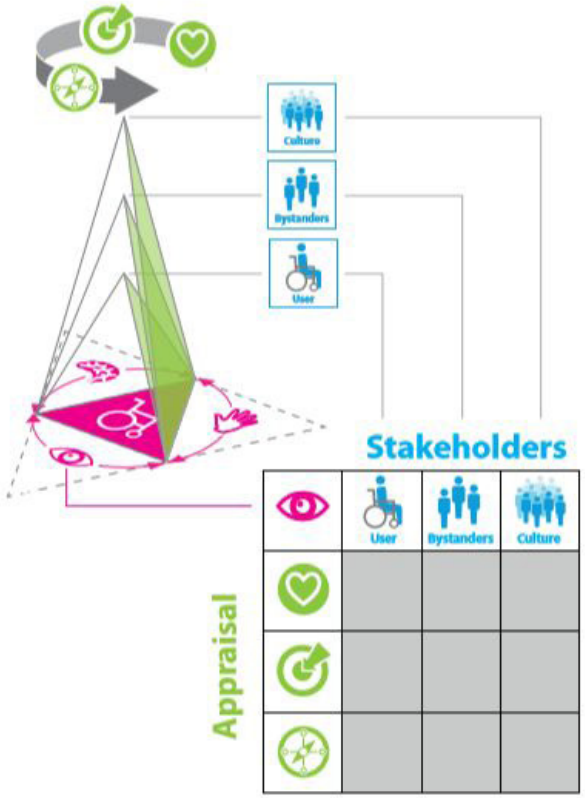
5. How can the cover be integrated with the existing technical solution? **Ch. 5**
    - 5.1 How many parts does the cover consist of?
    - 5.2 How can these parts be assembled?
    - 5.3 How is the cover placed on the product?

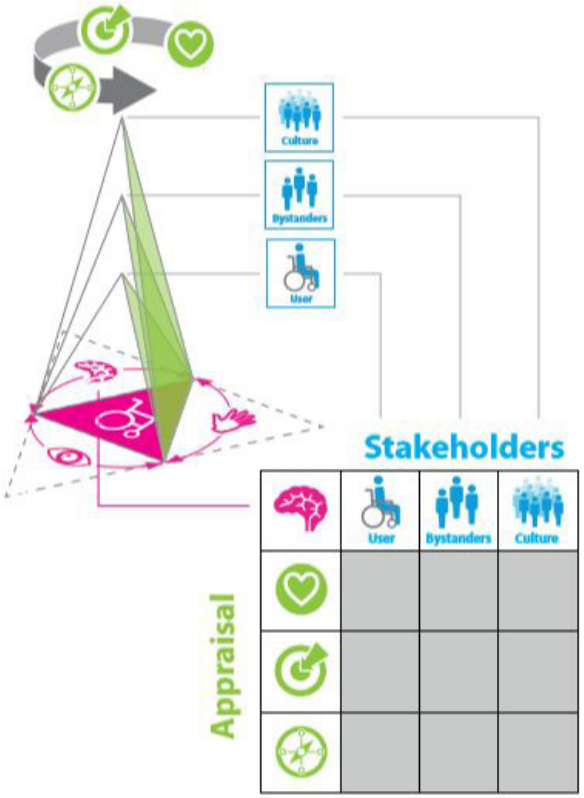
6. How can the cover be produced? **Ch. 4**
    - 6.1 What production methods are available within the company?
    - 6.2 What changes should be made in the design of the cover, to fit the production method?

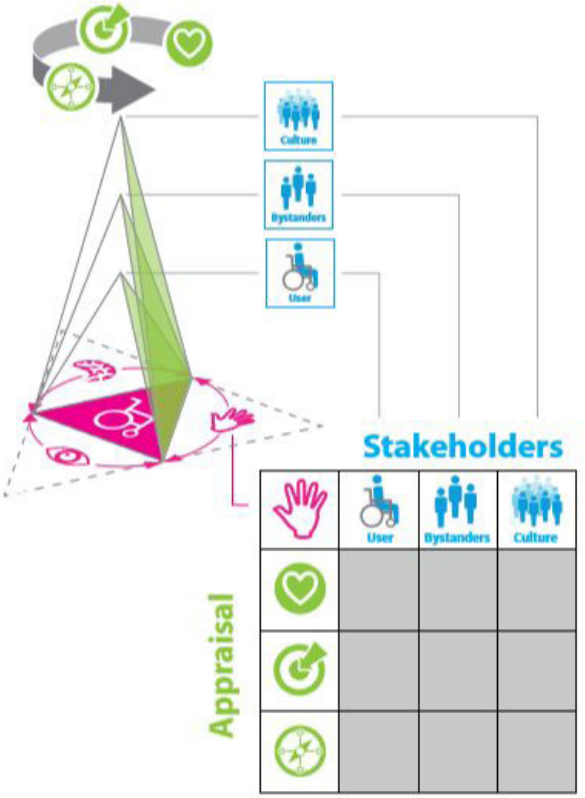
7. How can the final design of the cover be implemented in the other products of the wing-family?
    - 7.1 What are the core characteristics of the cover? NOT ANSWERED

# Appendix A

# A.1 PAMS (VAES, 2014)



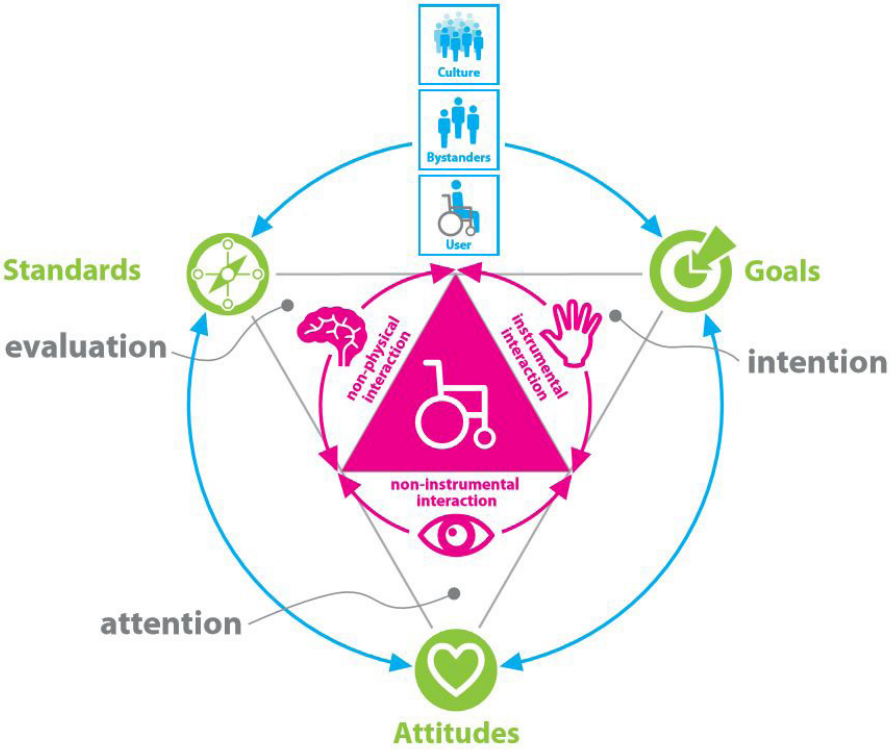
## Product in Use (Acting)

| Human intentions with products: using, operating or managing products. | User | Bystander | Culture |
|---|---|---|---|
| **Attitudes Appraisal** The stakeholder's prevailing tendency to like or dislike qualities of objects, people or activities. | Is the product discomforting or repelling during its use (in general or in specific situations)? *Applying and removing an adhesive eye patch may be uncomfortable and painful.* | Does using the product cause unease or a threat to others? *Fitting an artificial limb in public may cause unease in bystanders. When a user administers an insulin injection in public, the needle might alarm bystanders.* | Does using the product conflict with cultural habits, rules or laws? *A tourist meets an old man in India who takes off his prosthetic leg. Although this feels perfectly natural to the old man, this action may offend the tourist, who wonders whether it is appropriate to do this in the Indian culture.* |
| **Goals Appraisal** 'Things' that the stakeholder wants to accomplish or see happen. Goals provide orientation and purpose in human-product interaction. | Does the product fit its purpose of use, physically, functionally, ergonomically, and morally? *Are there functional inconveniences or ways in which the product obstructs the physical freedom of its user (not waterproof, dustproof, adjustable, too heavy, ...)? Is the product difficult to use in combination with other products?* | Does using the product interfere negatively with the behavior of others; does it prevent others from attaining their goals? *A wheelchair may increase the physical freedom of its user, while restricting the physical freedom of bystanders in crowded public places.* | Does using the product indicate inappropriate cultural or societal behavior? *Using alcohol in public can be considered as inappropriate in a particular culture, thus conflicting with the goal of proper social behavior.* |
| **Standards Appraisal** The stakeholder's expectations and beliefs about how users, others and objects should behave or act. Standards refer to value. | Are there any dissonant experiences (unbalances between thinking/feeling and acting) when using the product? *The use of a product can feel dissonant with somebody's feelings/ thoughts and behavior.* | Does using the product challenge the tolerance of bystanders? *E.g. parents of a child in a wheelchair value big handles when giving assistance to their child. This conflicts with the child's values and aspirations to be 'seen as independent'.* | Does the introduction of the product still need to overcome thresholds in view of cultural or social acceptability? *When more people use an asthma inhaler in public, this ritual becomes widespread, plausibly influencing its cultural acceptance.* |

## Product Perception (Sensing)

| Perceiving, playing with or caressing the product. **Human attention** | User | Bystander | Culture |
|---|---|---|---|
| **Attitudes Appraisal** The stakeholder's prevailing tendency to like or dislike qualities of objects, people or activities. | Does the product exhibit sensory discomforting or repelling features for its user? (Visual, noise, smell, tactile, taste) *A user experiences a claustrophobic feel when wearing a dust mask.* | Does the product exhibit a sensory discomforting or repelling impact on bystanders? *The unsuspected tactile impact when an unsuspected bystander shakes hands with a user of an artificial hand.* | Does product perception violate social or cultural taste? *Cultural attitudes regarding mini-skirts or piercings can be in conflict with or violate cultural taste.* |
| **Goals Appraisal** 'Things' that the stakeholder wants to accomplish or see happen. Goals provide orientation and purpose in human-product interaction. | Does product perception obstruct the user in obtaining his or her goals? *When a user perceives a pair of crutches for the first time, does the product 'look' reveal to its user how to achieve the goal of walking with crutches?* | Does product perception obstruct others in obtaining their goals? *Perceiving a user-product combination can induce avoidance/greater social distance in bystanders, conflicting with their goal of passing the user in a conventional way.* | Does product perception obstruct a culture in obtaining its goals? *Certain political symbols/ signs can obstruct or undermine cultural and societal goals.* |
| **Standards Appraisal** The stakeholder's expectations and beliefs about how users, others and objects should behave or act. Standards refer to value. | Does the user perceive unacceptable products or product aspects according to his quality standards (physical, ergonomical, psychological, moral)? *A product can be devalued through negative brand associations or a negative institutional identity.* | Do bystanders perceive products or product aspects of users that fail according to their quality standards: physically, ergonomically, psychologically, morally? *When bystanders perceive a wheelchair user, the encounter could elicit feelings of aversion, compassion, or admiration in the bystander.* | Does the perceived cultural significance and value of the product or product aspects indicate change over time or in durability? *Public views have changed on the way people with braces are perceived.* |

| Consequences of Product Use (evaluation and meaning) | | | |
|---|---|---|---|
| Fantasizing about, remembering, or anticipating usage or consequences of usage | **User** | **Bystander** | **Culture** |
| **Attitudes Appraisal**<br>The stakeholder's prevailing tendency to like or dislike qualities of objects, people or activities. | Does the look and feel of the product match with the personality and lifestyle of its user?<br><br>*Product semantics and product meaning need to complement the attitudes of the product user.* | Does the look and feel of the product and its user match with the attitudes of the bystander?<br><br>*A product that matches its user's personality can refer to a subculture or group that is disapproved of or rejected, e.g. extreme piercings.* | Does the look and feel of the product and its user match with cultural preferences?<br><br>*What are the stereotypical cultural habits associated with the product that shape this cultural evaluation?* |
| **Goals Appraisal**<br>'Things' that the stakeholder wants to accomplish or see happen. Goals provide orientation and purpose in human-product interaction. | Is the product tolerated purely out of necessity or physical dependency?<br><br>*Product tolerance is the minimal acceptance level when no higher level can be reached.* | Do the consequences of product use harm the physical or psychological integrity of others?<br><br>*Products in use can harm peoples' integrity. Physically: noise, smoke; Psychologically: personal space, freedom ...* | Cultural and societal goals should be met. Are the product and its features in compliance with these goals and the supporting regulations?<br><br>*Individual aspirations are secondary to societal goals. Fake products are 'outlaws'.*<br>*A fake Rolex watch can be linked to a lower social class, thus conflicting with the goal of its user to elicit status.* |
| **Standards Appraisal**<br>The stakeholder's expectations and beliefs about how users, others and objects should behave or act. Standards refer to value. | Does the product conflict with the user's expectations and beliefs following product use?<br><br>*People often carry out 'after sales checks' of their recently bought products. E.g. a new car.* | Does the product conflict with the bystander's expectations and beliefs following product use?<br><br>*During or after their encounter with a product user, bystanders can be confronted with their own vulnerability.* | Does the product conflict with the cultural values, expectations and beliefs following product use?<br><br>*How can the avoidance of conflict be turned into the opposite - a hype? How can it be turned into a product that is the result of a high generative level of creation and supported by the full blessing of culture and society?* |



# A.2 FUNCTIONAL SPECIFICATIONS OF THREE DIFFERENT WHEELCHAIR TYPES

| | Front wheel driven | Back wheel driven | Mid wheel driven |
|---|---|---|---|
| *Acceleration* | Front wheel | Back wheel | Mid wheel |
| *Turning circle* | large | large | small |
| *Number of wheels* | 4(2 large, 2 small) | 4(2 large, 2 small) | 6(2 large, 4 small) |
| *Small wheels* | pinnate | pinnate | pinnate or fixed |
| *Ease of use* | Easy to pass obstacles, slewing backwheels when driving forward | Hard to pass obstacles, stability when driving forward | Maneuvarable, use on sloped areas |
| *small wheels* | Prevention from tilting backwards | Prevention from tilting forward | Prevention from tilting forward and backward |

Table 2a: Properties of three types of electric wheelchairs

| | *Small house* | *Big house* |
|---|---|---|
| **Indoor** | Mid wheel driven | Front wheel driven |
| **Indoor + Outdoor** | Mid wheel driven | Backwheel |
| | *Flat area* | *Rough area* |
| **Outdoor** | Back wheel driven | Mid wheel driven / Front wheel driven |

Use environments and the choice of an electric wheelchair

# A.3 PRODUCTION GUIDELINES

## Guidelines for design for assembling:

- Minimize number of parts
- Standardize parts and materials
- Design product assemblies that are mistake proof
- Design for parts orientations and handling
- Minimize flexible parts and interconnections
- Design modular products with building blocks and subassemblies
- Design for automated assembly

## Design guidelines for casting:

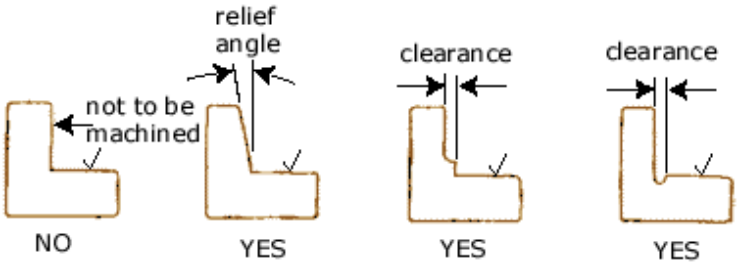
- Avoid sharp corners, sharp edges, rapid changes in cross-sections
- Apply fillets to sharp corners and edges
- Wall-thickness is uniform in the entire product
- Range of wall-thickness is two times the thinnest wall-thickness
- Transition of wall-thicknesses is as gradual as possible
- The mold wall-thickness corresponds with the minimum mold wall-thickness preferred for the uses material and casting type
- Avoid undercuts
- Add drafts to de design

## Guidelines Turning:

- Use standard hole sizes
- Create holes with conical bottoms
- Avoid partial holes
- Do not create holes that pass the 1:3(diameter : length) ratio of the drill used
- Holes can only be created on a surface that is perpendicular to the centerline of the hole
- A part is designed in a way that a tail stock is not required
- Cast-in reliefs are used for casted parts that need to be faced, this allows for tool clearance
- Avoid perpendicular surfaces to turned down surfaces to prevent burrs
- Keyways should be milled with the end-mill traversing the part axially
- Avoid turning in the areas of weldments, parting lines and flashes.
- Minimize the number of set ups required
- Design for the largest diameter cutters possible
- Carbide cutters are preferred
- No blending of radii into existing surfaces is preferred
- Faced surfaces should be angled to provide tool clearance
- Sharpe inside corners are filled according to the radius of the tool used to create that corner

## Guidelines Milling:

- Use standard hole sizes
- Create holes with conical bottoms
- Do not create holes intersecting with cavities
- Avoid partial holes
- Do not create holes that pass the 1:3(diameter : length) ratio of the drill used
- Holes can only be created on a surface that is perpendicular to the centerline of the hole
- A three-edge inside corner must be filled with the radius of the end mill, also a relief hole can be used to create a ninety-degree corner.
- Standard tool bit sizes are preferred
- Chamfers are preferred over fillings
- Only use constant radii for fillings of the corners
- If long end mills cannot be avoided, use the following clearances:




*References:*
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# A.4 FACTSHEET STRATASYS FORTUS MC 250 (STRATASYS LTD, 2016)

# Fortus
## 250MC

**Employ the most advanced Design Series capabilities.**

With the Fortus 250mc you can produce durable prototypes using ABSplus™, a production-grade thermoplastic. Built on a proven Stratasys® platform for reliable operation, the Fortus 250mc features a 10 x 10 x 12 inch (254 x 254 x 305 mm) build envelope and three layer thicknesses: .007, .010 and .013 inches (.178, .254 and .330 mm).

The Fortus 250mc is powered by Insight™ job processing and management software. Even novice users can process jobs with the easy-to-use default settings. Advanced users, meanwhile, have the flexibility to edit standard parameters that control the look, strength and precision of parts, as well as the time, throughput and efficiency of the build process. Like all Fortus 3D Printers, the Fortus 250mc runs on FDM® technology to build prototypes from the bottom up with precisely deposited layers of modeling and support material.

The Fortus 250mc delivers reliable, flexible prototyping in a responsive, accommodating package.


LEARN MORE ABOUT THE FORTUS 250MC AT STRATASYS.COM

stratasys

THE **3D PRINTING SOLUTIONS** COMPANY

# Fortus
## 250MC

**At the core: Advanced FDM technology**

Fortus systems are based on Stratasys FDM technology. FDM easily builds parts in real production-grade thermoplastics, resulting in the most durable parts.

Fortus systems offer powerful Insight software so advanced users can gain precise control over build parameters.

**No special facilities needed**

You can install a Fortus 3D Printer just about anywhere. No special venting is required because Fortus systems produce no noxious fumes, chemicals or waste.

**No special skills needed**

Fortus 3D Printer are easy to operate and maintain because there are no messy powders to handle and contain. They're so simple, an operator can be trained to run a Fortus system in less than 30 minutes.

