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Development of a Demonstration Tool for Bone Anchored Hearing Aids

Master of Science Thesis in the Master Degree Programme Industrial Design Engineering, MPDES

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Gothenburg, Sweden, 2013

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Published and distributed by:
Chalmers University of Technology
Department of Product and Production Development
SE-412 96 Gothenburg
Sweden

Telephone: +46 (0)31-772 1000

ACKNOWLEDGEMENTS

Carrying out this master thesis project and developing the final concept demonstration tool have involved meeting several persons and receiving their input. The master thesis group is very thankful for their time and engagement, as this thesis could never have been taken this far without them.

We would like to thank the team at Cochlear for initiating this project. Primarely Pernilla Pettersson for supervising us throughout this time and giving great guidance and engagement. We are also grateful to Göran Björn, Henrik Fryklund, Fredrik Breitholtz and Rom Mendel for their time and input during the evolvement of the demonstration tool.

From the healthcare sector we give our greatest appreciation to Ann-Charlotte Persson for the hospitality and for always taking time to let us learn and attend at the Hearing and Deafness department at Sahlgrenska hospital. We also want to thank Maria Rosengren, Lisa Sundström and Annika Eliasson at Hörselcentralen, Sunderbyns hospital, Luleå, for sharing their experiences and thoughts around the Baha consultations and working as audiologists.

Acknowledgements should also be made to Galantplast, Gothenburg and Kvarnby Textil, Mölndal for supporting us with materials during model making.

From Chalmers we want to thank our supervisor Sara Renström and our examiner Ralf Rosenberg for supervising and supporting us during these 20 weeks and never hesitating to help us analyze our problems and challenges.

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Gothenburg, 2013

ABSTRACT

The master thesis project "Development of a Demonstration Tool for Bone Anchored Hearing Aids", by Ellen Hultman and Samantha Lütkeman Pukala, was carried out at the department of Product and Production Development at Chalmers University of Technology. The project has been performed in collaboration with Cochlear BAS situated in Mölnlycke, Sweden.

Bone conducted hearing is an alternative when single sided deafness, conducted hearing loss or a mixture of the two occurs. The bone anchored hearing aid provided by Cochlear, called Baha, consists of three parts and require a surgical procedure to be implemented.

The project to come up with a new design of a demonstration tool was initiated as Cochlear defined a number of barriers to why patients refrain from the aid even though perceiving improved hearing. In addition new solutions to the Baha system will soon enter the market, which is why the company requested a new way to promote the Baha system options.

The final concept is a handheld product facilitating the conversation between the audiologist and patient. By interaction opportunities the tool promotes the patient to take a more active role during the counseling situation, aiming to create an understanding and build a relationship to the product. To overcome preconceptions the demonstration tool clearly and simply presents the different parts of the Baha system in relationship to placement by an ear. A soft asymmetric grip creates attention and subtle colors and shapes support the presentation of hearing aid.

Research for the design was done through interviewing audiologists working with the Baha system and observing patients during Baha consultations. Analyzing company core values, communication strategy and competitors in addition resulted in a context analysis. The analysis set the foundation for an idea generation to meet all needs and move design focus from being technology driven to softer values. Several concept evaluations together with Cochlear representatives resulted in a final result where materials, manufacturing, use experience, and visual appearance have been accounted for.

Keywords: *Industrial Design Engineering, Product Development, Demonstration Tool, Bone Anchored, Bone Conducted, Hearing Aids, Baha, Audiologist, Cochlear*

1. Contents

1. Introduction

Ground for this Master Thesis project is given in this chapter by history of bone conducted hearing as well as information about the company collaborated with. Furthermore, a detailed project scope description is accounted for.

1.1. Bone Conducted Hearing

This project regards developing a tool to demonstrate bone anchored hearing aids, known as Baha. The tool aims to create an understanding of bone conducted hearing and promote bone anchored solutions as an equal option to conventional hearing aids.

Hearing through bone conduction could seem like a new technology but has been known for long, since Antiquity. During the years 1700 and 1800 scientists and musicians experimented with bone and teeth conducted hearing aids in the form biting onto rods or strings attached to the sound source. During the 1950's the development of bone conduction was applied to eyeglasses, yet the use declined and further development was needed. The first bone anchored hearing solution, with a fitted implant, was done in 1977 at the Sahlgrenska University Hospital by Swedish doctors who had developed the technology and products ultimately becoming the Baha hearing system (Kompis, 2011).