**Get your benchmark on the future of manufacturing**

Fine details. Smooth surface finishes. Accuracy. Strength. The best way to see the advantages of a Fortus 3D Printer is to have your own model built on a Fortus system. Get one made for you, for free, at: stratasys.com

## SYSTEM SPECIFICATIONS

| SYSTEM CONFIGURATION | |
|---|---|
| Build Envelope (XYZ) | 10 x 10 x 12 inches (254 x 254 x 305 mm) |
| Material Delivery | One build material cartridge: 56.3 in3 (923 cc)<br>One support material cartridge: 56.3 in3 (923 cc) |

| MATERIAL OPTIONS | | |
|---|---|---|
| Layer Thickness: | ABS*plus* | |
| 0.013 inch (0.330 mm) | X | |
| 0.010 inch (0.254 mm) | X | |
| 0.007 inch (0.178 mm) | X | |
| Support Structure: | Soluble | |
| Available Colors: | Ivory<br>White<br>Black<br>Dark Grey | Red<br>Blue<br>Olive Green<br>Nectarine | Fluorescent Yellow<br>Custom Colors |

| OTHER SPECIFICATIONS | | |
|---|---|---|
| System Size/Weight | 33 x 29 x 45 inches<br>(838 x 737 x 1143 mm) | With crate: 409 lbs. (186 kg)<br>Without crate: 326 lbs. (148 kg) |
| Achievable Accuracy | Parts are produced within an accuracy of ± .0095 inch (± .241 mm)*<br>**Note: Accuracy is geometry-dependent. Achievable accuracy specification derived from statistical data at 95% dimensional yield.* | |
| Network Communication | 10/100 base T connection. Ethernet protocol. | |
| Operator Attendance | Limited attendance for job start and stop required. | |
| Operating Environment | Maximum room temperature of 86°F (30°C).<br>Relative humidity range: 30 to 70 percent, non condensing | |
| Power Requirements | 110–120 VAC, 60 Hz, minimum 15A dedicated circuit; or<br>220–240 VAC 50/60 Hz, minimum 7A dedicated circuit. | |
| Regulatory Compliance | CE / ETL / RoHS / WEEE | |
| Software | All Fortus systems include Insight and Control Center™ job processing and management software. | |

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# A.5 FACTSHEET ABSPLUS THERMOPLASTIC (STRATASYS LTD, 2016)

## ABS*plus*-P430

**PRODUCTION-GRADE THERMOPLASTIC**

**FOR DESIGN SERIES 3D PRINTERS**

ABS*plus*-P430

PRODUCTION-GRADE THERMOPLASTIC

FOR DESIGN SERIES 3D PRINTERS

ABS*plus*™ is a true production-grade thermoplastic that is durable enough to perform virtually the same as production parts. When combined with Design Series 3D Printers, ABS*plus* is ideal for building 3D models and prototypes in an office environment.

| MECHANICAL PROPERTIES | TEST METHOD | ENGLISH XZ AXIS | METRIC XZ AXIS |
|---|---|---|---|
| Tensile Strength, Ultimate (Type 1, 0.125", 0.2"/min) | ASTM D638 | 4,700 psi | 33 MPa |
| Tensile Strength, Yield (Type 1, 0.125", 0.2"/min) | ASTM D638 | 4,550 psi | 31 MPa |
| Tensile Modulus (Type 1, 0.125", 0.2"/min) | ASTM D638 | 320,000 psi | 2,200 MPa |
| Tensile Elongation at Break (Type 1, 0.125", 0.2"/min) | ASTM D638 | 6% | 6% |
| Tensile Elongation at Yield (Type 1, 0.125", 0.2"/min) | ASTM D638 | 2% | 2% |
| IZOD Impact, notched (Method A, 23°C) | ASTM D256 | 2.0 ft-lb/in | 106 J/m |

| MECHANICAL PROPERTIES | TEST METHOD | ENGLISH XZ AXIS | ENGLISH ZX AXIS | METRIC XZ AXIS | METRIC ZX AXIS |
|---|---|---|---|---|---|
| Flexural Strength (Method 1, 0.05"/min) | ASTM D790 | 8,450 psi | 5,050 psi | 58 MPa | 35 MPa |
| Flexural Modulus (Method 1, 0.05"/min) | ASTM D790 | 300,000 psi | 240,000 psi | 2,100 MPa | 1,650 MPa |
| Flexural Strain at Break (Method 1, 0.05"/min) | ASTM D790 | 4% | 4% | 2% | 2% |

| THERMAL PROPERTIES[2] | TEST METHOD | ENGLISH | METRIC |
|---|---|---|---|
| Heat Deflection (HDT) @ 66 psi | ASTM D648 | 204°F | 96°C |
| Heat Deflection (HDT) @ 264 psi | ASTM D648 | 180°F | 82°C |
| Glass Transition Temperature (Tg) | DSC (SSYS) | 226°F | 108°C |
| Melting Point | - - - - - - - - - | Not Applicable[3] | Not Applicable[3] |
| Coefficient of Thermal Expansion | ASTM E831 | 4.90x10$^{-05}$ in/in/°F | 8.82x10$^{-05}$ mm/mm/°C |

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## ABS*plus*-P430

**PRODUCTION-GRADE THERMOPLASTIC**

**FOR DESIGN SERIES 3D PRINTERS**

| ELECTRICAL PROPERTIES[4] | TEST METHOD | VALUE RANGE |
|---|---|---|
| Volume Resistivity | ASTM D257 | 2.6x10$^{15}$ - 5.0x10$^{16}$ ohm-cm |
| Dielectric Constant | ASTM D150-98 | 2.3 - 2.85 |
| Dissipation Factor | ASTM D150-98 | 0.0046 - 0.0053 |
| Dielectric Strength | ASTM D149-09, Method A, XZ Orientation | 130 V/mil |
| Dielectric Strength | ASTM D149-09, Method A, ZX Orientation | 290 V/mil |

| OTHER[2] | TEST METHOD | VALUE |
|---|---|---|
| Specific Gravity | ASTM D792 | 1.04 |
| Flame Classification | UL94 | HB (0.09", 2.50mm) |
| UL File Number | - - - - - - - - - | E345258 |
| Rockwell Hardness | ASTM D785 | 109.5 |

| SYSTEM AVAILABILITY | LAYER THICKNESS CAPABILITY | SUPPORT STRUCTURE | AVAILABLE COLORS |
|---|---|---|---|
| uPrint SE™ | 0.013 inch (0.330 mm) | Soluble Supports | Ivory[6], White |
| uPrint SE Plus™ | 0.010 inch (0.254 mm) | Breakaway Supports | Black, Dark Grey |
| Dimension Elite™ | 0.007 inch (0.178 mm)[5] | (BST 1200es only) | Red, Blue |
| Dimension SST 1200es™ | | | Olive Green, Nectarine |
| Dimension BST 1200es™ | | | Fluorescent Yellow |
| Fortus 250mc™ | | | |

*The information presented are typical values intended for reference and comparison purposes only. They should not be used for design specifications or quality control purposes. End-use material performance can be impacted (+/-) by, but not limited to, part design, end-use conditions, test conditions, color etc. Actual values will vary with build conditions. Product specifications are subject to change without notice.*

*The performance characteristics of these materials may vary according to application, operating conditions, or end use. Each user is responsible for determining that the Stratasys material is safe, lawful, and technically suitable for the intended application, as well as for identifying the proper disposal (or recycling) method consistent with applicable environmental laws and regulations. Stratasys makes no warranties of any kind, express or implied, including, but not limited to, the warranties of merchantability, fitness for a particular use, or warranty against patent infringement.*

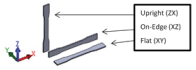
*[1]Build orientation is on side long edge. [2]Literature value unless otherwise noted. [3]Due to amorphous nature, material does not display a melting point. [4]All Electrical Property values were generated from the average of test plaques built with default part density (sparse). Test plaques were 4.0 x 4.0 x 0.1 inches (102 x 102 x 2.5 mm) and were built both in the flat and vertical orientation. The range of values is mostly the result of the difference in properties of test plaques built in the flat vs. vertical orientation. [5]0.007 inch (0.178 mm) layer thickness available on Dimension Elite and Fortus 250mc only. [6]Ivory is the only color option for uPrintSE. The test data was collected using ABSplus Ivory (Natural) specimens. ABSplus colored materials will have similar properties, but can vary up to 10%.*

*Orientation: See Stratasys Testing white paper for more detailed description of build orientations.*

*XZ = X or "on edge"*

*XY = Y or "flat"*

*ZX = or "upright"*

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Rehovot 76124, Israel
+972 74 745-4000
+972 74 745-5000 (Fax)

# A.6 REQUIREMENTS

| VALUE | REQUIREMENTS/CHARACTERISTICS | SPECIFICATIONS | POSSIBLE SOLUTION |
|---|---|---|---|
| *Functionality/ usability* | Product is serial to the body | | |
| | Material feels comfortable | Material does not feel cold | |
| | Appearance does not hinder the functionality of the product | Product and wheelchair, together fit through a standard door (80 cm) | |
| | | Product does not protrudes from the maximum size of the wheelchair | |
| | Product is resistand to external influences | Product can handle driving agains a wall with 12 km/h | |
| | | Product is (splash)waterproof | |
| *Producability* | Product contains as few parts as possible | | |
| | Product is as standardized as possible | | |
| | Product can be obtained by using Focal Meditechs currently available production methods | Product is produced by milling, turning and/or 3D printing | |
| | | Product can be produced according to the guidelines presented in appendix A.3 | |
| | Internal construction can be reached easily for maintenance | Product parts are easily releasable | |
| *Acceptability* | Product does not create stigma | | Product fits the guidelines of objective conicinnety |
| | Product creates possitive reaction from bystanders | Desirede associations: Empowermenet, Strengt, Friendlyness, dynamical | Product is blue or black coloured |
| | | | Products is filled or chamfered |
| | | | Product is not all symmetrical (vertical) |
| | | | Product is not all asymmetrical (vertical) |
| | | | Productsurfaces are devided horizontally |
| | | | Product surface devision according to a 1:1.5 ratio |
| | Product is appealing to the majority of the users | Product resembles mainstream products | |

| VALUE | REQUIREMENTS/CHARACTERISTICS | SPECIFICATION | POSSIBLE SOLUTION |
|---|---|---|---|
| | | Main shape does not contain very contrasting thicknesses | |
| | | Circular shapes are repetetively present on the product | |
| | | Product is simple | |
| | | Detailling of the product is determined by material choices | |
| | Product is not associated with medical products | Product is not white | |
| | Product matches user's personality and lifestyle | Product personalizable | |
| | Product is fully finished | No screws and other assembling parts visible | |
| | | Construction is not unintended visibile | |
| | Product is not inconspicious | Product is not hided | |
| | | Product is not unchoicenly striking | Product is personalizable |
| | | Product matches the colouring of the wheelchair(mostly black) | |
| *Other* | Product is reimbursed by health insurances | | |

# A.7 PROPERTIES OF THE WING FAMILY

| | Gowing | Dowing | Darwing |
|---|---|---|---|
| *Main function* | Perform activities of daily living | support uncoordinated movements | Perform activities of daily living |
| *Basic solution* | Spring balancing and electric balancing | Spring balancing, electric power | Electric balancing |
| *Placement* | Base of wheelchair | Wheelchair/tabletop | Back of the wheelchair |
| *User control* | Keyboard | Rotational button | Screen/joystick |
| *Memory* | None | None | Four combinations of settingsfor different actions |
| *Angle stabelizer* | Manual | None | Automatic/manual |
| *Adjustments* | Working angle, balancing height, degree of compensation | Elbow rest, degree of assistance | Degree of balancing |
| *Independent movement of the upperarm and forearm* | None | None | Yes |
| *Positionlock* | Two | None | One |
| *Detachable* | yes, partly and totally | Yes | Yes |
| *Extras* | Stopfunction(transition from electric to sping balancing) | | |

# Appendix B

# B.1 EVALUATION OF THE PLACEMENT POINTS AND NODES

***Preparation:***

*Goal: Choice of placements and nodes*

*What to evaluate: the appearance of different placements and nodes for a dynamic arm support on a wheelchair*

Method:

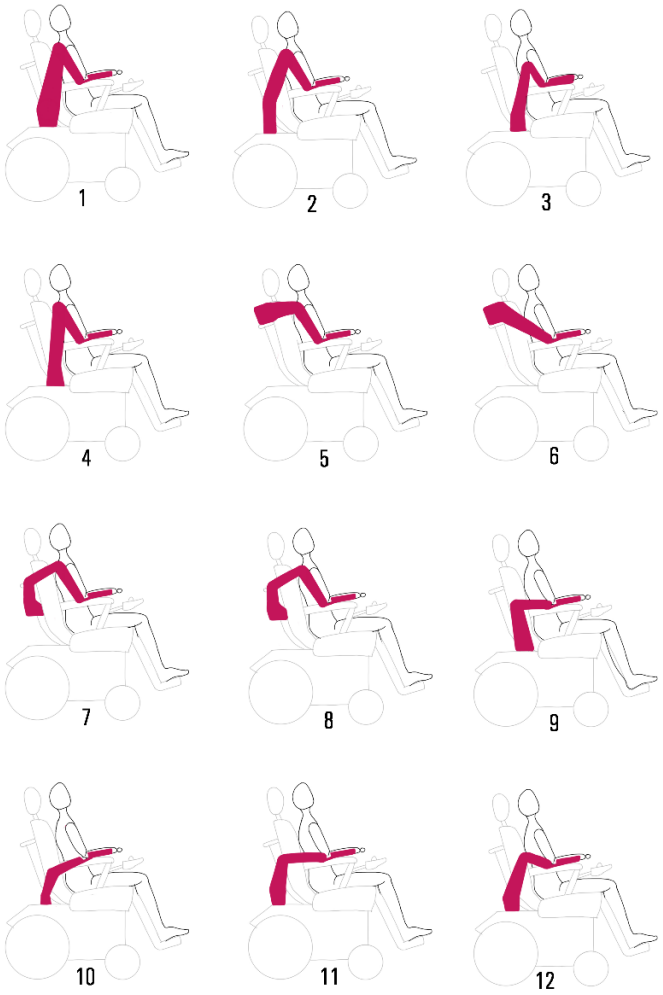
- Ranking the different designs with a questionnaire
- Discussing the appearance during a group discussion

Necesseties:

- Questionnaires
- Poster/Presentation
- Beamer
- Pen + Paper
- Partictipants

Set-up:

All participants are taking part of the sales advisors meeting. The evaluation takes place during a break of that meeting. All attendees are employees of Focal Meditech, but have different backgrounds. The evaluation will take place in the conference room.




FOCAL meditech luisteren maken verbeteren

Questionnaire (in Dutch):

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Geslacht: m / v | | | | | | | |
| Leeftijd: | | | | | | | |
| Mijn technische voorkennis is: | slecht | 1 | 2 | 3 | 4 | 5 | goed |
| Top 3: | | | | | | | |
| Motivatie keuzes: | | | | | | | |

Age, gender and the technical knowledge are questioned to test if these factors influence the choices.

The top three was asked to determine which design was most likable by the participants.

The motivation of this top three was asked to use as a startup for the discussion.

***Execution:***

1. Give short presentation about Industrial Design and the assignment
2. Show a poster with twelve different placements and different numbers of nodes.
3. Ask participants to fill in the questionnaire and choose a favorite design, based on only its appearance
4. Ask participants who would like to share their choice and explain the reason for this choice
5. Ask participants who agrees or disagrees and why
6. Let participants discus the designs and take notes of the discussion.

After the evaluation during the sales advisors meeting, the poster is shown to the other employees of the company during lunch time, these employees also filled in the questionnaire.

***Results:***

Number of participants questionnaire: 19
Number of participants discussion: 12

Results questionnaire:

| Gender | Age | Technical knowledge | nr 1 | nr 2 | nr 3 |
|---|---|---|---|---|---|
| m | 62 | 5 | 3 | 9 | 10 |
| m | 21 | 3 | 3 | 5 | 7 |
| m | 62 | 5 | 1 | 9 | 8 |
| m | 68 | 1 | 1 | 8 | 12 |
| m | 63 | 3 | 3 | 10 | 8 |
| m | 58 | 1 | 10 | 11 | 9 |
| m | 60 | 3 | 10 | 11 | 9 |
| m | 54 | 1 | 3 | 4 | 2 |
| m | 55 | 5 | 1 | 9 | 10 |
| m | 28 | 3 | 10 | 11 | 9 |
| m | 52 | 5 | 10 | 9 | 11 |
| m | 30 | 5 | 10 | 3 | 12 |
| m | 49 | 4 | 3 | 9 | 11 |
| m | 33 | 5 | 9 | 1 | 3 |
| v | 50 | 2 | 10 | 12 | 9 |
| m | 29 | 5 | 10 | 9 | 3 |
| m | 32 | 5 | 9 | 3 | 11 |
| m | 21 | 5 | 6 | 4 | 3 |
| m | 38 | 1 | 10 | 2 | 12 |

| | | | |
|---|---|---|---|
| **Average Age** | 45 | Min. 21 | Max. 68 |
| **Average Knowledge** | 3,5 | Min. 1 | Max. 5 |

For each testperson the top choice (nr 1) got three points. The second choice (nr 2) got two points and the third choice (nr 3) got one points. For each design the points where summed and can be found in the table below.

| | | | | | | |
|---|---|---|---|---|---|---|
| **Design number** | 1 | 2 | 3 | 4 | 5 | 6 |
| **score** | 11 | 3 | 22 | 2 | 2 | 3 |
| **Design number** | 7 | 8 | 9 | 10 | 11 | 12 |
| **Score** | 1 | 4 | 20 | 28 | 9 | 4 |

Results discussion:

*Resemblance with body:*

- Resemblance with the body looks more natural and is preferred

*Resemblance with wheelchair:*

Resemblance with the wheelchair is more inconspicuous and preferred

*Resemblance with competition:*

- Nr. 12 looks like the Armon

*Material choice:*

- New materials like carbon fibre would look more nice
- Aluminum is already used

*Acceptance of the product:*

- Design is the first impression of the product
- Acceptance is determined by the psychological aspects of the product
- Acceptance is partly determined by the fitting process. Some users are already scared when they see the great variety of arm supports that they can try. Therefore, the arm supports are now placed in boxes when used for the fitting process.

*Conspicuous or inconspicuous design:*

- Inconspicuous by following the body shape or the shape and appearance of the wheelchair
- Product can be hided or emphasize the individuality of the user.
- Hiding the product is hard to do, since it still is quite big.
- Skin coloured products are not inconspicuous.
- Darwing is sold in black and silver, but almost all users have a black Darwing. So inconspicuous design is better than emphasizing the individual
- Red accents are used on the currently available products to accentuate the interaction possibilities; this is a very conspicuous factor of these products.
- Inconspicuous is preferred by the user
- The user should stand out when using the product
- The techniques used should stand out in the design
- The product should be as small as possible

*Tips for continuation of the assignment:*

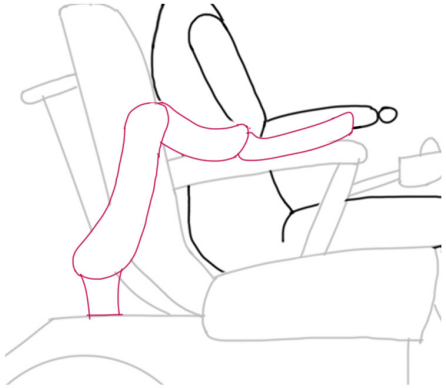
- Keep production and material properties in mind during the design process → round shapes are hard to produce
- Look at the product in its context, wheelchair and user are always involved
- Maintenance and repair are often needed when the product is in use.
- The most mentioned motivation for the choice of an appearance are about a natural and serene looks, following the body or wheelchair and the space that the arm support takes in.

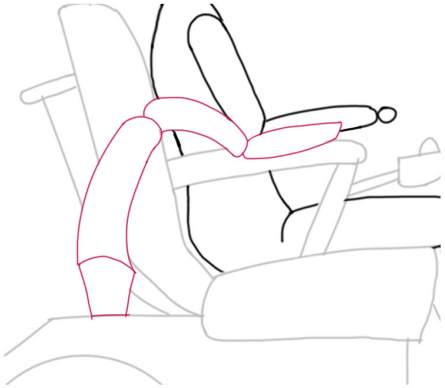
***Conclusion:***

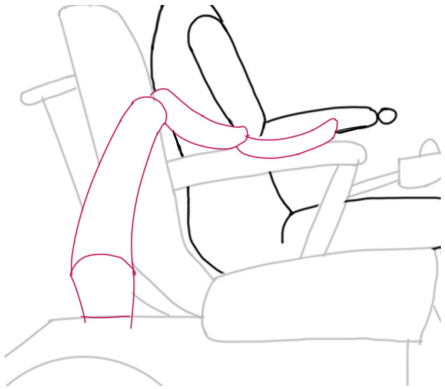
Out of the evaluation, it can be concluded that the arm support should have a serene and natural look. The placement of the wheelchair and the number of nodes should contribute to this look. Also the structure should either follow the user's body or the shape of the wheelchair and the wheelchair should not take in too much space on the wheelchair.

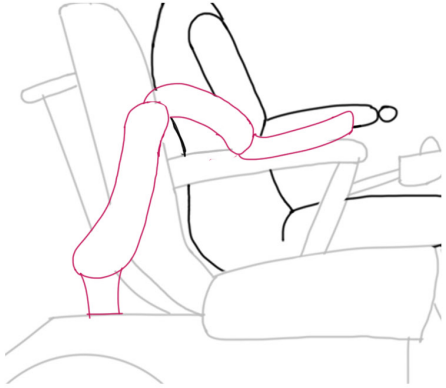
The results of the questionnaire will be taken into account when choosing the basic shape/starting point for the further the design. Also the feasibility of these designs and a theoretical analysis will be taken into account when choosing one of the presented designs in this evaluation.