Since then the Baha system has been refined through the years. It is not a relatively common solution compared to conventional hearing aids like behind the ear aids (BTE) or in the ear aids (ITE) (hrf, 2013). A bit negligently the bone-anchored hearing aid has been seen as a bit of a last solution when BTE or ITE aids have not been enough (Pettersson, 2012).

1.2. Commissioning Company

Cochlear Limited, which was established in 1983, has their head quarters in Sydney Australia. The company has three product categories regarding hearing aid, the cochlea implant hearing system Nucleus, the bone anchored hearing system Baha and the electro acoustic hearing system Hybrid. Cochlear has had Baha in their product range since 2005. (Acquisition, 2005)

Cochlear was for long the major supplier of the Baha solution, which is also the registered trademark of the their product. In recent years a few other companies have entered the market with equivalent solutions. In addition to the competition for customers the target group is also seen as possible to broaden. Baha does not have to be a last alternative but instead an equally functional solution which could improve hearing to many more than who are subjected to the solution today (Pettersson, 2012).

In order to tackle the competition and gain customers choosing Baha, Cochlear has set up a communication strategy. Focus is to be shifted from facts and technology orientation to instead put softer values and the emotional engagement first. By tools communicating company core values Cochlear wants to enhance the user experience, increase the conversion of people choosing Baha and create a long lasting customer relationship.

Today the sound of using a Baha hearing system can be experienced prior to surgery, yet from a potential candidate perspective little information about life with

the Baha as a product and the surgery is given. The existing demonstration tool, see image 1, informative texts, illustrations and pictures do not reach all the way so a new demonstration tool to fill the gap is desired.

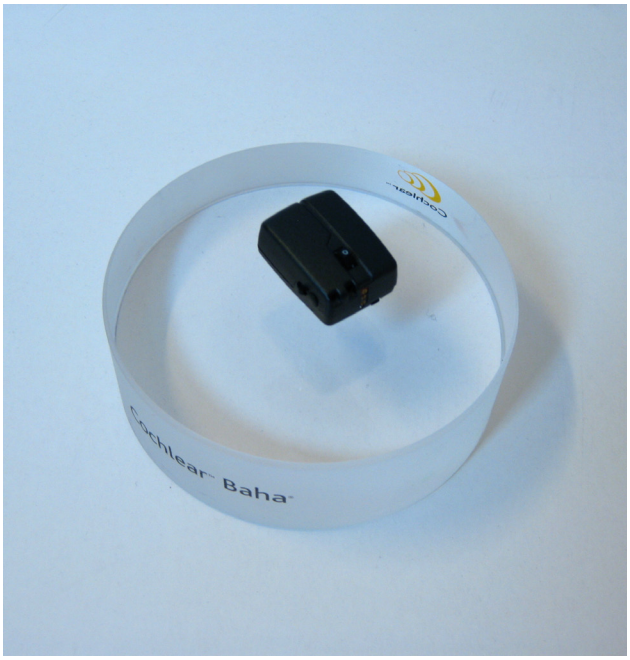


Image 1. The demonstration tool of today

1.3. Purpose

The purpose of the Master Thesis project is to design a new physical demonstration tool to be used during the audiologist counseling.

Research questions:

- How could a new demonstration tool communicate an understanding of the surgery and daily care with the Baha system?
- How could a new demonstration tool facilitate an attractive presentation of the products through; display of the Baha system, explanation of features and benefits, functional use by snap-training and communication of the company core values?

1.4. Goal

The goal is to, as result of the thesis project, have developed a concept possible to implement in the near future. This concept should consider aspects like price, (material, production volume, manufacturing methods etc.), usability and cognitive ergonomics. The longterm perspective of this project is to establish Cochlear's position as leading in providing reliable products and optimized solutions that will last and function well with future innovations.

1.5. Constraints

The project does not focus on the detailed aspects of the Baha itself in terms of technology or design.

The market for the demonstration tool is global yet restrictions will apply on how much the project can be validated in other countries' contexts than Sweden's.

The project will be brought as close to manufacturing as possible. Yet academic aspects will be prioritized and preparatory work for manufacturing such as collecting ultimate quotes cannot be obtained within the master thesis scope.

Although the target group of people with hearing loss is diverse, this project is directed towards adults as the parents make the decisions for their children.

1.6. Project and Report Outline

Two students hereafter referred to as the master thesis group conducted this project. The project contains six main phases, image 2, that have been conducted using an iterative process. This means that even though they are described separately in this report they have been processed and developed several times as the project proceeded. For a more detailed process flow chart see appendix 1.

Throughout the phases input and guidance have been given from mainly two stakeholders. Pernilla Petterson, who is a senior product manager of Implant and Surgery at Cochlear Bone Anchored Solutions, initiated the project and has been the primary support. Along the evolvement of the project she has involved employees with relevant expertise to support development and make decisions. Ann-Charlotte Persson, authorized audiologist at Sahlgrenska hospital in Gothenburg, has been providing information and support of the patients and the healthcare context. Regular contact and meetings have been held with both stakeholders and the proceedings of the project have been done in consensus.

Each chapter in the report start with an introduction of what the chapter will discuss. An execution will follow and then the chapter will finish with the main results and outcomes of the particular phase. This means that sub deliverables of the phase might be mentioned in the execution as they lead forward to the main result. Thus the reader can move straight to the result for quick review of the phase outcome or go through the execution for a deeper insight. For less experienced readers within the subject, methods and theory is a good start, while more experienced readers might find the research phase a more interesting beginning.

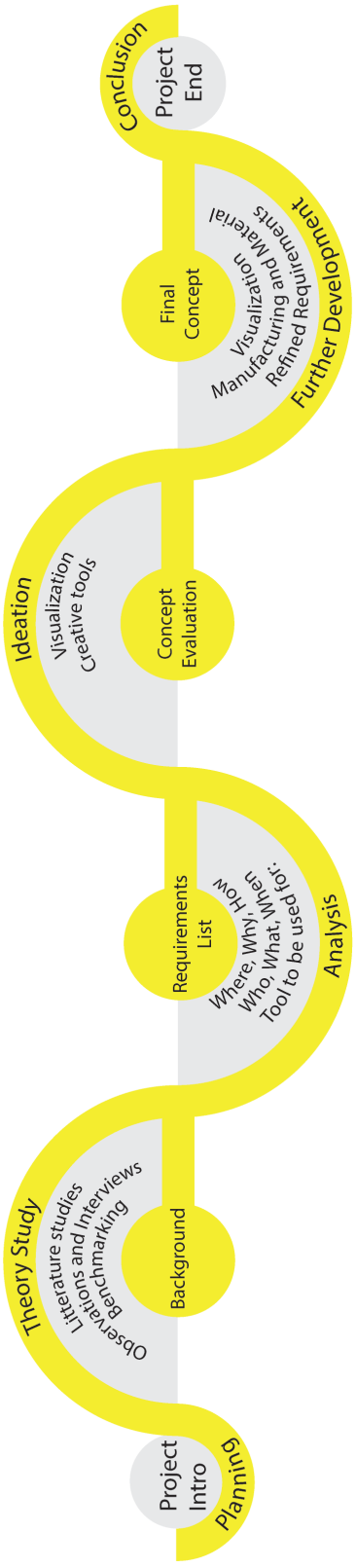
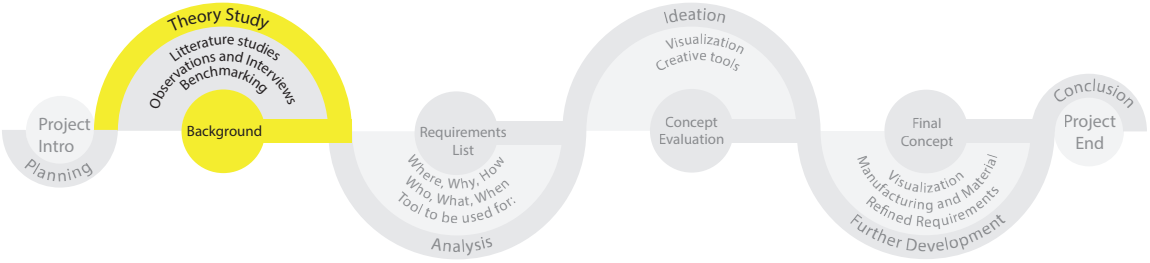


Image 2. Project Outline



2. Background

The background chapter covers several areas, ranging from the Baha system and hearing loss to Cochlear's market position and strategy as well as design experience and manufacturing. An understanding of these areas are needed to set a foundation for this thesis as they all play a part in the demonstration tool being designed. The Baha system needs to be understood in order to know what is important to communicate with the tool and finding out more about hearing loss will direct who the tool is for. Understanding Cochlear's market strategy and the creation of an experience through design will give input on how to communicate in order to reach the best outcome.