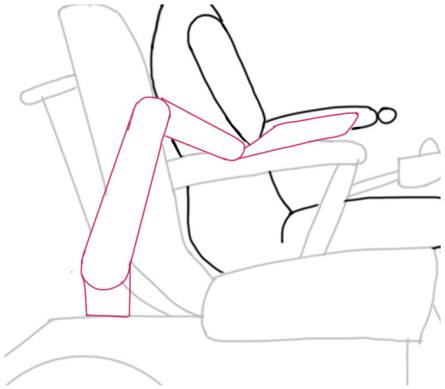
# B.2 ITERATION 1

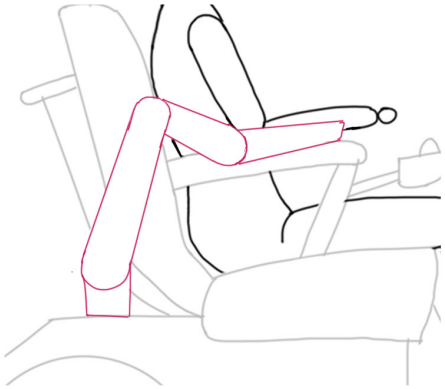


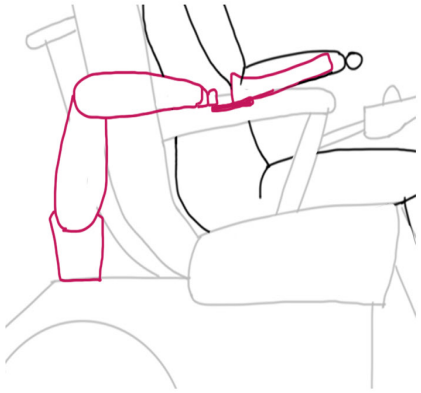


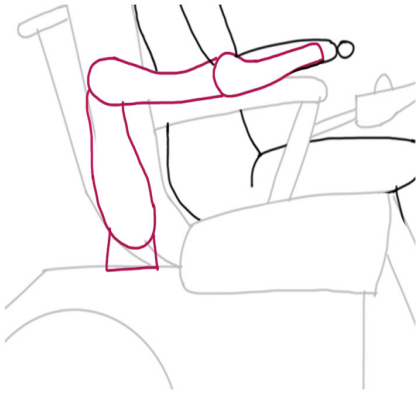


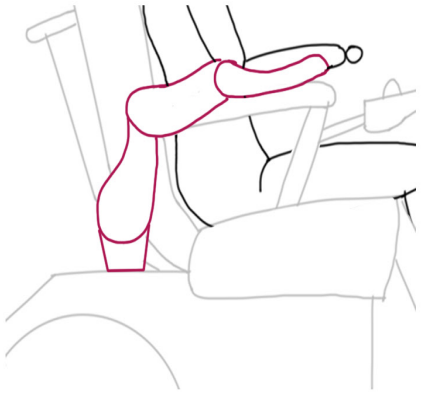


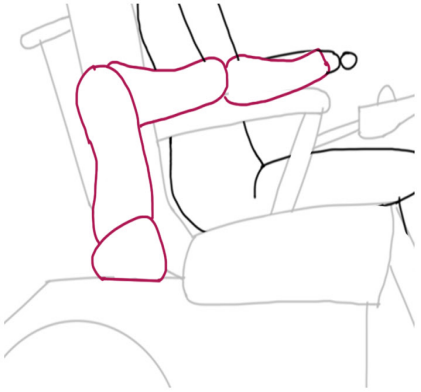


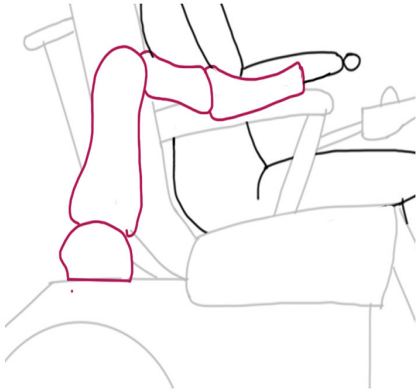


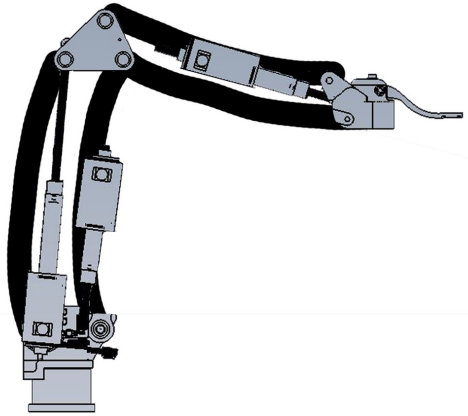


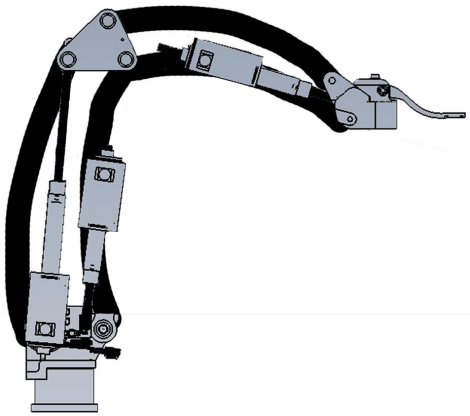


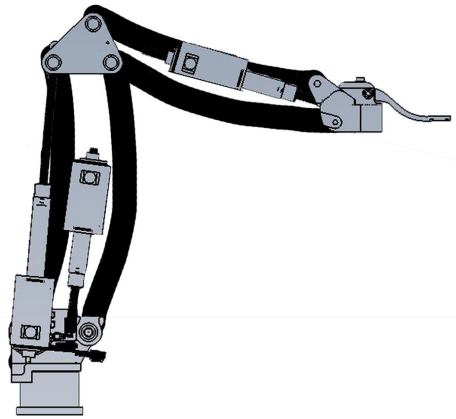


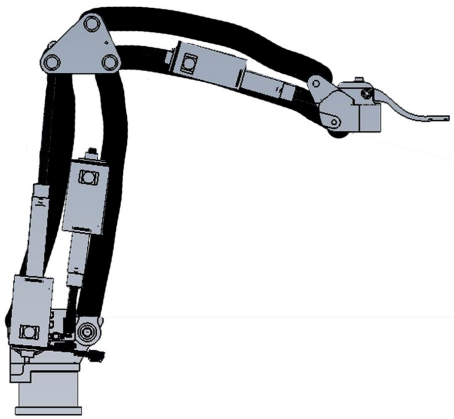


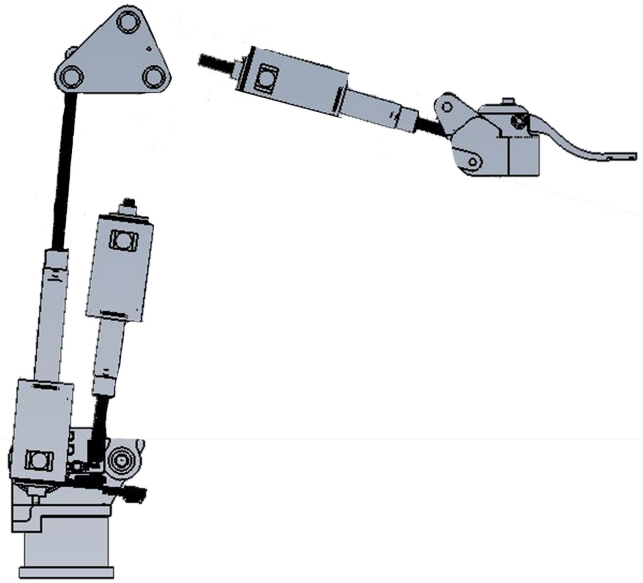












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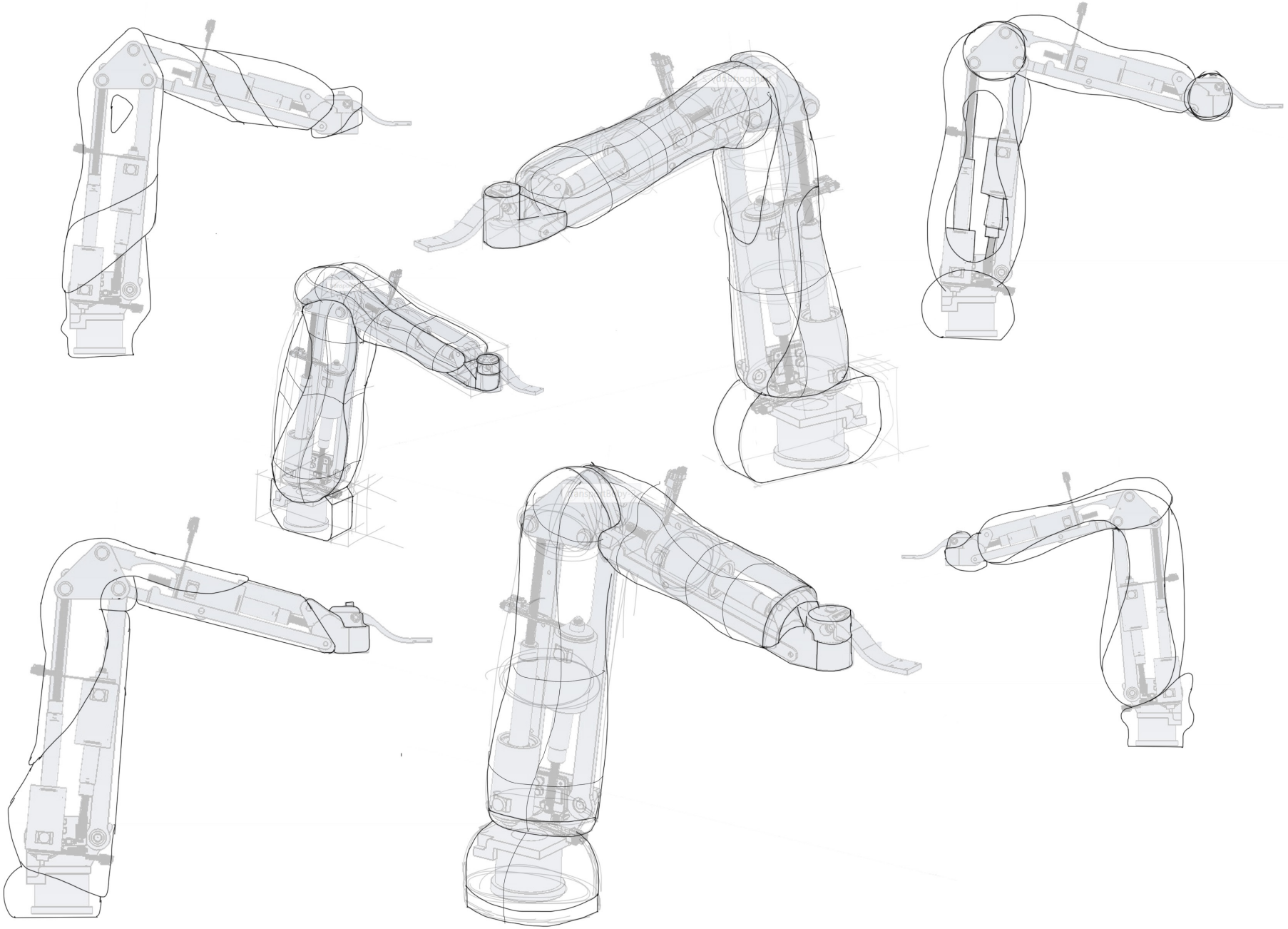