2.1. Baha – Product and Function

The Baha hearing aid consists of an implant, an abutment and a sound processor. The titanium implant is ossiointegrated (Brånemark, 2010) in the skull bone, meaning the bone cells are attached directly to the implant. The titanium abutment is connected with the implant and will be surrounded by tissue as it comes out of the skin layer to connect to the sound processor, image 3 and 4. The sound processor has an exterior of the biocompatible plastic PEEK.

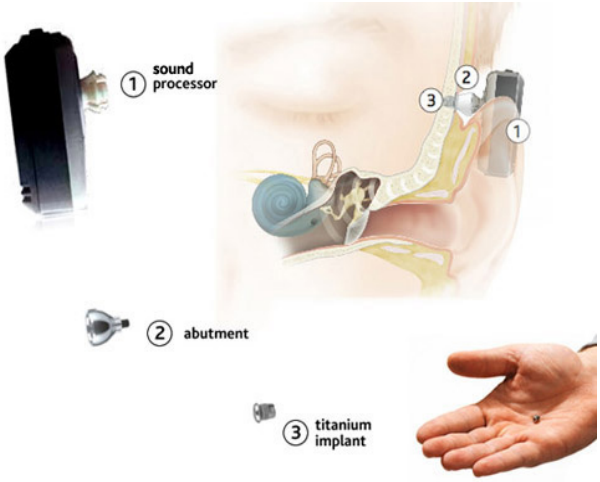


Image 3. Baha integration (Baha integration, 2013)

Image 4. Baha System (Baha system, 2013)

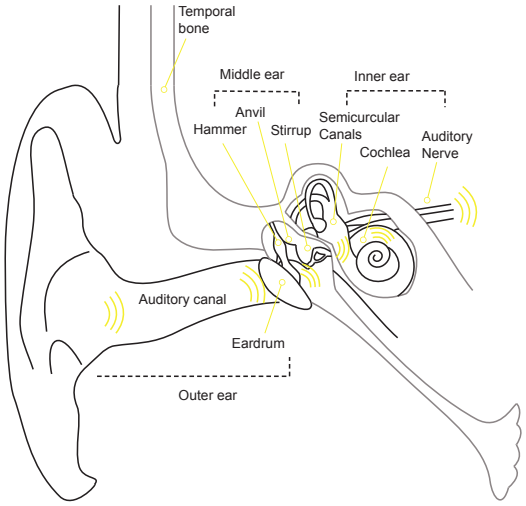


Image 5. Normal sound transmition

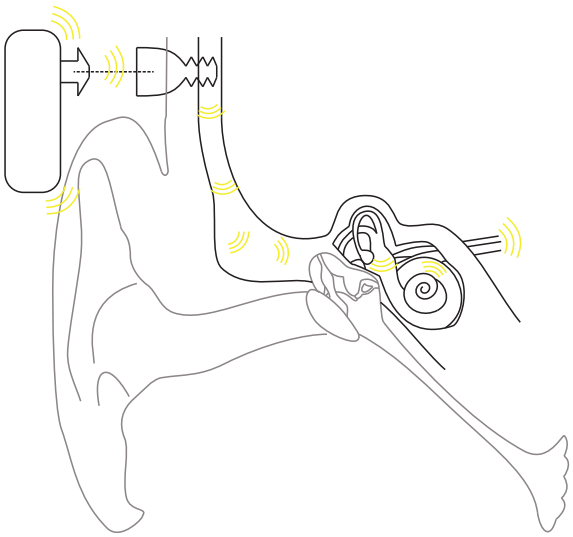


Image 6. Transmition with the Baha system

In usual hearing, see image 5, vibrations in the air travel through the outer ear putting the eardrum in movement. This forwards the vibrations via the small bones in the middle ear to finally be received by the cochlea, also known as the inner ear.

If the outer and/or middle ear are somehow damaged a Baha system transmits the airborne vibrations through the sound processor and onto the abutment and the implant, see image image 6. The implant makes a vibrating connection via the skull bone directly to the Cochlea, and thereby hearing is created (University of Maryland, 2012, Audio bone 2008).

The Baha sound processors, image 7, picks up frequencies up to 8000Hz where normal speech is within 1000 to 3000 Hz. There are three different strengths of sound processors that make up for 45, 55 and 65 db hearing reduction, see appendix 2.

To facilitate for different environments the user might be in, the sound processor has three different programs to alter between. These programs can be individually set to fit the specific user. Yet there is a standard program making automatic switches to suit the most commonly used environment (Persson, 2012). The programs used to be set by an analog interface, but new processors have digital software.