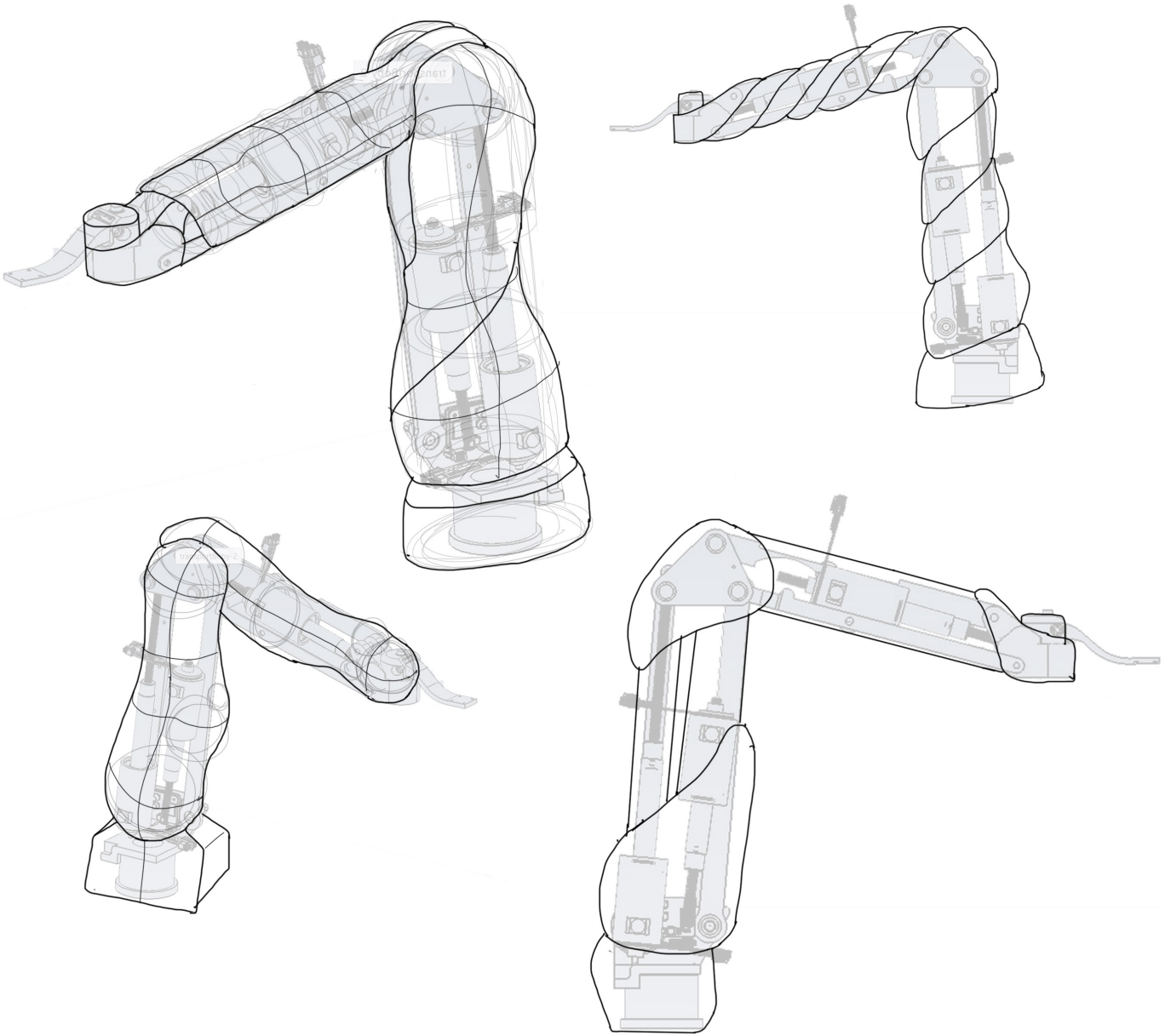

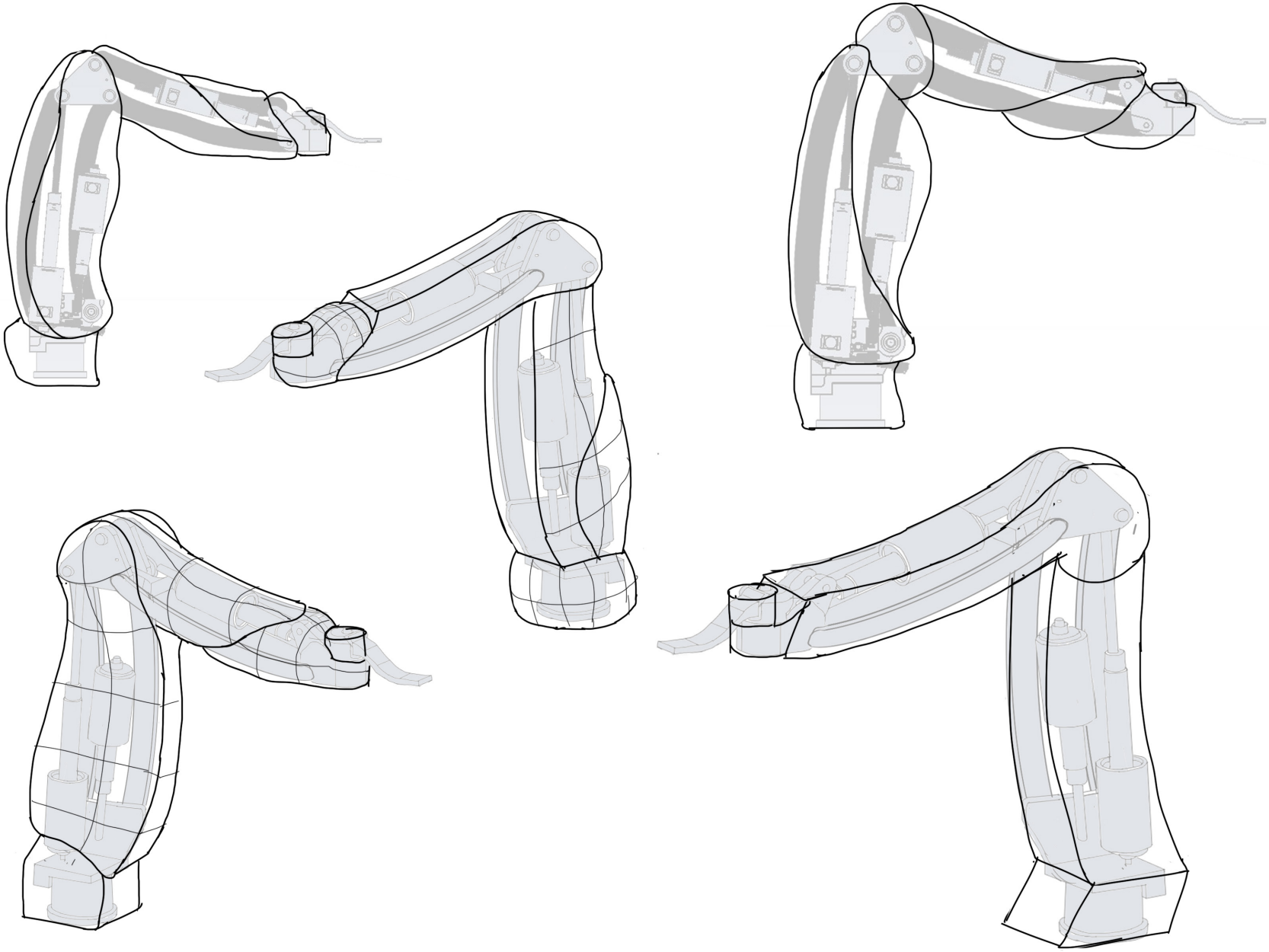

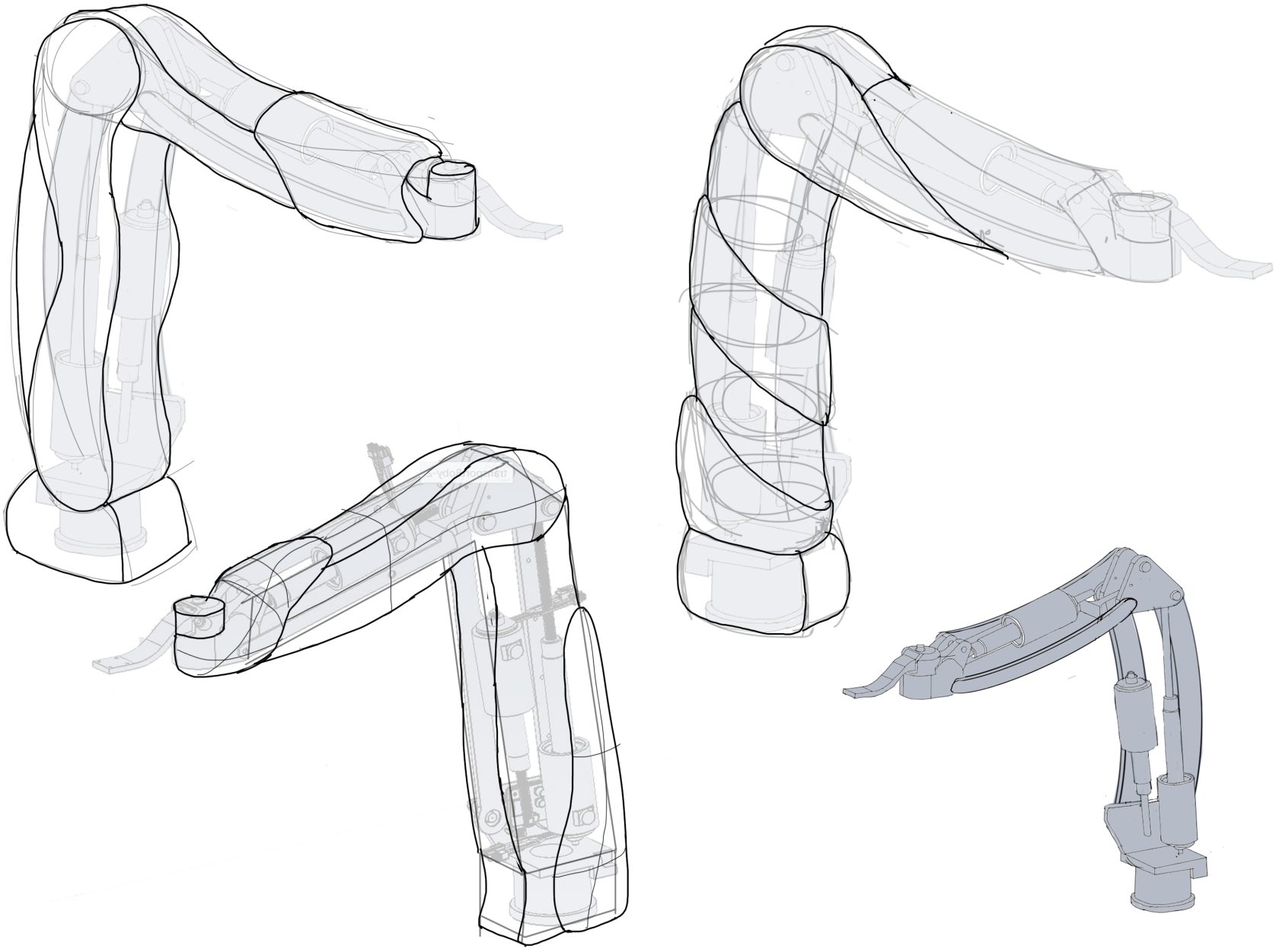

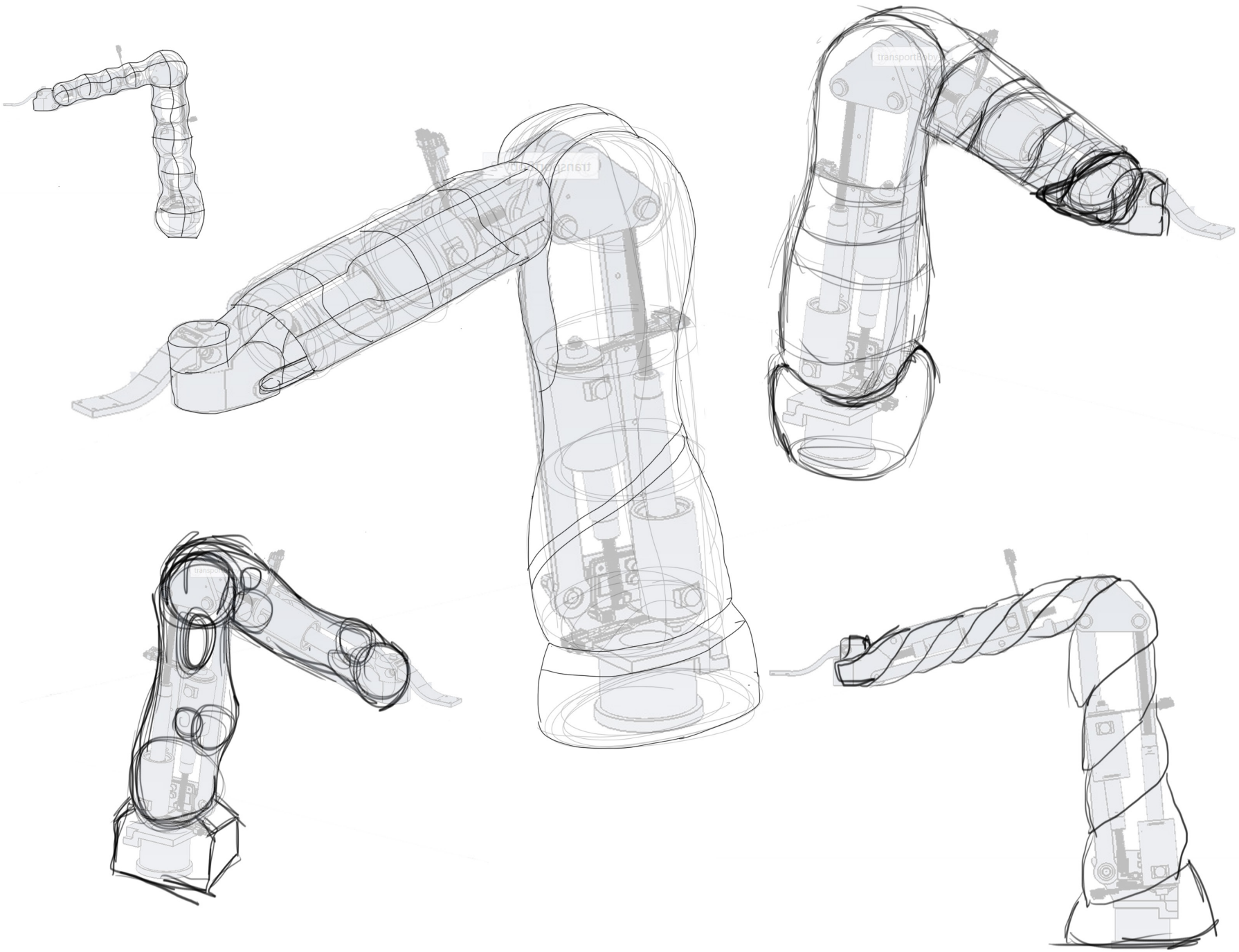

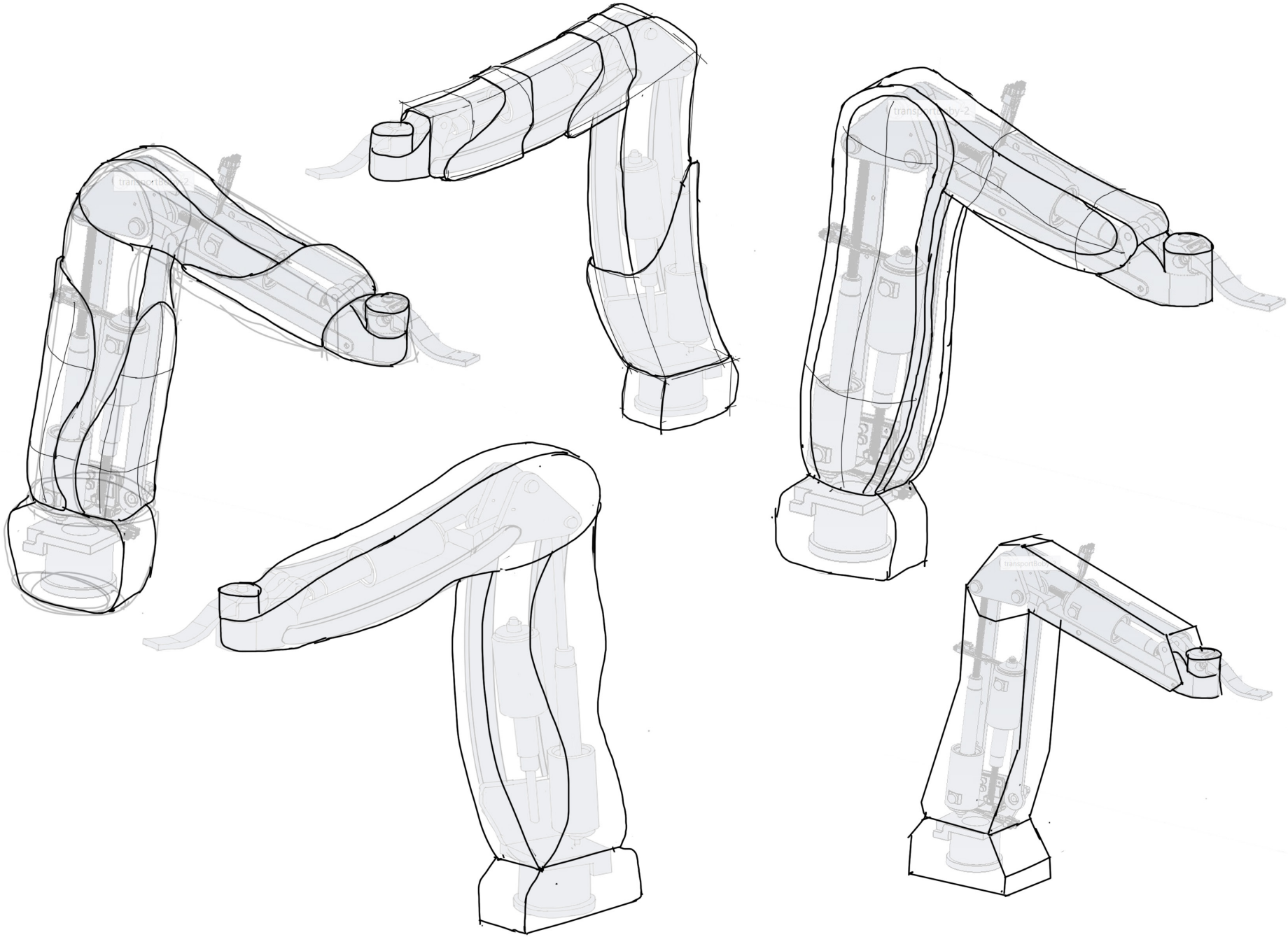

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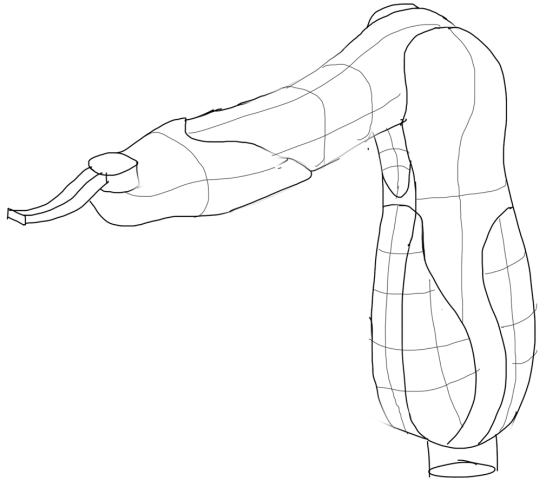

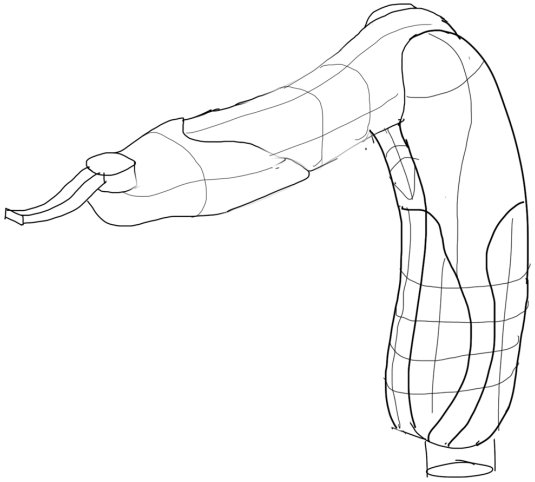

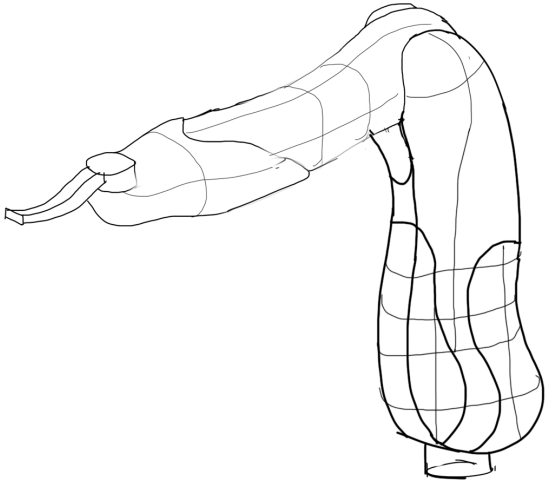

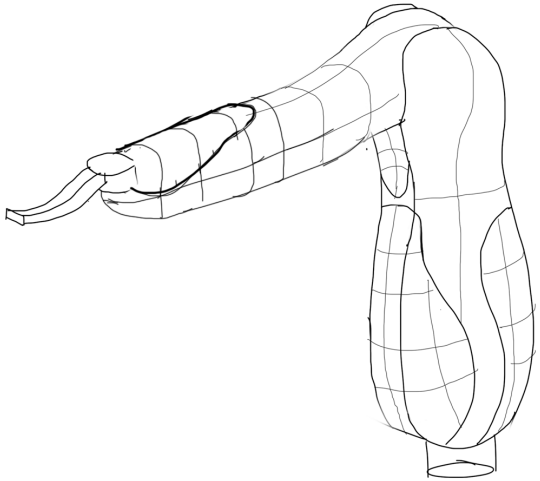

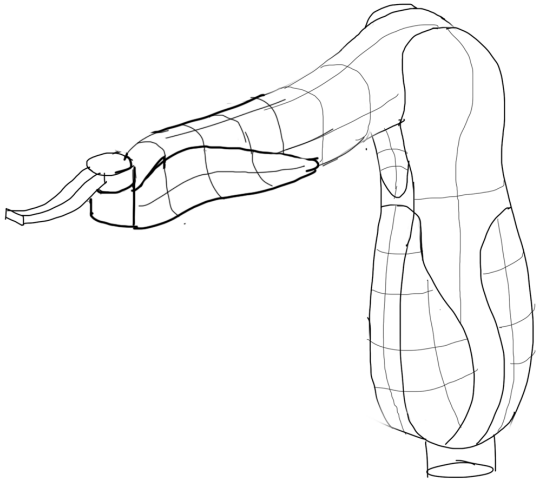

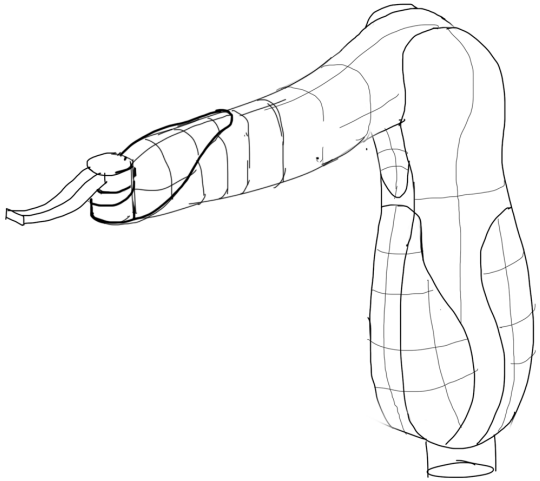

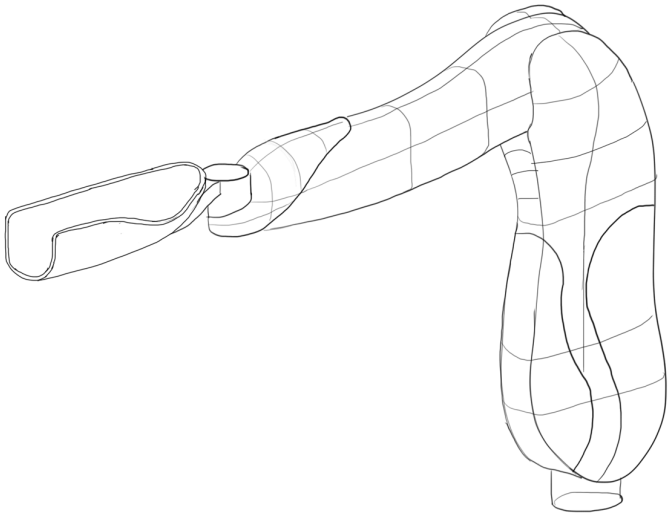

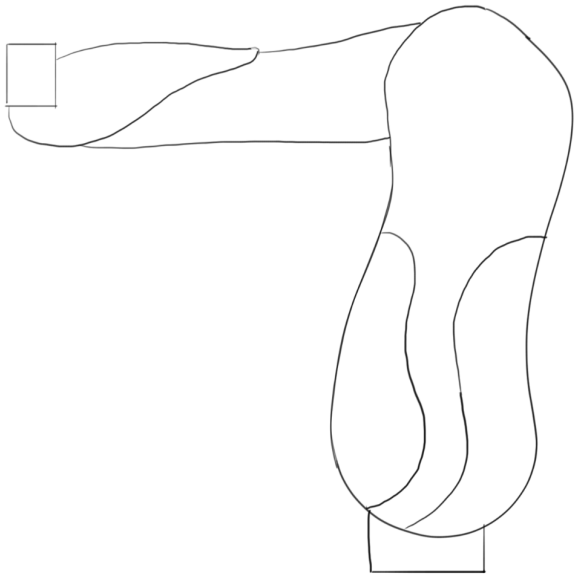

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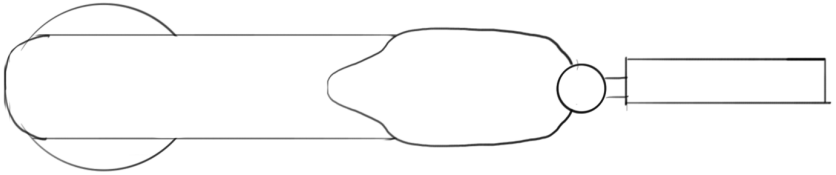

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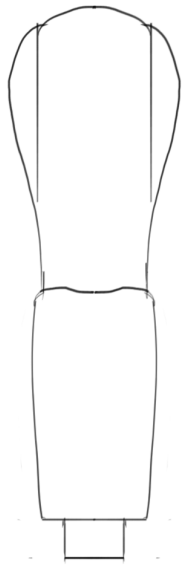

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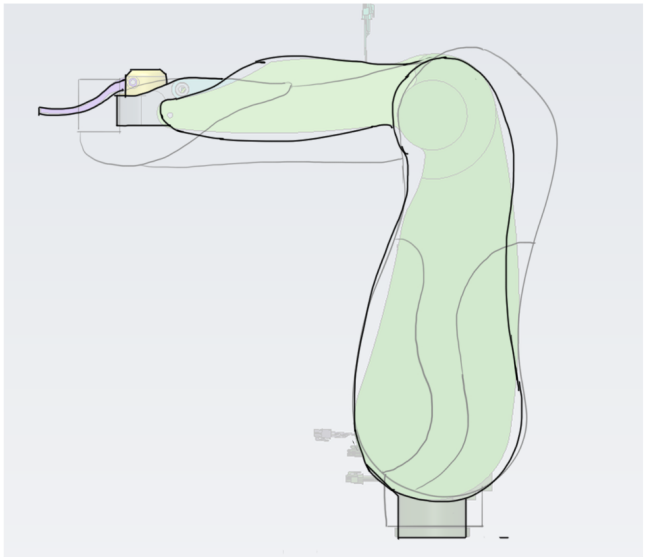