To further suit the individual the sound processor comes in different colors to either blend in with e.g. the recipients hair color, or to stand out in brighter colors. Also different accessories, see appendix 2, will facilitate certain activities and environments like an audio streamer for television, FM receiver for noisy environments, telecoil for public buildings supplied with loop and for talking on the phone and a safety line. These accessories vary for the different processors. Samples of these accessories are shown in image 8.

Image 7. Baha sound processors lined up by increasing strenght (Baha Sound processors, 2013)

Image 8. Samples of Baha accessories and color options (Baha accessories, 2013)

2.2. Reasons for Baha

Bone conducted hearing through the Baha system can be a solution for in general three different types of hearing loss; conductive hearing loss, single sided deafness and a mixture of the previous two (Pettersson, 2012). Basically one cochlea or inner ear needs to be intact, meaning there has to be a sensorineural function in order for Baha to work as a hearing aid.

Conductive hearing loss can have many different causes. The issue is that the sound vibrations cannot travel as normal in the outer and middle ear to reach the cochlea of the inner ear. Deformity of the ear canal, otosclerosis and chronic otitis among other issues can be reasons for conductive hearing loss (Dillon, 2007) . The Baha system is placed behind the impaired ear to improve the perceived hearing.

Single sided deafness, sensorineural hearing loss, means that one ear has significantly or totally reduced hearing. The impairment regards the inner ear meaning that the cochlea is damaged. To solve this sort of hearing loss the Baha system is placed behind the impaired ear and sound vibrations reaching the malfunctioning ear are via the skull bone redirected to the better ear (SSD, 2013).

Mixed hearing loss is where both conductive hearing loss and single sided deafness occurs (Pettersson, 2012). When both ears are affected a Baha for each ear is a solution.

It is estimated that 5000-6000 people in Sweden have bone anchored hearing aids at the present time (Persson, 2012).

2.3. How to get a Baha

The healthcare systems way of providing hearing aids have within this project only been studied in Sweden due to time and economical limitations, although the Baha solution is provided in several other countries around the world.

Companies providing hearing aids do offer self-counseling information most commonly via their homepages. Self counseling is an estimative first step to use by the individual to see what type of hearing loss the person might have and what hearing aid would

be suitable. Yet to get a hold of the aid, contact with a healthcare professional is needed.

Within Sweden and the different county councils there is no common structure of how to provide patients with hearing aids. Since the use of Baha is very low, the process of how to get this particular aid is even less structured.

Counseling

Due to the development of the technology behind Baha occurring in Gothenburg, the healthcare sector of Västra Götaland has been leading in the handling and knowledge of the Baha solution. Recently healthcare professionals in Gothenburg working with different aspects of the Baha solution have developed a care program of how patients will receive a Baha, ranging from initial counseling to activation of the sound processor (Cochlear Workshop 2012, Eeg-Olofsson).

Hearing diagnostics and rehabilitation are done in following steps according to the program.

1. Examining hearing diagnostics with standardized tone and speech audiometry.
2. Referral briefing in Bone Conduction Team (BCT). Decision if patient is appropriate for bone anchored hearing aid.
3. Evaluative appointment at audiologist prior to hearing rehabilitation.
4. Hearing rehabilitation is planned individually based on patient needs, prerequisites and wish for interventions. Patient is informed about existing bone anchored hearing aids. Patient gets to try bone-anchored hearing aid on softband/ headband during a minimum of four weeks.
5. Revisit and evaluation of bone anchored hearing aid on softband/headband at audiologist.
6. When outcome is positive, doctor's appointment for surgery and medical evaluation. Patient is there informed about the operation and the side effect that can arise from it.

Surgery

Moving forward with a bone anchored hearing aid will involve surgery. The operation takes about 40 minutes and the patient can usually return home the same day. The surgery is generally performed in the following steps (Surgery Baha, 2013, Cochlear Counseling Software, 2008).

1. The hair is shaved around the area. The insertion point for the implant is marked out approximately 50-55 mm from the ear canal, on a relatively flat bone area in line with the upper part of the pinna. Commonly used hats or helmets can be brought to make sure there is no interference with the Baha system location. Yet if the implant is placed too far up it will be farther from the cochlea and the amplification will not be as good. If the implant is placed too far down the bone will be more porous, which will make the implant less stabile.
2. The patient is locally anaesthetized down to the periosteum layer and the pinna is bent over the ear canal to make room for the operation area.