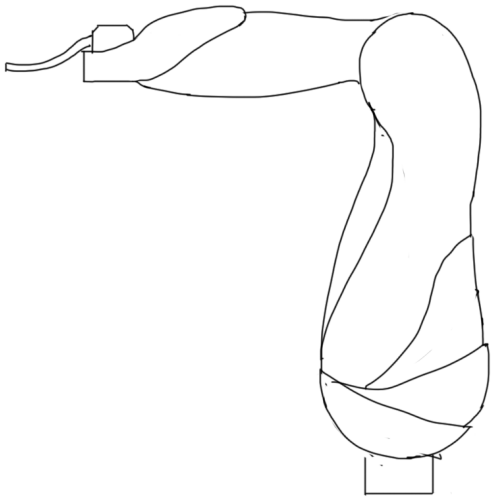

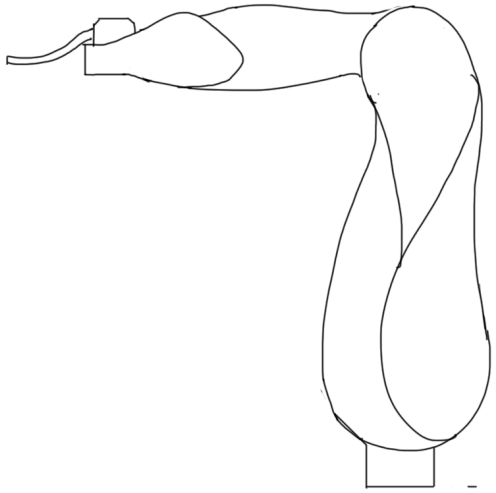

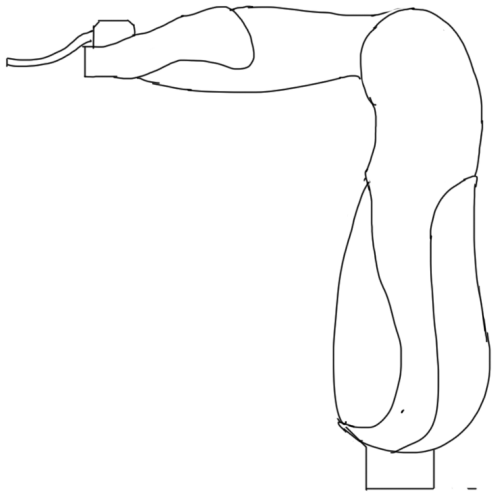

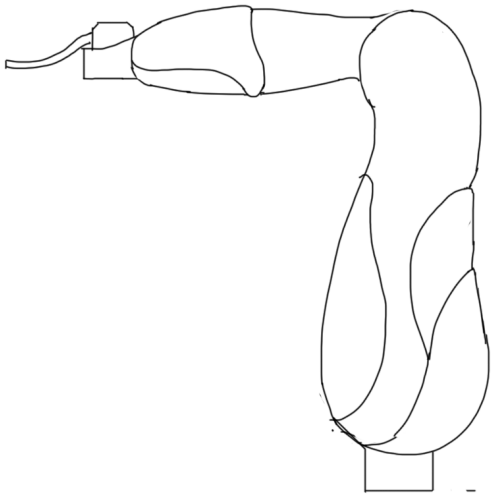

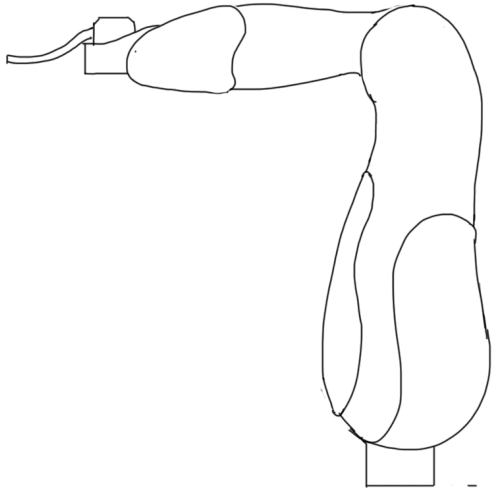

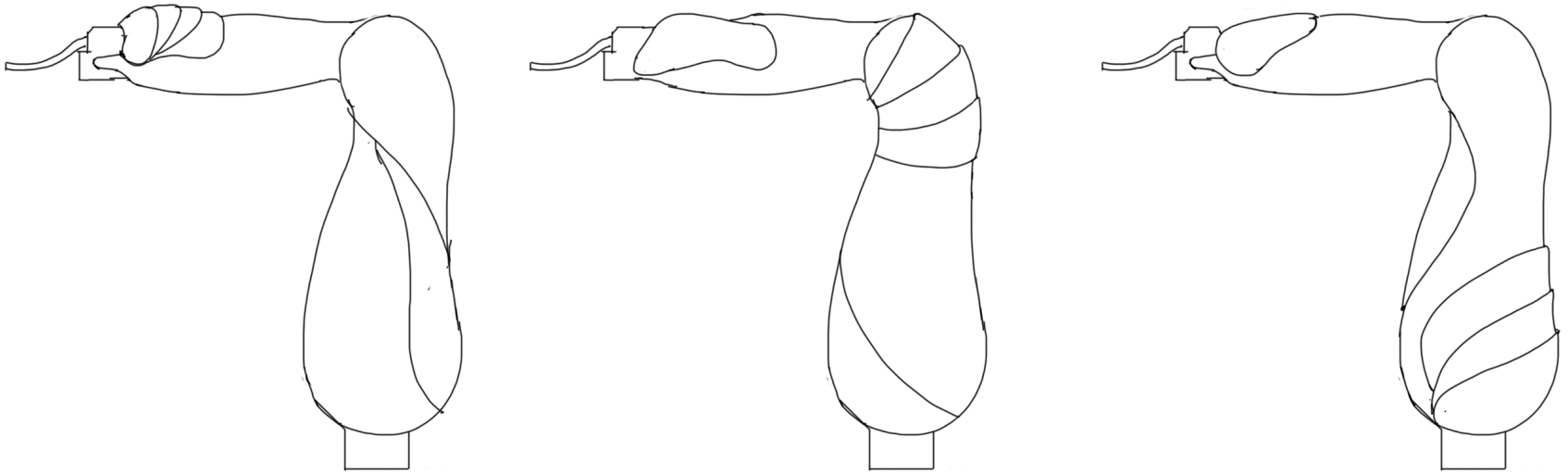

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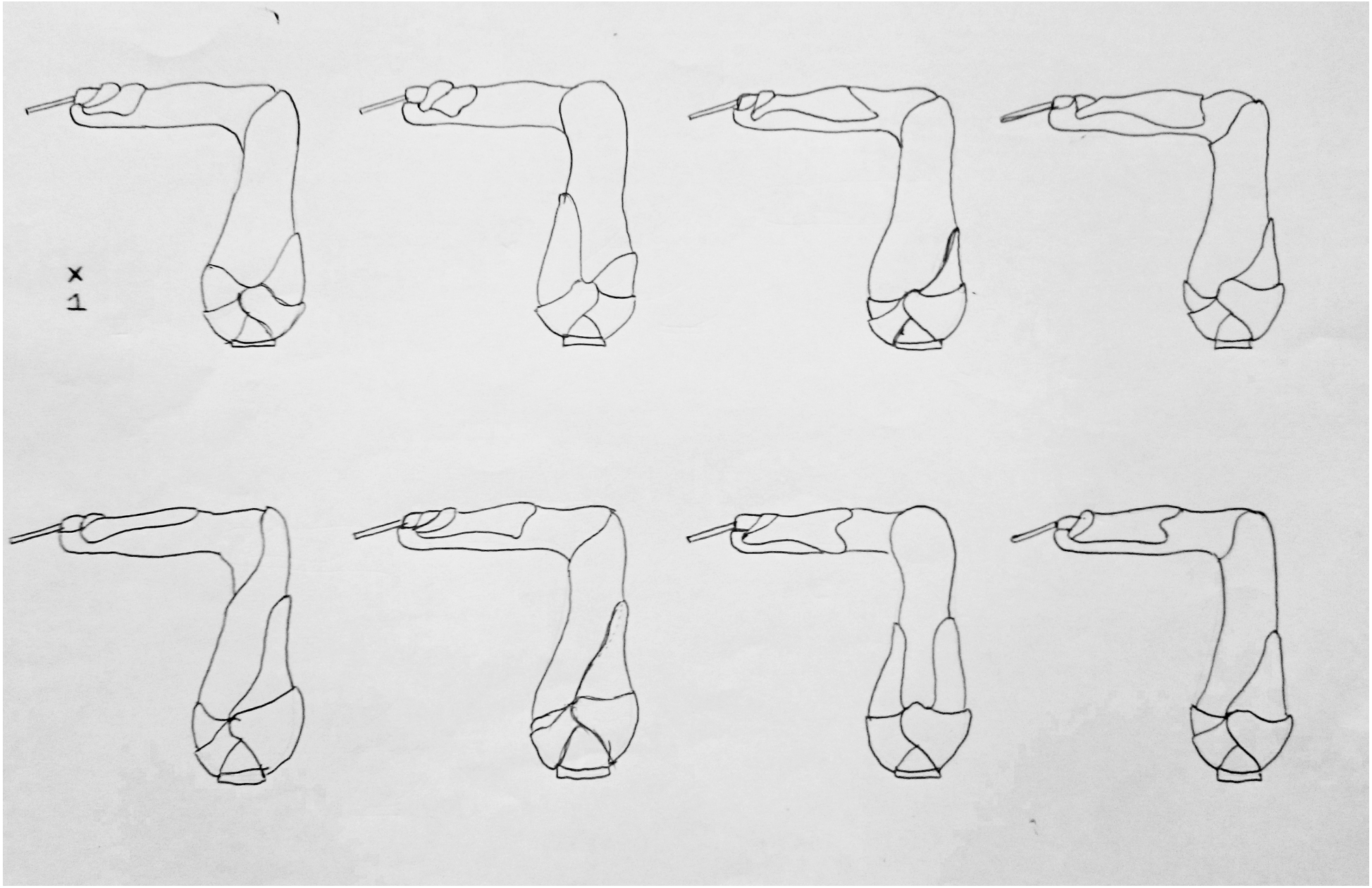

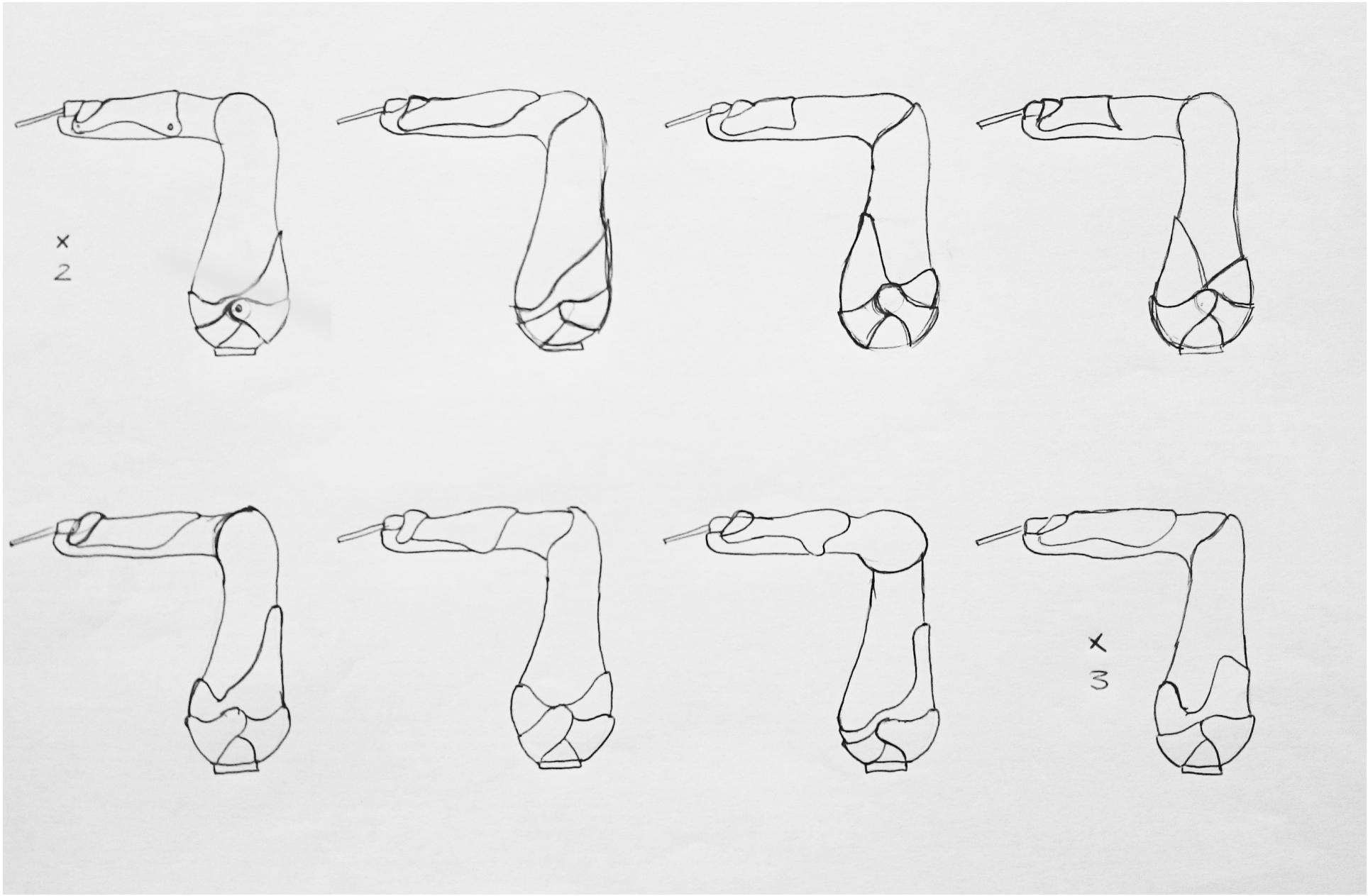
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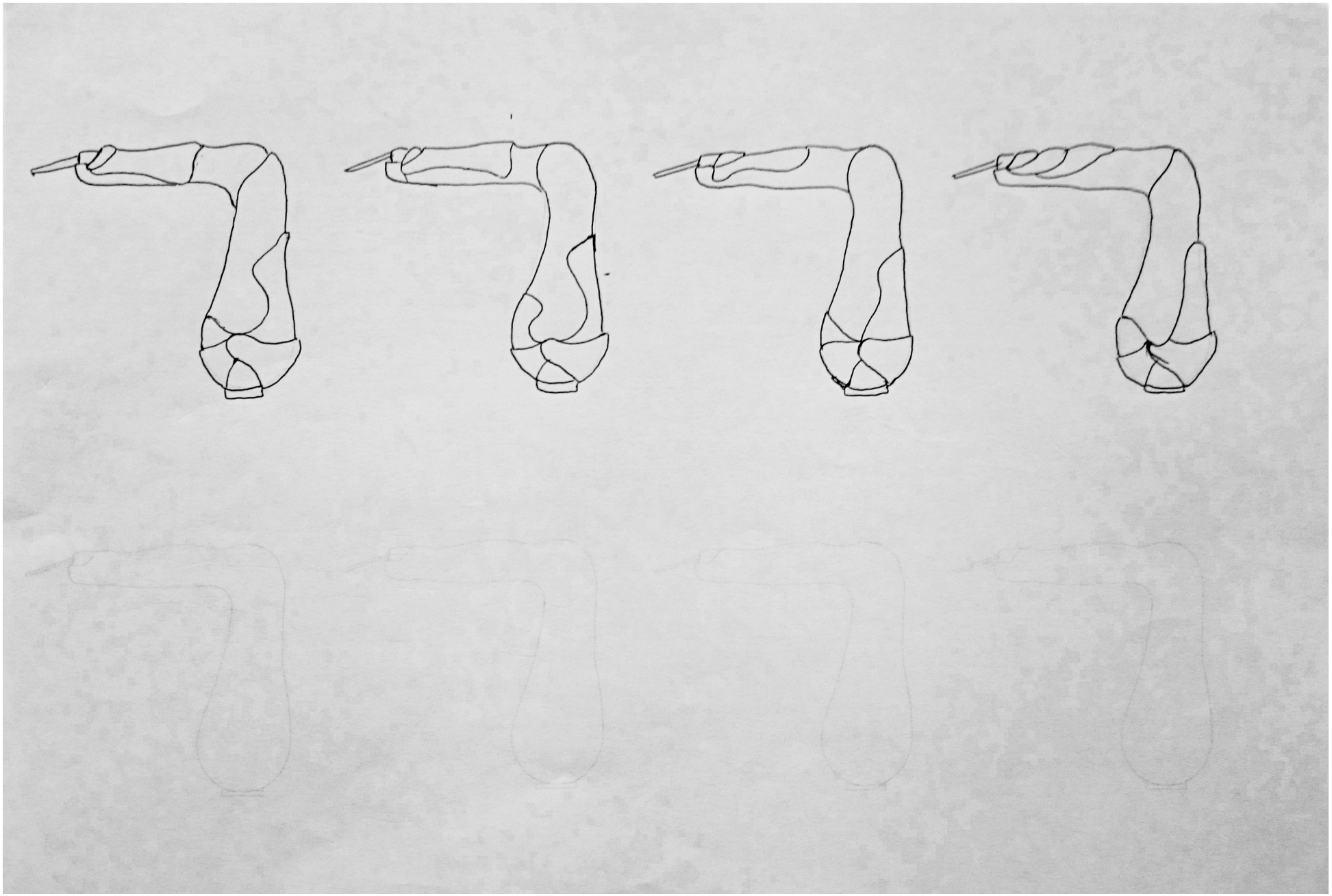

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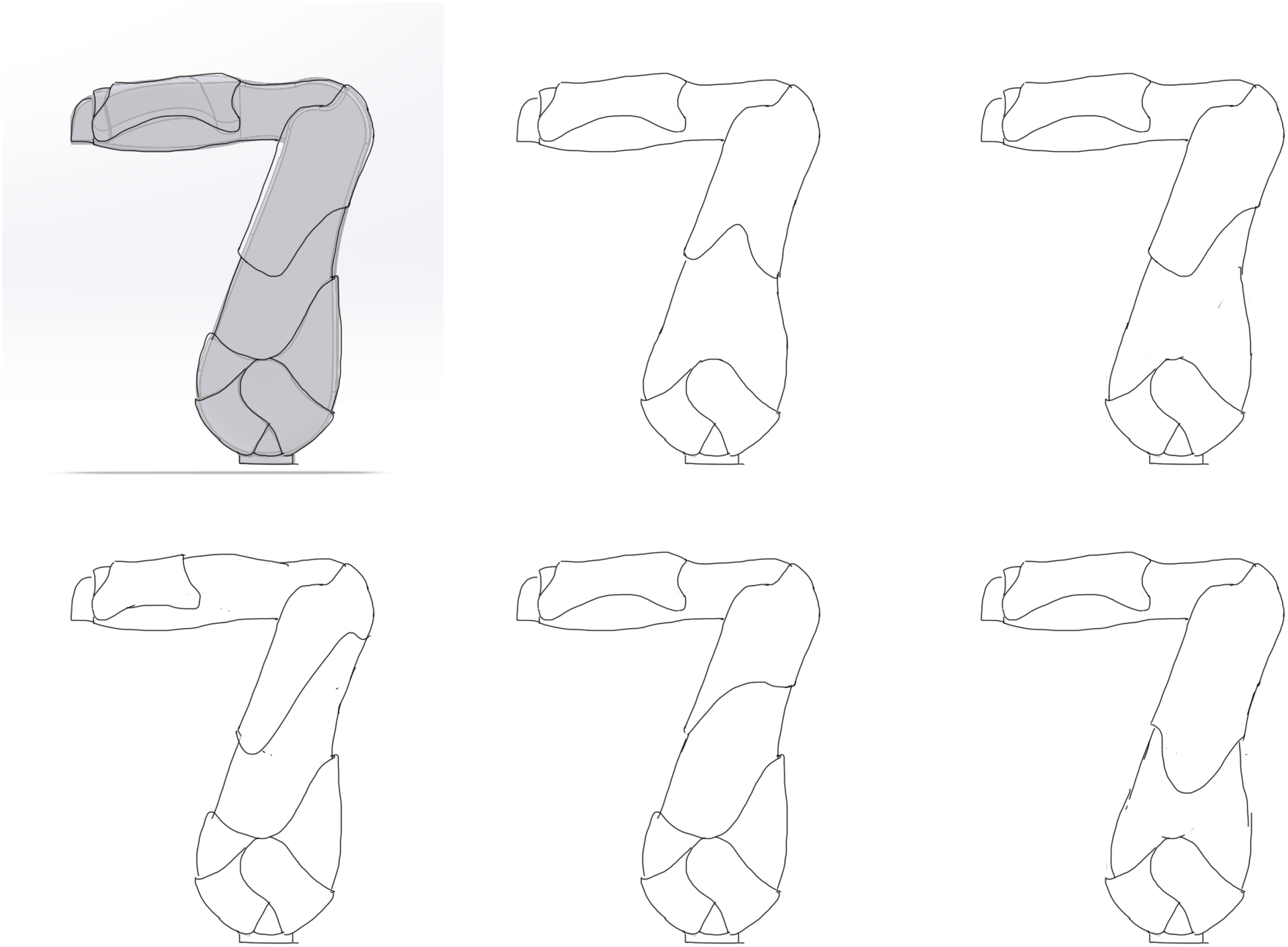
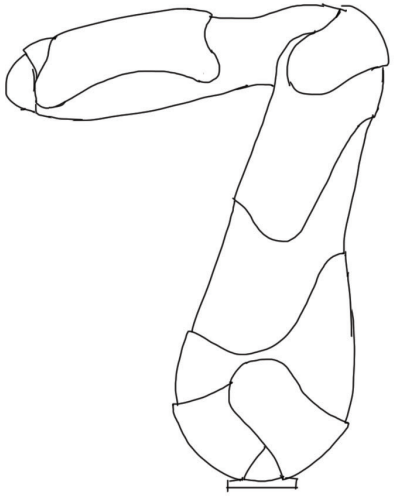
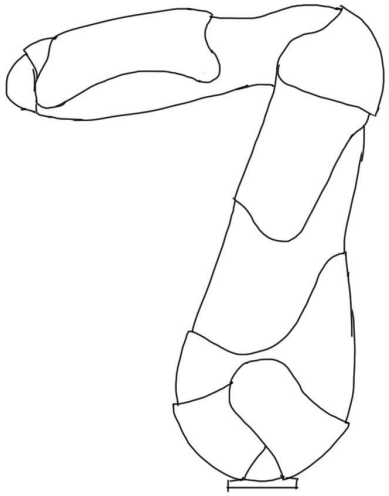
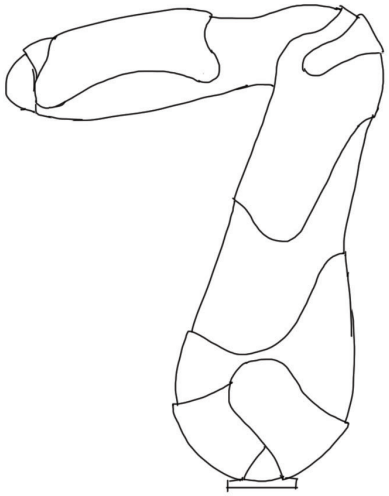
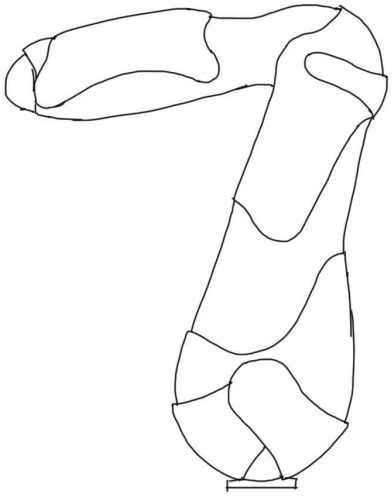
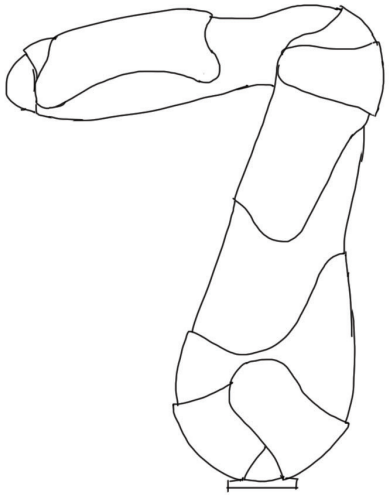
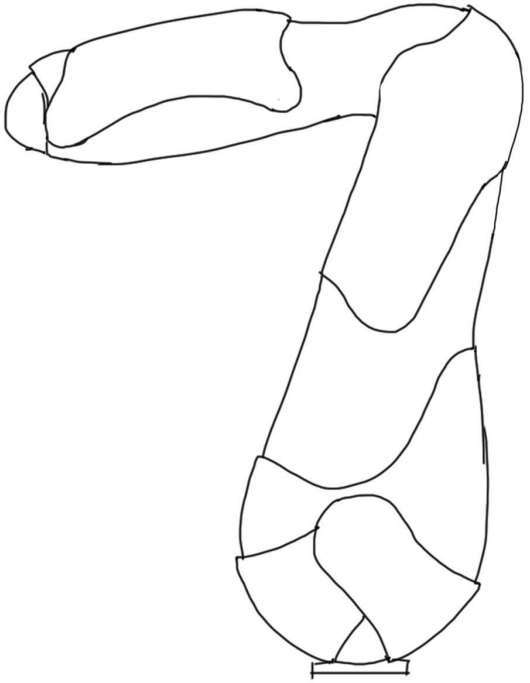