The surgery can now continue in two different ways either using:

The linear incision Technique

3. A linear incision is made trough the soft tissue and periosteum. The implant hole is drilled 3-4 mm into the skull bone. The implant is placed.
4. Approx. 40x60 mm of soft tissue is removed and skin is sewn together. This leaves the patient with an as small scar tissue as possible

Or The Baha Dermatome Technique

3. A dermatome, a razorblade like tool, is used to create a 40x60 mm skin flap. The implant hole is drilled 3-4 mm into the skull bone. The implant is placed.
4. Approx. 40x60 mm of soft tissue is removed and skin is sewn together. The technique is easier to use yet takes longer to heal and leaves a bigger scar.

The surgery can also be done in one or two stages. For patients with good bone quality and thickness the FAST method is recommended. This procedure involves soft tissue reduction and insertion of an implant with a premounted abutment. For people with soft, compromised or bone less than 3mm in thickness the first stage is performed as mentioned above for an implant and cover screw. Later at a second stage the abutment is fastened on to the implant.

Care and Complications

After the surgery the abutment is left with a dressing and healing cap until the stiches are removed. After 5-6 days the audiologist will check the healing process and after 5-6 weeks the fitting of the sound processor can take place. Adjustments and sound processor programs will then be set for the individual.

Living with Baha demands aftercare. The abutment is mainly cleaned with toothbrush-like brush e.g. during a shower. An after care kit is ususally provided by the company behind the bone anchored hearing aid (Procedure Baha, 2013).

The surgery is relatively harmless yet as with all medical interventions here can be complications (Breitholtz, 2009).

- Numbness can occur round the abutment area where soft tissue has been removed.
- Infection around the abutment and soft tissue area can arise during the healing process and in the event of lacking after care.
- Skin overgrowing the abutment. (Can be helped with a longer abutment).
- Flap necrosis can occur for the skin flap when healing with no underlying soft tissue.
- If the implant fails to osseointegrate it can fall out of the skull bone.

2.4. Living with Hearing Loss and Hearing Aids

Hearing, as one of the five senses, plays a great role in the perceptions of a context and the personal experience. Orientation when sight is reduced, communication with other people and reflex reactions as a response to warning signals are all made through hearing.

Realizing the sense of hearing is being reduced can be an overwhelming experience. Usually linguistic sounds are lost and the nuances in conversations disappear. Also listening to a group conversation is difficult and much more attention is required which is tiring. Telephone and doorbell signals are missed out on as well as sounds or name calling from afar. The healthcare sector in the county council of Västra Götaland working with hearing loss has compiled several advices on communication strategies for persons with hearing loss. The advices also includes strategies for relatives and friends (Leaflet, Hörsel- och Dövverksamheten). Considering position in a room, having the better ear towards the sound source, speaking towards the person with hearing loss and not covering the mouth so lips can be read are just a few advice given.

To ease hearing loss there are many different hearing aids. Many individual factors play a part in what specific aid it is that will suit each and every person. A hearing aid can never replace a normally functioning ear, but it can come very close to a natural sound experience if it is used the right way.

Deaf communities and hearing loss associations exist all over the world. Living with hearing loss can involve a lot of challenges so the exchange of information and experience is of great value, both from healthcare professionals and between individuals. In Sweden HRF, Hörselskadades Riksförbund, is a large national association that has sub groups e.g. towards children, relatives and regional offices.

Communities and associations function as a gathering point and can create a sense of belonging to those who identify themselves with it. In helping people and introducing hearing aids to them there also has to be humbleness, showing that the interventions towards hearing loss are made on the premises of the individual. Only if and to the extent the personal engagement stretches, aids should be provided. (UR dövidentitet och hörande, 2007, UR dövkultur och identitet, 2007)

Many factors have to match during the consultation of hearing aids and hearing loss. The audiologist has a theoretical knowledge that has to be applied in a personal way to meet the patient. Facts and results have to be presented in a clear way and the patient has to be willing and ready to take in the information. If the diagnostics of hearing loss becomes too emotional to handle the patient is most likely not able to handle problem solving at the moment and a softer approach to the consultation is needed. (Clark, 2010, Gailey)

2.5. Design Theory – Experience and Healthcare

Design has generally been connected to function and aesthetics. Function in a more mechanical meaning where the design should e.g. provide a specific use or optimization. The functions and the aesthetics are strong factors playing a role in users perception of the product and the desire to use it. Together a user experience of the product is created.

The experience perspective especially comes into play when products are not directly aimed towards a purchasing consumer but when the product is mainly handled or involved in a certain context or situation, e.g. receiving oxygen at hospital involves the experience of an oxygen mask, which is the central product. The uprise of services, involving products, replaces contact with just the actual product. Services are strongly

connected to experience, e.g. getting service at a car mechanic, where the consumer pays for the service of getting the car repaired as to buying tools and fixing it by oneself.

An experience involves the perception and although the perception of an object can be very clear the experience can be less obvious (Schifferstein, 2008). The state of mind or the mood the perceiver is in as well as what context the object is placed in will matter for the experience and interaction.

In the design of a product there is a relationship between the concrete, e.g. that the object has a sharp angle, which can be perceived by sight or touch, and the symbolic, that it is experienced as e.g. aggressive.

To achieve a stronger experience one theory is that people prefer an optimal level of arousal when it comes to perceiving the symbolic in an object. Asymmetric shapes are said to give greater arousal as the object becomes more expressive and dynamic (Ibid.)

In the experience of an object, metaphors are a way to reduce the cognitive workload by making users relate to something they already know. Relating to a product and associating it with something can, when it is in a positive matter, enhance the experience of emotional attachment. This will be fruitful for a company over time, as it will make customers loyal wanting to stick with e.g. the brand.

Product attachment can be determined by four factors (Ibid):

- Pleasure – provided to the user by the product. Here surprise can enhance the pleasure by the physiological effect of e.g. increased heart rate that makes the user focus more on the object. A surprise effect also tends to more likely be stored in the memory.
- Self-expression – connects and shows ones personality and differentiates the individual from others. Product and meaning need to be intertwined to be less likely to replace.
- Group affiliation – the product make the user a part of a group, which it identifies itself with or wants to be identified with.
- Memories – the product brings out positive memories, effective ways to this can be by odors and making the object age gracefully.

Yet to predict the meaning of a product in advance is hard and is also highly dependent on the individual.

2.5.1. Design Experience in a Healthcare Context

Experience is well connected to the context and environment. In a healthcare context extra attention should be given to supportive design, helping the user to cope with the situation as they are usually dealing with a condition to improve (Koblanck, 2004). Design for everyone (Bohgard, 2009) is also an important aspect as patients, especially of hearing loss, is a very diverse group. The design needs to be considerate towards the difference in mental and physical conditions, cultural backgrounds and so on.

The healthcare sector includes many areas, towards the patient these could primarily be quality, security and service in the care provided. All of this makes up one experience for the patient. Feeling seen and listened to and understanding the treatment and care about to be given are important aspects in the communication between the patient and professionals. E.g. time limitations and terminology can shift focus from professionals to patients point of view (Wolf, 2013).

2.6. Materials

This section will account for materials suitable for the demonstration tool to be designed.

2.6.1. EVA (Ethylene-Vinyl-Acetate)

EVA is an elastomer build around PE, see chapter 2.6.2. It has properties like being soft, flexible and tough, which are kept even in lower temperatures. EVA has good chemical resistance and can be processed by usual thermoplastic processes e.g.: blow molding, rotational molding, extrusion, injection molding and transfer molding. EVA is applied e.g. as dispensers, cable insulation and in running shoes (Ashby, 2010).

2.6.2. PE (Polyethylene)

PE is very resistant to food and most water-based solution, thereby it is commonly used for household products (Ashby, 2010). It is a cheap material, easy to mold and can be produced in the form of rods, films, sheets, foams and fibers. PE can come in various colors or be transparent, translucent or opaque. It has a bit of a waxy feel to the surface of it, the surface can be textured or coated but is difficult to print on.

PE can be made from renewable sources and is classified as highly recyclable. The longer and less

branched the molecule chains of PE are, the stiffer and stronger the material gets (HDPE). Exposing the surface of PE (LLPE in particular) to fluorine gas makes the surface a fluoro-polymer, know as "Super PE", which is resistant to organic solvents like petrol, cleaning fluids and cosmetics. Very low density PE (VLDPE) is similar to EVA.

2.6.3. PLA (Polyactide)

PLA is made from corn maize or milk and is a biodegradable thermoplastic. It is glossy and clear but stiff and brittle. It can be processed into fiber or films, be thermoformed, extruded or injection molded. Being a biopolymer PLA is expensive costing about twice as much as PP.

PLA is commonly used for food packaging, cups, plastic bags etc. Since it is made out of renewable sources it can be recycled but one good appropriate option is industrial composting at end of life (Ashby, 2010).

2.6.4. PMMA (Ploymethylmathecrylate)

PMMA or Acrylic is also known under the trading name Plexiglass. It is stiff and hard as a polymer, and similar to glass transparent and fragile. PMMA comes as sheets, rods or tubes by casting or extrusion. PMMA's transparency can be colored, the surface scratches more easily than glass, but coatings can help that.