# B.8 EVOLUTION OF THE CONSTRUCTION, PLACED ON A WHEELCHAIR

# Appendix C

**INHOUD VAN DEZE APPENDIX**

# C.1 QUALITATIVE EVALUATION

***Voorbereiding:***

*Doel:*

- Evaluatie van de associaties bij het product

*Subdoelen:*

- Evaluatie van de associaties bij het product zonder context en minimale voorkennis
- Evaluatie van de associaties bij het product met context en voorkennis
- Verschil tussen associaties met of zonder context evalueren
- Plaatsing van het product in een opvallendheid - techniek/design grafiek evalueren

*Methoden:*

Kwalitatieve analyse door middel van een vragenlijst en discussie

***Uitvoering:***

*Opstelling:*

- Vier deelnemers (design studenten)
- 5 laptops
- PowerPointpresentatie met benodigde afbeeldingen
- Voicerecorder
- Vragenlijst (4x)
- Filmpje
- Projectruimte
- Blauwe pennen(4x)
- Rode pennen (4x)

*Opzet:*

Vier design studenten zullen gevraagd worden om deel te nemen aan een discussie waarbij de associaties bij het ontworpen product zullen worden geëvalueerd. Als eerste zullen zij alleen een PowerPointpresentatie toegestuurd krijgen die zij kunnen openen op de laptop. De presentatie bevat afbeeldingen die nodig zijn om de vragen van de vragenlijst te beantwoorden en als handvat dienen tijdens de discussie. Als eerste wordt de deelnemers

***Voorbereiding:***

*Doel:*

- Evaluatie van de associaties bij het product

*Subdoelen:*

- Evaluatie van de associaties bij het product zonder context en minimale voorkennis
- Evaluatie van de associaties bij het product met context en voorkennis
- Verschil tussen associaties met of zonder context evalueren
- Plaatsing van het product in een opvallendheid - techniek/design grafiek evalueren

*Methoden:*

Kwalitatieve analyse door middel van een vragenlijst en discussie

***Uitvoering:***

*Opstelling:*

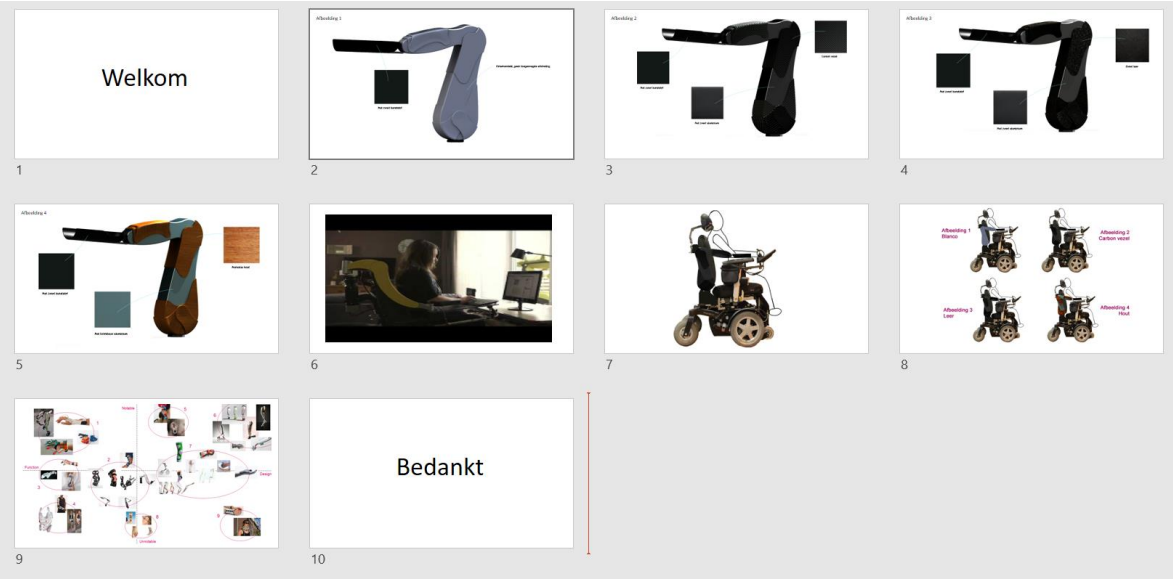
- Vier deelnemers (design studenten)
- 5 laptops
- PowerPointpresentatie met benodigde afbeeldingen
- Voicerecorder
- Vragenlijst (4x)
- Filmpje
- Projectruimte
- Blauwe pennen(4x)
- Rode pennen (4x)

*Opzet:*

Vier design studenten zullen gevraagd worden om deel te nemen aan een discussie waarbij de associaties bij het ontworpen product zullen worden geëvalueerd. Als eerste zullen zij alleen een PowerPointpresentatie toegestuurd krijgen die zij kunnen openen op de laptop. De presentatie bevat afbeeldingen die nodig zijn om de vragen van de vragenlijst te beantwoorden en als handvat dienen tijdens de discussie. Als eerste wordt de deelnemers

gevraagd om met minimale voorkennis (weten dat het product een armsteun is op een rolstoel) om de van de vier verschillende concepten de associaties die ze daarbij hebben te ranken.  Vervolgens zal een discussie worden gehouden voor de reden van deze rankingen voor alle vier de concepten. Na deze discussie krijgen de deelnemers een filmpje te zien over de werking van een dynamische arm ondersteuning en een uitleg over de werking van het ontworpen product en de materialen waar het van gemaakt is en hoe de uitstraling van de vier verschillende concepten bereikt wordt. Vervolgens wordt de deelnemers gevraagd de vragenlijst opnieuw in te vullen (met een andere kleur pen) voor het product in context en met voorkennis. Na het invullen van de vragenlijst zullen de antwoorden opnieuw bediscussieerd worden.  Als afsluiting van deze evaluatie wordt de deelnemers gevraagd om het uiteindelijke product (de versie met carbon vezel en aluminium uitstraling) te plaatsen in een assenstelsel waar de techniek/design focus en opvallendheid op uitgezet zijn. Vervolgens wordt ook hier om een argumentatie gevraagd voor hun keuze.

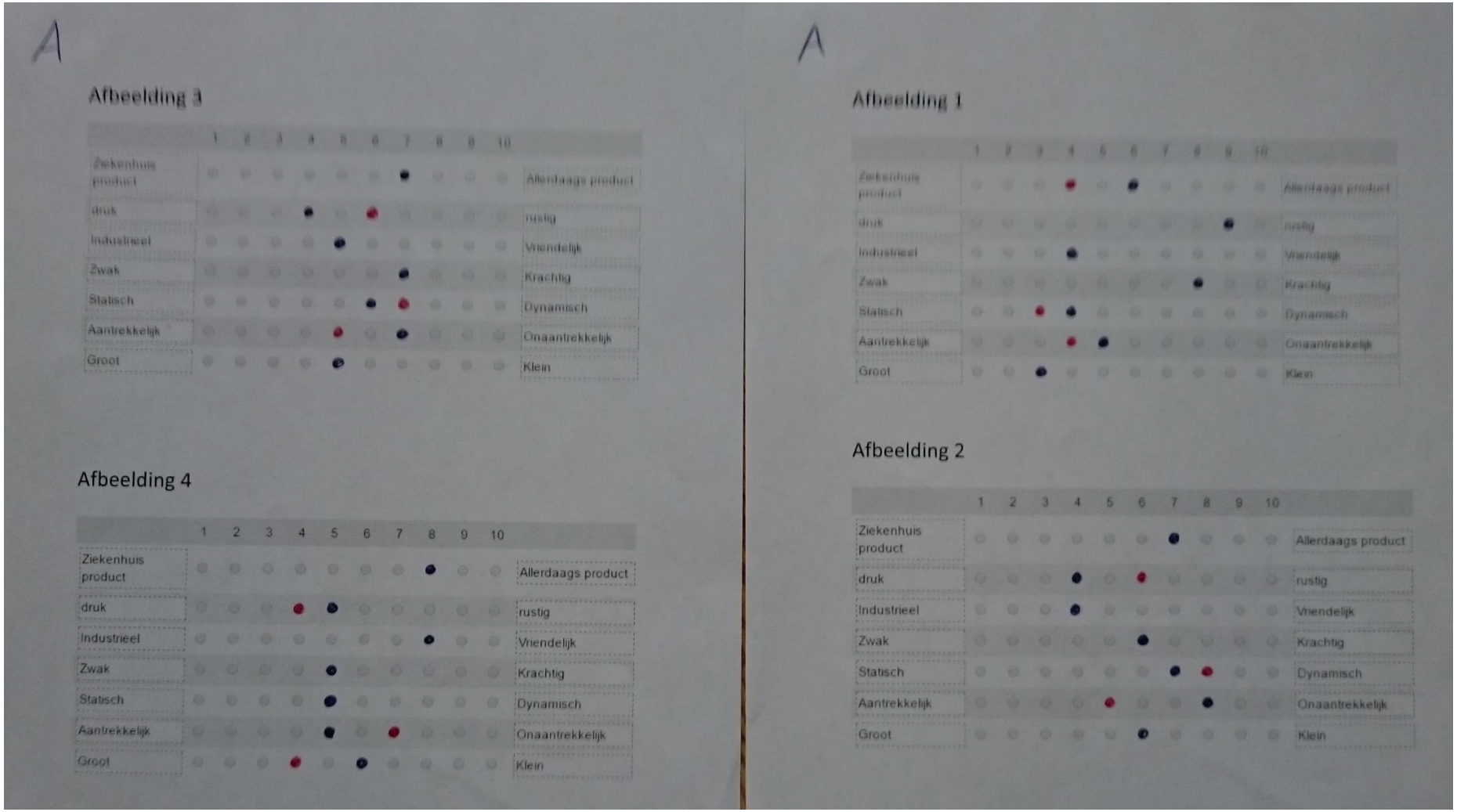
*Vragenlijst/PowerPointpresentatie:*




| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Ziekenhuis product | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | Allerdaags product |
| druk | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | rustig |
| Industrieel | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | Vriendelijk |
| Zwak | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | Krachtig |
| Statisch | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | Dynamisch |
| Aantrekkelijk | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | Onaantrekkelijk |
| Groot | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | Klein |

***Resultaten:***

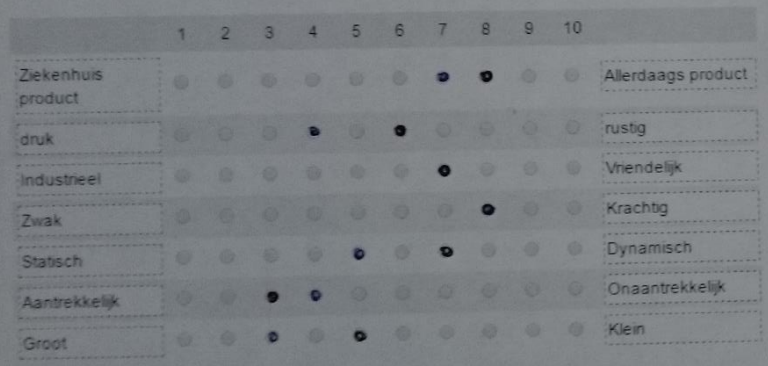
*Vragenlijst:*



B

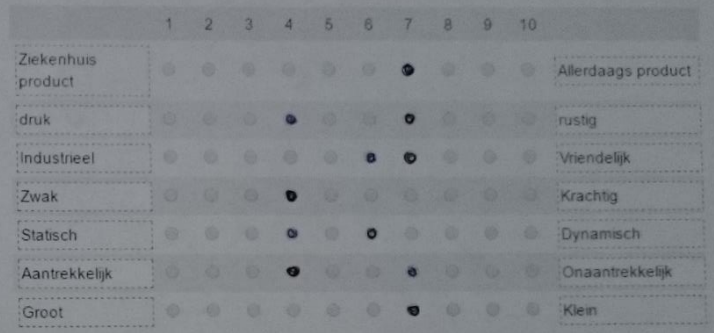
## Afbeelding 1


## Afbeelding 2




B

## Afbeelding 3

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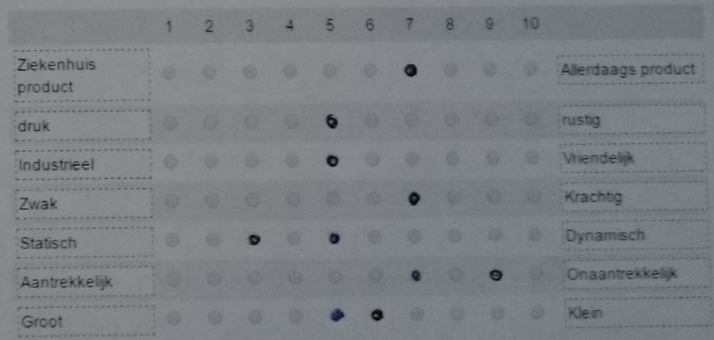
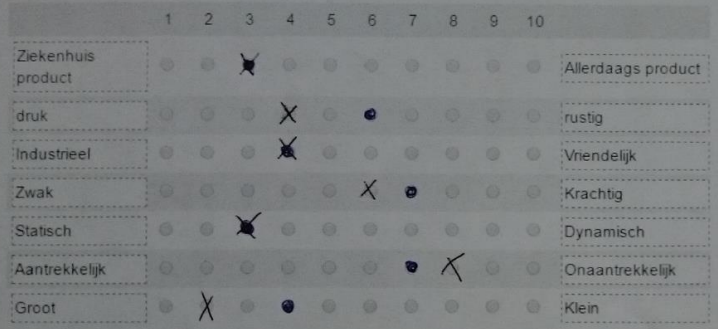


C

Afbeelding 1

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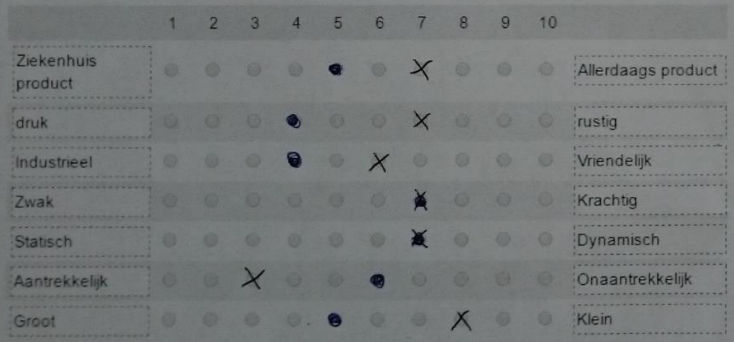


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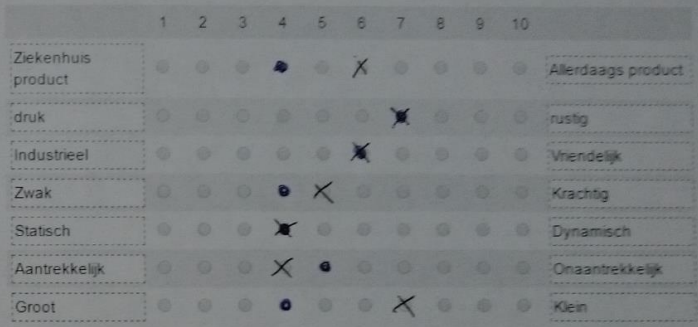
Afbeelding 3

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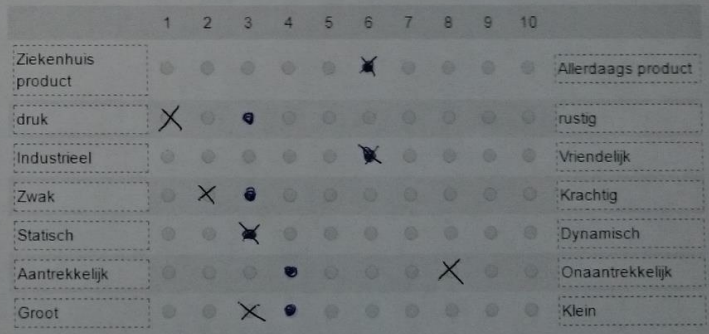

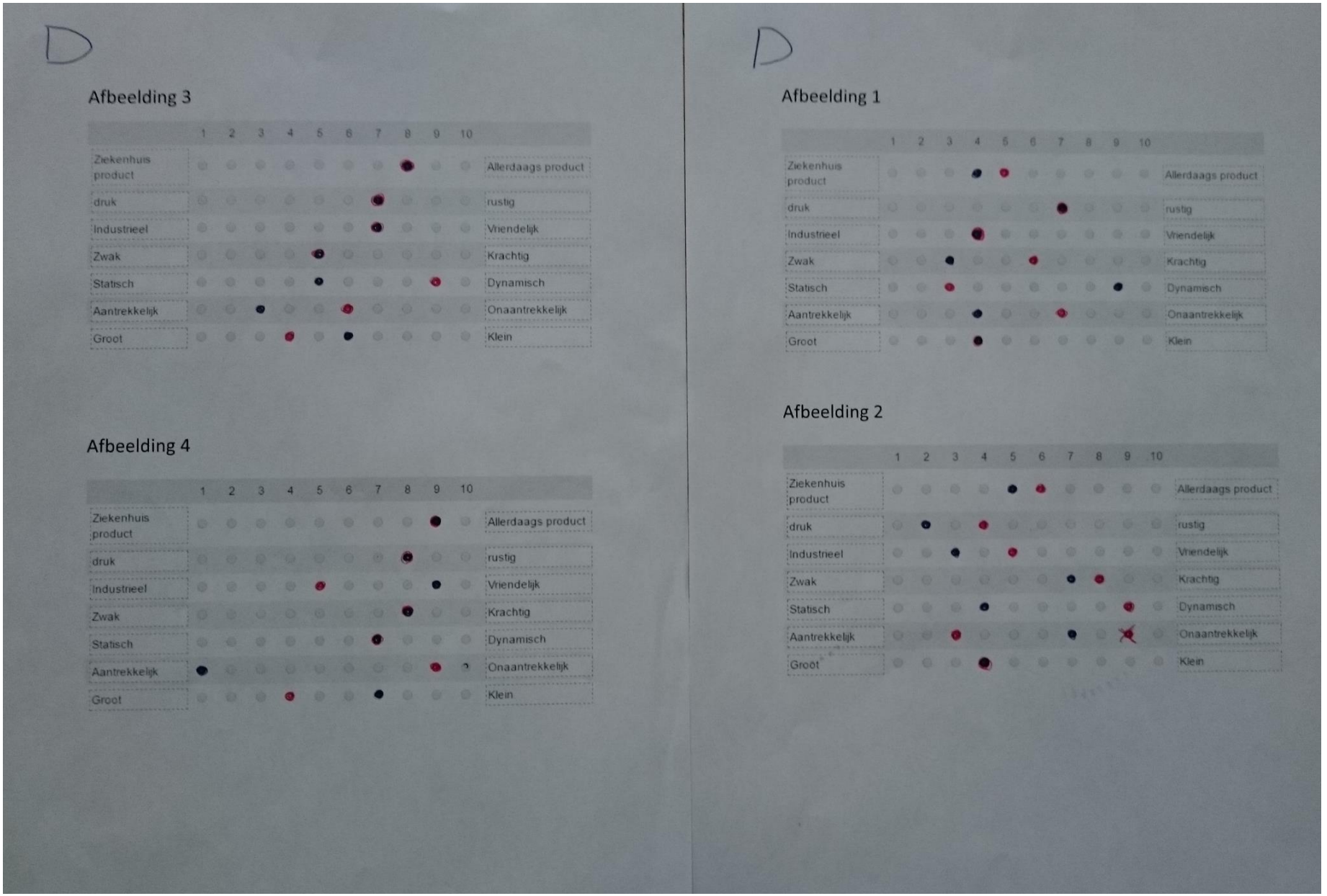
D
Afbeelding 3
1 2 3 4 5 6 7 8 9 10
Ziekenhuis product
Allerdaags product
druk
rustig
Industrieel
Vriendelijk
Zwak
Krachtig
Statisch
Dynamisch
Aantrekkelijk
Onaantrekkelijk
Groot
Klein
Afbeelding 4
1 2 3 4 5 6 7 8 9 10
Ziekenhuis product
Allerdaags product
druk
rustig
Industrieel
Vriendelijk
Zwak
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Statisch
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Onaantrekkelijk
Groot
Klein
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1 2 3 4 5 6 7 8 9 10
Ziekenhuis product
Allerdaags product
druk
rustig
Industrieel
Vriendelijk
Zwak
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Dynamisch
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Onaantrekkelijk
Groot
Klein
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Ziekenhuis product
Allerdaags product
druk
rustig
Industrieel
Vriendelijk
Zwak
Krachtig
Statisch
Dynamisch
Aantrekkelijk
Onaantrekkelijk
Groot
Klein

*Discussie:*

1. Discussie zonder context en met weinig voorkennis:

Afbeelding 1:

Deze versie van het product wordt gezien als meer ziekenhuis product dan een consumentenproduct. Redenen hiervoor zijn, dat het lijkt alsof het goed schoon te houden is en omdat het helemaal in een kleur is, wat bij veel ziekenhuis ook altijd het geval maar dan in het wit. De redelijke lichte kleur en de vele scharnierend lijkende punten maken het product er best ingewikkeld in uitstraling en dat past ook meer bij een ziekenhuis product passen dan bij een consumentenproduct.

Het product wordt bevonden als redelijk rustig, voornamelijk door het gebruik van de vloeiende lijnen en het ontbreken van onnodige frutsels. Door het gebruik van de verschillende vlakken lijkt het product iets minder rustig, maar deze vlakken vormen nog wel een geheel, waardoor het product alsnog rust uitstraalt. Ook lijken de vlakken een functie te hebben en maken het product daarom niet onnodig druk.

Het product lijkt meet een industrieel product dan een vriendelijk product. Dit komt voornamelijk door het gebrek aan positieve gevoelens dat het product oproept, wat volgens alle deelnemers wel een vereiste is voor een vriendelijk product. Ook lijkt het zonder context en met minimale voorkennis op een machine wat meer industrieel is dan vriendelijk.

Aan de ene kant lijkt het product heel krachtig, door de stevige uitstraling van het materiaal en het massieve geheel. Het eerste wat bij een van de deelnemers op komt is alsof het product net zoveel aan kan als een Nokia telefoon van vroeger. Echter door de vele scharnierend lijkende vlakken van hetzelfde materiaal lijkt het product minder stevig en dus zwakker.

Doordat het product er heel massief uit ziet, en niet flexibel. De deelnemers zijn het erover eens dat het maar een vrijheidsgraad heeft, hooguit twee. Dit maakt dat het product meer gezien wordt als statisch dan dynamisch. Wel geven de verschillende vlakken een wat dynamische indruk mee aan het product.

Het product wordt wel gezien als aantrekkelijk en dat komt vooral door de vloeiende lijnen en ronde vormen. De simpele uitstaling van het geheel, ondanks de verschillende vormen en vlakken speelt hier ook een belangrijke rol in. Wel wordt de massieve uitstraling van het product gezien als een onaantrekkelijk aspect van het product. Hierdoor lijkt het product niet subtiel en redelijk groot.

Deze massiviteit maakt ook dat het product groot lijkt, dit komt ook vooral omdat je niet weet wat het is. Eerste indruk lijkt het formaat van een hijskraan.

Afbeelding 2:

Deze versie van het product lijkt een meer alledaags product ten opzichte van de eerste versie. Dit komt vooral door de kleur, bij zwart is het moeilijk te zien of iets schoon of vies is, waardoor het bijna nooit wordt gebruikt voor ziekenhuis producten. Ook lijkt het product nu minder makkelijk schoon te maken.

Het product lijkt een stuk minder rustig als werd gezegd bij de eerste versie, dit komt door het drukke patroon van de carbonvezel en doordat het product nu niet meer uit een kleur/materiaal is gemaakt.

Dit maakt het product naast minder rustig, wel meteen en stuk dynamischer. Ondanks de massieve uitstraling lijkt het door de carbonvezel stukken alsof het product heel snel kan bewegen, wat een dynamische maar ook sportieve uitstraling geeft. Dit effect wordt versterkt door de vloeiende lijnen in het product.

Doordat het hele product nu niet meer uit een stuk en een materiaal soort is gemaakt, lijkt het product ook minder groot. Dit komt ook door de donkere kleuren die zijn gebruik in deze versie.

Drie van de vier deelnemers vinden het product nu aantrekkelijker dan de eerste versie, doordat het minder ziekenhuis en minder statisch/groot lijkt. Een van de deelnemers vind deze versie minder aantrekkelijk dan de eerste versie, doordat deze versie minder rust uitstraalt en minder een geheel is.

Door de kleur en materiaalkeuze lijkt het product nu kleiner, maar daarnaast ook een stuk industriëler. De materialen die gebruikt zijn zie je veel in industriële producten terugkomen. Lijkt nu kleiner, doordat het niet massief uit een stuk is. Aan de andere kant lijkt het product door de verschillende vlakken in vloeiende lijnen die door de verschillende materialen nu beter te zien zijn ook weer vriendelijker.  De deelnemers waren allen om deze reden in twijfel over de ranking van deze versie op deze schaal.

Afbeelding 3:

Deze versie van het product lijkt nu een stuk meer alledaags dan de voorgaande versies. Dit komt vooral door het leer, dat je helemaal niet snel in ziekenhuis producten zal tegenkomen.

Het leer zorgt daardoor ook voor dat het product kleiner lijkt, me zal niet snel leer kiezen voor hele grote producten. Dit maakt het product niet alleen kleiner ogend, maar ook zwakker, zeker ten opzichte van de versie met carbonvezel. Leer is een zacht materiaal, wat veel minder kracht uitstraalt dan een hard materiaal als carbon vezel. Hierdoor lijkt het product wel ook een stuk vriendelijker, leer geeft het product een zachte en huiselijke uitstraling mee.

Deze versie lijkt dynamischer dan versie 1, door het gebruik van verschillend materiaal voor verschillende vlakken, maar wel minder dynamisch dan versie 2, aangezien het leer geen dynamisch en sportief patroontje bevat en de carbonvezel van versie 1 dat wel heeft.

Op het gebied van aantrekkelijkheid van deze versie zijn de deelnemers er niet over uit. Deze versie wordt iets aantrekkelijker bevonden dan de eerste versie, maar iets minder aantrekkelijk dan versie 2. De enige reden die hiervoor wordt gevonden is dat leer snel slijt en er dan snel minder aantrekkelijk uit ziet.

Afbeelding 4:

Deze versie ziet er het meest van allen versies uit als een alledaags product, dit komt door de kleur en het hout.

Door de lichte kleuren zijn de kappen in deze versie extra goed zichtbaar. Hierdoor lijkt het ook alsof de onderste kappen los kunnen (door middel van iets simpels als een magneet of klittenband).

Dit product lijkt ook een stuk vriendelijker dan alle andere producten, door de kleur en het materiaal, maar daarmee ook een stuk zwakker, aangezien hout niet wordt gezien als een heel sterk of krachtig materiaal. Ook de blauwe kleur ziet en vriendelijker maar zwakker uit. Wel ziet het product er krachtiger uit doordat de stukken hout meer naar voren springen en daardoor het verticale en het horizontale onderdeel van het product beter op elkaar lijken aan te sluiten.

Aan de ene kant lijkt dit product meer dynamisch omdat de verschillende vlakken en vloeiende lijnen in deze kleur en materiaal samenstelling meer opvallen. Aan de andere kant lijkt het product een stuk statischer omdat houten onderdelen vaak niet heel veel bewegen ten opzichte van elkaar, in andere producten.

Twee van de deelnemers vinden dit de mooiste versie van alle versies, voornamelijk door de dynamiek in combinatie met de vriendelijkheid en de positieve gevoelens die het product oproept.

De andere twee deelnemer vinden het product juist helemaal niet aantrekkelijk. Het blauwe aluminium en hout op zich wordt als heel mooi bevonde, maar vinden deze uitstraling niet passen bij een ziekenhuis product (het product wordt gezien als een ziekenhuis product omdat het bedoeld is voor een beperking) en deze deelnemers vinden de materialen kleuren ook geen mooie combinatie.

2. Discussie met context en met voorkennis:

Afbeelding 1:

Ten opzichte van deze versie zonder context en voorkennis, oogt versie 1 nu een stuk zwakker en onaantrekkelijker. Deze versie valt heel erg op ten opzichte van de rolstoel, maar lijkt nog steeds een industrieel product.

Wel lijkt het product de gebruiker extra kracht en ondersteuning te bieden, dus het doel van het product komt duidelijk naar voren in de uitstraling van het product. Ook lijkt het product in deze context een stuk kleiner en niet meer zo erg machinaal/hijskraanachtig.

Ondanks dat het product zo erg opvalt ten opzichte van de rolstoel, lijkt het product met context nu een stuk statischer, aangezien de verschillende vlakken door het gebruik van maar een kleur veel minder opvallen binnen het geheel.

Onaantrekkelijker, statischer en krachtiger, in context lijkt hij bij de rolstoel wel krachtig en veel ondersteuning bieden. Lijkt statischer omdat je van veraf de vormen van de kappen wat minder ziet

Door de context, voornamelijk de rolstoel, lijkt het product nog meer een ziekenhuis product dan zonder context.

Afbeelding 2:

Deze versie past veel beter in de context dan de vorige versie. Het lijkt een geheel met de rolstoel, waardoor het totale beeld rustiger wordt. Doordat het geheel een eenheid lijkt, wordt het geheel ook een stuk vriendelijker en een stuk kleiner.

Ook lijkt het product meer een alledaags product nu het in de context is geplaatst, omdat het bij de rolstoel lijkt te passen dat (in tegenstelling tot de armsteun) wel gezien wordt als alledaags product.

Ondanks het rustige geheel, vallen de verschillende vlakken en vloeiende organische lijnen nog wel heel erg op door de carbonvezel uitstraling. Hierdoor lijkt het product nog steeds dynamisch en soepel te bewegen. Deze samenwerking tussen rust en dynamiek maken het geheel ook heel veel aantrekkelijker.

Afbeelding 3:

Eigenlijk kunnen bij deze versie dezelfde argumenten worden genoemd als bij de tweede versie. In het geheel lijken beide versies erg op elkaar. Wel is dit concept net iets groter, minder aantrekkelijk, minder krachtig en minder dynamisch. Dit komt doordat de kleur van deze versie net niet zo goed past bij de rolstoel als versie 2 en omdat de textuur van het leer net even anders is dan die van de carbon vezel. Ook valt het verschil tussen de verschillende vlakken bij deze versie net iets minder op.

Wat ook voor zowel versie 2 en versie 3 geld, is dat ondanks dat het product nog steeds bestempeld wordt met ziekenhuisproduct (voornamelijk op basis van zijn functies) wel goed in het dagelijks leven is kan voorstellen.

Wel wordt deze versie gezien als een stuk minder aantrekkelijk. Dit komt voornamelijk tussen het contrast tussen het zachte leer en het harde aluminium en de zachte rolstoel.

Afbeelding 4:

Door de omgeving lijkt het product nu heel veel meer ziekenhuis product, dan zonder context. Ook lijkt het door de context een stuk drukker. Dit komt omdat er nu niet alleen contrast in binnen het product, maar ook tussen het product en de omgeving. Ook lijkt het product door de vele grote contrasten minder vriendelijk en een stuk groter.

3. Keuzes:

Unaniem kiezen ze voor afbeelding 2 (carbon vezel), omdat deze het meeste wegvalt in de rolstoel. Een van de deelnemers is uitdrukkelijk van mening dat je het product eigenlijk niet wilt zien, zodat de beperking ook niet te zien is. De andere kiezen voor afbeelding 2 (carbon vezel), omdat deze het meest rustig, maar toch redelijk dynamisch geheel is met de rolstoel.

4. Plaatsing in grafiek:

Een van de deelnemers zou de uiteindelijke keuze, de versie met carbon vezel plaatsen in de linker onder hoek van de grafiek, omdat het nog steeds een ziekenhuisproduct is volgens deze deelnemer en heel nadrukkelijk een functie heeft. Het product is nog steeds gemaakt voor de functie en niet voor de vorm. Ook vindt deze deelnemer het product niet opvallen in het geheel en dat ook niet de bedoeling, het product mag volgens deze deelnemer niet gezien worden. Vandaar de linker onder hoek

Twee van de andere deelnemers waren het erover eens dat het product redelijk neutraal is in dit assenstelsel. Volgens deze deelnemers valt het product niet nadrukkelijk op, maar past ook niet bij de producten die helemaal niet opvallen. Ook vinden deze deelnemers dat je kunt zien dat er nagedacht is over de vorm, maar niet nadrukkelijk omdat de vlakken nog steeds een functie hebben. Daarom zouden deze deelnemer het eindproduct plaatsen in dezelfde categorie als alle andere producten van Focal Meditech.

De laatste deelnemer was het eens met twee deelnemers en hun motivatie zoals hierboven, maar vond het product iets meer design gericht, omdat de materialen die gebruikt worden op de kappen puur voor de uitstraling zijn en niet omdat deze specifiek van dat materiaal moeten worden.

***Conclusie:***

Product wordt ook gezien als ziekenhuis product alleen op basis van de functies, in tegenstelling tot de rolstoel die dan weer wel wordt gezien als dagelijks product. De vorm en uitstraling van het product dragen wel bij naar meer associaties met een consumentenproduct.

Versie 2, de versie met zwart aluminium en carbonvezel wordt gezien als de meest aantrekkelijke versie. De belangrijkste reden hiervoor is de combinatie tussen de dynamiek van de vlakken, lijnen en structuren en de eenheid en rust die het geheel uitstraalt.

Doordat het product er ondanks de verschillende vlakken en lijnen nog steeds massief uit ziet lijkt het product nog steeds redelijk groot en niet flexibel, maar wel krachtig.

De context beïnvloed de grootte van het product en de rust die het geheel uitstraalt in positieve zin. Daarentegen beïnvloedt het de ziekenhuis associatie negatief.

Zonder context zijn de gewenste associaties op het gebied van de algehele vorm positief. De vorm wordt gezien als dynamisch maar niet te druk en het product ziet eruit als een geheel. Zonder context zijn de uitstraling van het formaat en ziekenhuis/industrie associaties nog verbeter punten. De materiaalkeuze beïnvloed deze associaties meestal positief, voornamelijk voor het uiteindelijk gekozen concept (versie 2).

Met context verschilt het heel erg per versie of de gewenste associaties positief of negatief beïnvloed worden. Voor versie 2 en versie 3 geld dat de dynamiek, rust, grootte en kracht positief worden beïnvloed. In versie 2 en 4 worden deze associaties juist negatief beïnvloed. De ziekenhuis uitstaling wordt in context juist versterk, doordat de beperking van de gebruiker in context goed zichtbaar is, terwijl het product in context met de rolstoel juist meer een consumentenproduct lijkt. Dit geld voor alle vier de versies.

Overal kan gesteld worden dat de keuze van het bedrijf om de carbon versie (versie 2) te maken een goede keuze was aangezien deze het beste scoorde aan de hand van de gestelde gewenste associaties. Verbeterpunten hierbij zijn nog wel de ziekenhuis en industrie uitstraling. Voor dit concept geld dat de context het product positief beïnvloed en het product de context juist beïnvloed. De context laat het product meer rust uitstralen en doet het product kleiner lijken. Terwijl het product de context juist meer kracht en dynamiek geeft.

Wat betreft de plaatsing van het product in de opvallendheid – techniek/design grafiek is er nog vooruitgang te boeken. Het product is niet zo design gericht als gewenst was gesteld tijdens de analyse. Wel zit het goed met de opvallendheid van het product. Het product wordt precies zoals als gewenst gesteld niet als heel opvallen en niet als heel onopvallend verklaart.

# C.2 QUANTITATIVE EVALUATION

***Voorbereiding:***

*Doel:*

- Verschillen en voorkeuren tussen de verschillende concepten evalueren

*Subdoelen:*

- Stigma meten van de omstanders
- Gewenst gestelde associaties evalueren voor alle vier de concepten, met weinig context en achtergrondinformatie
- Gewenst gestelde associaties evalueren voor een ander product uit de wing-familie (Gowing)
- Voorkeur bepalen van omstanders

*Methoden:*

Kwantitatieve evaluatie door middel van een online enquête.

***Uitvoering:***

*Opstelling:*

- Online enquête
- Deelnemers met computer of smartphone

*Opzet:*

Om de verschillen en voorkeuren van de verschillende concepten en een bestaand product uit de wing-familie te evalueren zal een online enquête worden uitgezet. De verschillende subdoelen zullen door verschillende vragen worden getoetst. Het meten van stigma van omstanders zal worden gedaan door middel van een afbeelding van het gekozen eindontwerp door Focal Meditech geplaatst op een rolstoel met de contour van een gebruiker de laten zien en te vragen naar de reactie op eerste ingeving. Aan de hand van deze reacties kan globaal worden bepaald of het eindproduct veel of weinig stigma oproept bij omstanders. De evaluatie van de gewenste associaties zal worden gedaan door elk concept te beoordelen aan de hand van een aantal afwegingen die de gewenst gestelde associaties weergeven. Deze vragen moeten worden beantwoord met als enige voorkennis de korte uitleg over de definitie van een dynamische armondersteuning in de introductie van de enquête en een context plaatje dat was weergeven bij de stigma vraag. Dit is gedaan om een zo intuïtief mogelijk antwoord te vergaren van de deelnemer, immer de mening van omstanders worden ook in een flits bepaald. Na het evalueren van de associaties mogen de concepten en de Gowing gerankt worden op basis van eigen mening en daarna kan worden aangegeven welk product de deelnemer het liefst zou gebruiken indien hij/zij zelf een armondersteuning nodig heeft. Op deze manier zal de voorkeur van de omstanders bepaald worden.

*Vragenlijst:*

## Uitstraling van een dynamische arm ondersteuning

**Beste lezer,**

**Bedank voor het deelnemen aan deze enquête. Voor mijn bachelor opdracht van de studie studie Industrieel Ontwerpen aan de Universiteit van Twente heb ik mij afgelopen tijd bezig gehouden met de uitstraling van een dynamische arm ondersteuning. Een dynamische arm ondersteuning is een product dat word geplaatst op de rolstoel van mensen met een beperkte spierfunctie. Deze arm ondersteuning meet de gewenste beweging van de gebruiker en zal vervolgens deze beweging gaan versterken. Hierdoor kunnen zelfs mensen met geringe spierkracht weer zelfstandig dagelijkse taken uitvoeren. Deze enquête bevat 10 vragen naar uw mening over de uitstraling van de ontworpen dynamische arm ondersteuning. Het gaat om subjectieve metingen, dus geen enkel antwoord is fout. Het invullen van deze enquête zal zo'n 5 minuten in beslag nemen.**

**Alvast bedankt!**

**Emily Bohan**

BEGIN ENQUÊTE

## Uitstraling van een dynamische arm ondersteuning

1

Wat is het eerste dat in u op komt bij het zien van de onderstaande foto?

Typ een zin

TERUG

1/9

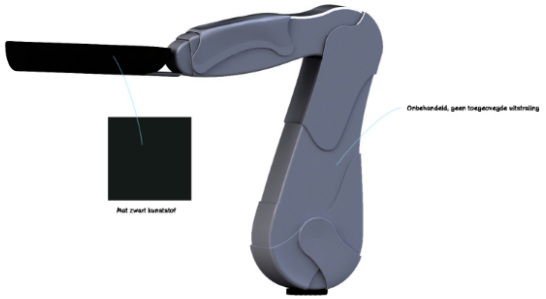
VERDER

## Uitstraling van een dynamische arm ondersteuning

De volgende vijf vragen zullen gaan over de uitstralingseigenschappen van vier verschillende varianten van de dynamische arm ondersteuning.

3

Welke uitstralingseigenschappen zijn volgens u van toepassing op de bovenstaande dynamische arm ondersteuning?




| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Ziekenhuis product | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Allerdaags product |
| druk | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | rustig |
| Industrieel | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Vriendelijk |
| Zwak | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Krachtig |
| Statisch | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Dynamisch |
| Aantrekkelijk | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Onaantrekkelijk |
| Groot | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Klein |

TERUG 2/9 VERDER

## Uitstraling van een dynamische arm ondersteuning

4

Welke uitstralingseigenschappen zijn volgens u van toepassing op de onderstaande dynamische arm ondersteuning?


| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Ziekenhuis product | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Allerdaags product |
| druk | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | rustig |
| Industrieel | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Vriendelijk |
| Zwak | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Krachtig |
| Statisch | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Dynamisch |
| Aantrekkelijk | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Onaantrekkelijk |
| Groot | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Klein |

TERUG 3/9 VERDER

## Uitstraling van een dynamische arm ondersteuning

5

Welke uitstralingseigenschappen zijn volgens u van toepassing op de onderstaande dynamische arm ondersteuning?

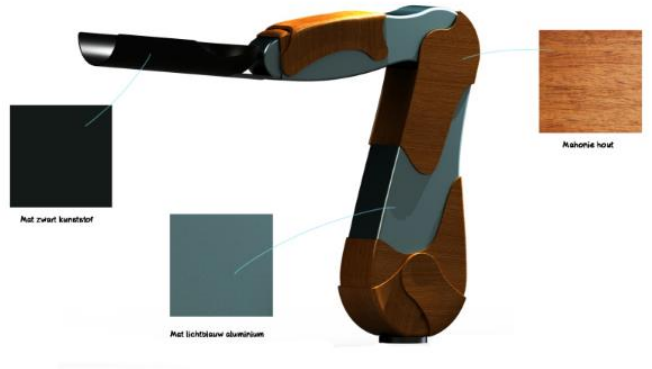

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Ziekenhuis product | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Allerdaags product |
| druk | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | rustig |
| Industrieel | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Vriendelijk |
| Zwak | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Krachtig |
| Statisch | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Dynamisch |
| Aantrekkelijk | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Onaantrekkelijk |
| Groot | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Klein |

TERUG 4/9 VERDER

## Uitstraling van een dynamische arm ondersteuning

6

Welke uitstralingseigenschappen zijn volgens u van toepassing op de onderstaande dynamische arm ondersteuning?




| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Ziekenhuis product | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Allerdaags product |
| druk | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | rustig |
| Industrieel | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Vriendelijk |
| Slap | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Krachtig |
| Statisch | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Dynamisch |
| Aantrekkelijk | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Onaantrekkelijk |
| Groot | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Klein |

TERUG 5/9 VERDER

## Uitstraling van een dynamische arm ondersteuning

7

Welke uitstralingseigenschappen zijn volgens u van toepassing op de onderstaande dynamische arm ondersteuning?


| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Ziekenhuis product | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Allerdaags product |
| druk | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | rustig |
| Industrieel | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Vriendelijk |
| Zwak | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Krachtig |
| Statisch | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Dynamisch |
| Aantrekkelijk | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Onaantrekkelijk |
| Groot | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Klein |

TERUG 6/9 VERDER

## Uitstraling van een dynamische arm ondersteuning

8

Welke versie vind u het mooist? Rangschik de vier verschillende versies, van mooist(boven aan) tot minst mooi (onderaan). Maak uw rangschikking door de afbeeldingsnummers te verslepen

Afbeelding 1

Afbeelding 2

Afbeelding 3

Afbeelding 4

Afbeelding 5

1. Afbeelding 1
2. Afbeelding 2
3. Afbeelding 3
4. Afbeelding 4
5. Afbeelding 5

TERUG 7/9 VERDER

9

Welk van de volgende dynamische arm ondersteuningen zou u kiezen als u zelf een dynamische arm ondersteuning nodig heeft?

- Afbeelding 1
- Afbeelding 2
- Afbeelding 3
- Afbeelding 4
- Afbeelding 5

TERUG 8/9 VERDER

***Resultaten:***

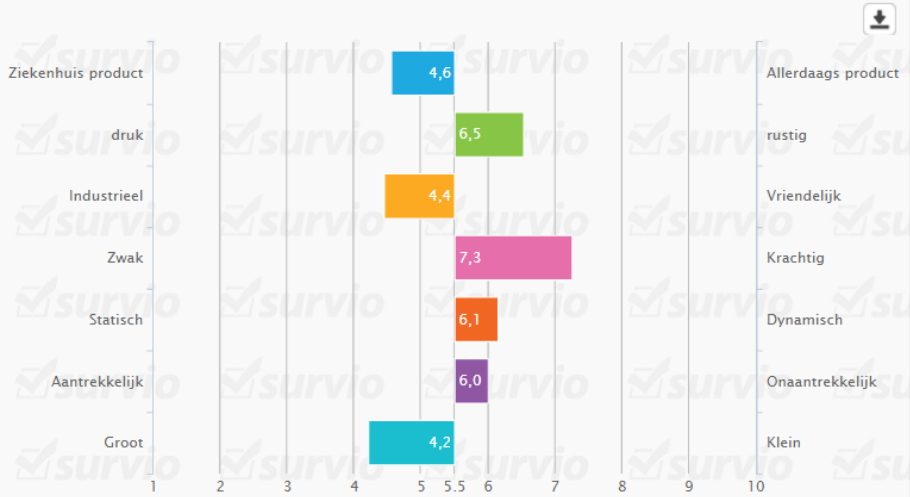
Aantal deelnemers: 46

**1 Wat is het eerste dat in u op komt bij het zien van de onderstaande foto?**

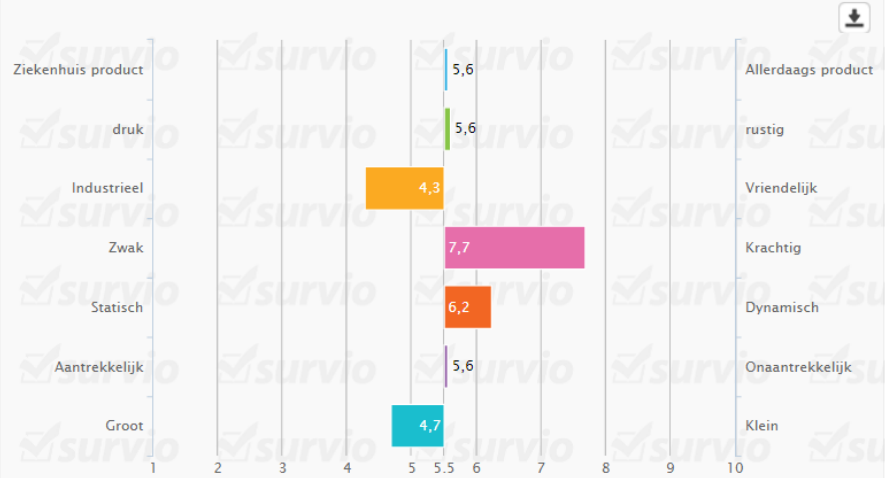
| | | | |
|---|---|---|---|
| Test | Elektrische rolstoel (3x) | Er zijn veel lelijke onderdelen te zien | Groot en log |
| Log | Mechanisch | Gek dat er geen ondersteunings voor de pols is (geen leuning) | Lichanelijke handicap |
| Beperkt | Lijkt op een gewone rolstoel. Die je dagelijks ook ziet. | Handicap | niet zo mooi, wel praktisch |
| Persoon met een beperking, kan niet meer lopen. | Ingewikkeld. | Futuristisch; veel mechaniek te zien | Speciale rolstoel voor mensen met spierziekte, traag, immobiel, duur. modern |
| Chaos | Beperking | zwaar verstandelijke beperking | rolstoel invalide beperking moeilijk |
| Geavanceerde rolstoel voor iemand met een verminderde lichamelijke functie | Een scootmobiel | Scootmobiel | Elektrische rolstoel met veel steun en hulpmiddelen |
| mooie ondersteuning voor hun die het nodig hebben | De wielen zitten achterstevoren | Druk(veel informatie) | Het doet mij denken aan Stephen Hawkins de wetenschapper in rolstoel |
| Wat een groot, ouderwets ding | Praktisch | Een supersonische en uitgebreide rolstoel voor iemand met een beperking. | Rolstoel |
| Gehandicapt | Futuristisch, een beetje startrek | een rolstoel met een schemerlampje? | rolstoel |
| handicap | Ingewikkeld, iemand in deze stoel heeft een behoorlijke beperking. | Deze persoon is afhankelijk van techniek. | technisch, hulpbehoevend, confronterend |
| Naar mijn idee staan de wielen verkeerd om. En de hoofdsteun staat te ver naar voren. ik zie ook geen voetsteun. Het ziet er heel ongemakkelijk uit. | mens in rolstoel met extra ondersteuning onder de arm | Een instrument voor iemand met een ernstige beperking | een persoon met een lichamelijke beperking |
| | Een volledig geoutilleerde, bescheiden formaat rolstoel. | | |

## CONCEPT BLANC

**2 Welke uitstralingseigenschappen zijn volgens u van toepassing op de bovenstaande dynamische arm ondersteuning?**



3 Welke uitstralingseigenschappen zijn volgens u van toepassing op de onderstaande dynamische arm ondersteuning?




## CONCEPT CARBON

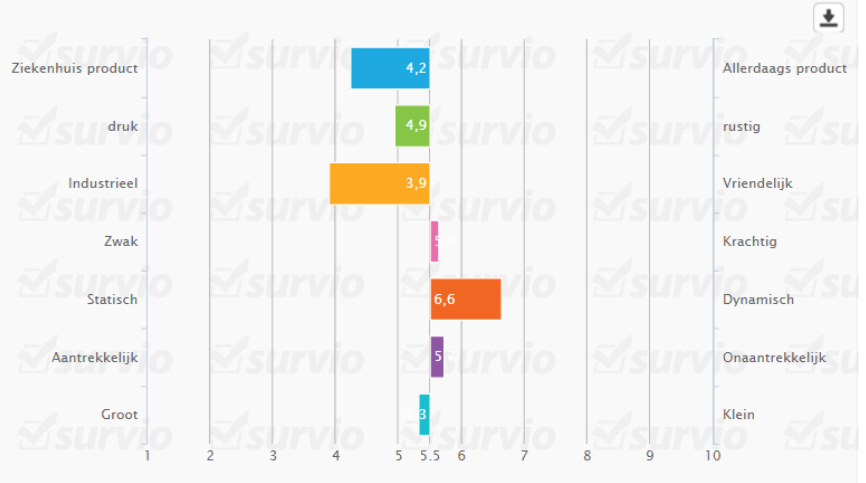
5 Welke uitstralingseigenschappen zijn volgens u van toepassing op de onderstaande dynamische arm ondersteuning?


## CONCEPT WOOD

4 Welke uitstralingseigenschappen zijn volgens u van toepassing op de onderstaande dynamische arm ondersteuning?


## CONCEPT LEATHER

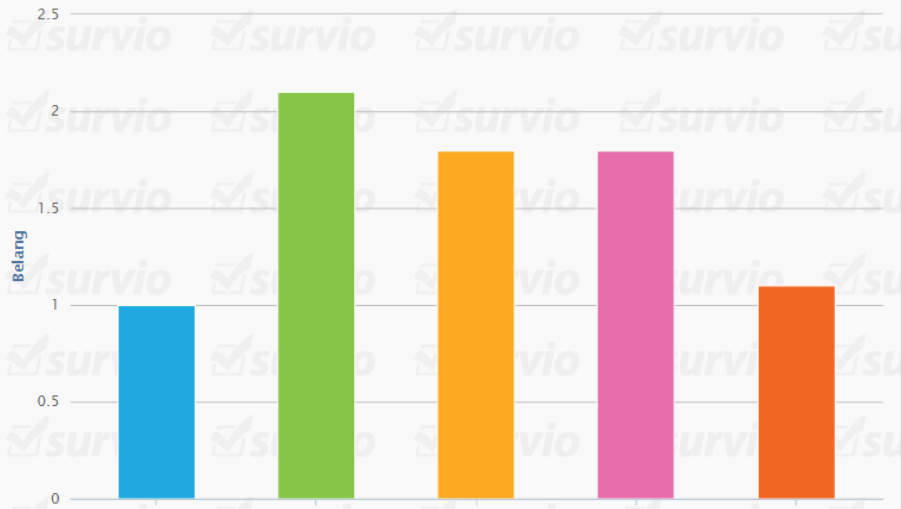
6 Welke uitstralingseigenschappen zijn volgens u van toepassing op de onderstaande dynamische arm ondersteuning?




## GOWING

**7 Welke versie vind u het mooist? Rangschik de vier verschillende versies, van mooist(boven aan) tot minst mooi (onderaan). Maak uw rangschikking door de afbeeldingsnummers te verslepen**

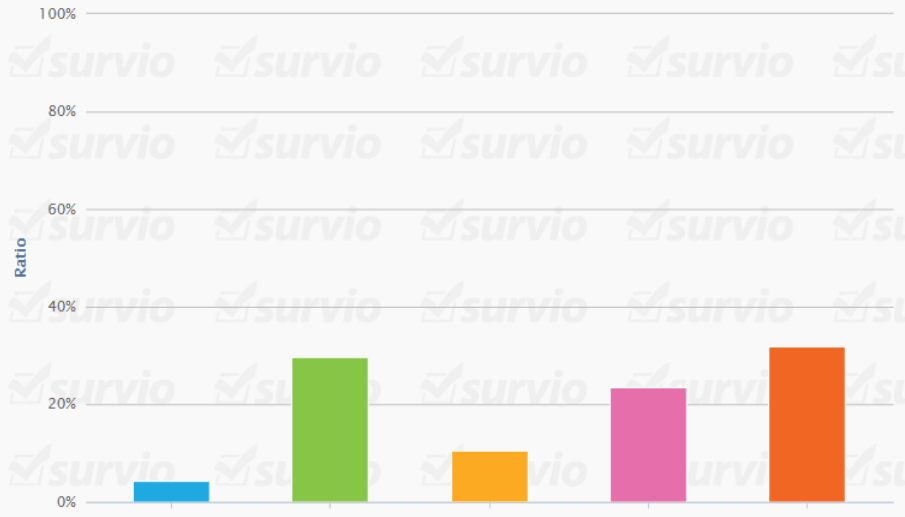
Verticaal Horizontaal




| # | Antwoord | Belang |
|---|---|---|
| ● | Afbeelding 1 | 1 |
| ● | Afbeelding 2 | 2,1 |
| ● | Afbeelding 3 | 1,8 |
| ● | Afbeelding 4 | 1,8 |
| ● | Afbeelding 5 | 1,1 |

**8 Welk van de volgende dynamische arm ondersteuningen zou u kiezen als u zelf een dynamische arm ondersteuning nodig heeft?**

Verticaal Horizontaal




| # | Antwoord | Antwoorden | Ratio |
|---|---|---|---|
| ● | Afbeelding 1 | 2 | 4,3 % |
| ● | Afbeelding 2 | 14 | 29,8 % |
| ● | Afbeelding 3 | 5 | 10,6 % |
| ● | Afbeelding 4 | 11 | 23,4 % |
| ● | Afbeelding 5 | 15 | 31,9 % |

***Conclusie:***

Van alle reacties op de afbeelding met het eindconcept in context en gebruiker kwamen de volgende reacties het meest voor: complexe rolstoel met veel zichtbare onderdelen, groot en log en berking. Deze reacties geven aan dat van stigma nog steeds sprake is, maar deze stigma gaat meer over gebruiker en rolstoel en geheel dan specifiek over de armonderstening.

Een mogelijke reden voor het gebrek aan reactie op de armondersteuning specifiek is dat er gereageerd is op een afbeelding en niet op de echte situatie, waardoor de armondersteuning moeilijker te zien was.

Versie 1 scoorde op grootte en type product (ziekenhuis en industrieel) net onder een voldoende. Krachtig scoorde als enige een ruim voldoende. De rest van de associaties scoorde rond de voldoende. De punten die onder de voldoende scoorde zijn het meest afhankelijk van de omgeving, de afwezigheid van de context zou hiervoor dus een goede reden kunnen zijn.

Versie 2 scoorde op grootte en type product (industrieel) net onder de voldoende. Krachtig scoorde ruim boven voldoende en de rest scoorde rond de voldoende. Ten opzichte van het blanco product is eigenlijk alleen het type product (ziekenhuis) positief beïnvloed. Ondanks deze positieve invloed veranderd de aantrekkelijkheid van het product niet.

Versie 3 scoorde op type product (ziekenhuis/industrieel) drukte en aantrekkelijkheid precies voldoende. De grootte van het product is ook bij deze versie net onder de voldoende. Dynamiek en kracht scoren boven de voldoende. Behalve op grootte scoort dit product hetzelfde of zelfs beter als de versies hiervoor.

Versie 4 scoorde op type product (ziekenhuis/industrieel), vriendelijkheid, kracht en dynamiek net boven voldoende. Aantrekkelijk precies voldoende en grootte en drukte net onder voldoende. Deze versie is dus een stuk drukker dan de andere versies, maar ook dit beïnvloed de aantrekkelijkheid niet.

De Gowing scoorde op type product (ziekenhuis en industrieel) ruim onder de voldoende. Zwakte, grootte en aantrekkelijkheid precies voldoende en dynamiek net boven voldoende. Opvallend is dat de Gowing negatiever scoort op type producten dan het ontworpen product, maar wel een stuk kleiner lijkt. Terwijl in het echt de Gowing een stuk groter is dan de McArm. Een mogelijke reden hiervoor kan zijn de grootte van de getoonde afbeelding. De totaal afbeelding was even groot, maar omdat de Gowing in het echt groter is, lijkt hij optisch een stuk dunner in de enquête.

Alle versies, inclusief de Gowing scoorden allemaal ongeveer even groot op aantrekkelijkheid. Versie 2 en 4 scoorde het beste op de andere punten en zouden dus in theorie de betere producten moeten zijn, maar overal scoort het ontwerp in geen van de vier versies ruim voldoende, behalve op dynamiek er is dus nog veel verbetering mogelijk.

Op basis van de gemaakte rangschikkingen kan worden gesteld dat het verschil tussen de vier concepten en de Gowing niet heel groot was. De Gowing en versie 1 scoren iets lager dan de andere drie versies. Versie 2 scoorde het beste van allemaal.

In de keuze voor eigen gebruik zit meer variatie. Versie 1 en versie 3 worden bijna niet gekozen. Versie 4 is de middenmoot van alle getoonde producten en versie 2 en de Gowing scoorden een bijna gelijke hoogste score. Ondanks dat de Gowing als een van de twee minst mooie producten werd gekozen, is dit toch het meest gekozen product voor eigen gebruik. Dit zou kunnen komen omdat de Gowing een afbeelding is van een bestaand product en de andere renders zijn van een virtueel model. Dit zou de uitstraling van de bruikbaarheid kunnen beïnvloeden.

Overal kan worden gesteld dat versie 2 het dichts in de buurt komt van een uiteindelijk product, maar op basis van de associaties die intuïtief zijn beoordeeld net voldoende voortkomen uit het ontwerp, maar dat nog veel verbetering nodig is.