PMMA is used for all type of lenses, windows, CDs etc. Acrylics are non toxic and recyclable and not very resistant to solvents, acetone and strong acids and bases (Ashby, 2010).

2.6.5. PP (Polyproylene)

PP is very similar to PE in aspects regarding price, process methods and areas of use. PP properties are similar to HDPE yet is stiffer, more rigid and tolerates higher temperatures. PP is water resistant and comes in various colors. When drawn into fibers PP has a great strength and resilience exceeding the ones of PE, this is why ropes and fabric are popular applications. Like PE, PP is recyclable and is made by processes relatively energy efficient (Ashby, 2010).

2.6.6. Polymer Foams

Foams are cellular materials originating from solid polymers. Foams can range from soft and flexible to hard and stiff by expansion and solidification or by melting through an either physical, chemical or mechanical blowing agent. Polymer foams will cushion and insulate energy, e.g. expanded EVA and PVC with small cell sizes and an intact surface is used to absorb shock and vibration for running shoes.

The polymer foam can be created in place, by injection molding, extrusion, thermo-formed, laminated or casted (Ashby, 2010).

2.6.7. SBS (Styrene-Butadiene Elastomers)

SBS is a synthetic rubber with hard and soft segments. The styrene provides the thermoplastic properties and the butadiene the rubber properties (TPS, 2010). The elastomer is low in strength, which usually demands reinforcement. SBS has a low cost but a low recycle potential as well (Ashby, 2010).

2.6.8. TPE (Thermoplastic Elastomers)

TPE has the properties of vulcanized rubber yet can be processed as thermoplastics by being molded or extruded (Ashby, 2010). There are variations of TPE. TPE is highly recyclable and can be reused during process. TPE can range from gel-like to stiff (TPE, 2010).

2.7. Manufacturing

This section will account for manufacturing methods suitable for the demonstration tool to be designed.

2.7.1. Laser Cutting

Laser cutting is done by the material being vaporized due to the high-energy intensity. Usually continuous carbon dioxide lasers are used, except for small details where Nd-YAG lasers are more sufficient. The lasers output effect, focus, added gas and the absorption ability of the material make up the function of the process effect. Plastic thickness up to 50 mm can be processed and caution has to be taken regarding possible toxic gases being emitted (Hågeryd, 2002).

2.7.2. Milling

A milling cutter is appropriate for processing of flat materials and small to medium sized pieces. As with all types of cutting machining a milling cutter processes a material by chip removal. The tools and types of milling cutters can have large variations. The tool can

have a vertical or horizontal placement, and in addition to its rotating movement it also needs to move in a vertical or horizontal direction. The material of the tool needs to be hard and strong at high temperatures, though to not chip itself against the processes material and wear resistant (Hågeryd, 2002).

2.7.3. Expanded Foam Molding

Expanded foam molding creates a three-dimensional solid shapes and the foam material at once. Beads of the desired material are placed in a mold. Being exposed to heating and pressure these beads expand by a foaming agent. The shape will get a smooth closed surface when in contact with the mold. Thermoplastics are easy to mold like this and the method is cheap, which is why many single-use articles and disposable products are manufactured this way (Ashby, 2010).

3. Methods – What and Why

Several methods have been used in this master thesis project to get a thorough development and to have helping tools for the different project stages. Methods can be categorized after their properties and thereby be matched to suit the purpose of the data collected (Bohgard, 2010).

3.1. Method Categorization

The origin of the data makes a method analytical or empirical. An empirical method studies the users of an actual system. In an analytical method no user is studied, instead people with specific knowledge make evaluations of the system.

The type of data collected makes a method objective or subjective. Objective data is gained from measurements that are not dependent on a specific individual. Subjective data is collected from personal experiences. Methods can have both objective and subjective elements.

The type of results makes a method quantitative or qualitative. Quantitative results are usually in figures from objective methods observing or measuring. Semi-quantitative results origin from rankings or categorizations on e.g. a scale. Qualitative results are more detailed and arise from questions like who, what, why, where, when and how. When using a qualitative methods caution must be taken on how influence is made on participants.

The extent of user involvement makes a method participative or expert (Bohgard, 2010). In participative methods there is a high level of user involvement in implementing and controlling data collection and analysis. In an expert method only the implementer controls the data collection. Most commonly the user acts as an information source and the implementer controls the implementation (ibid.).

3.2. Planning

Planning was done during the project initiation and followed up throughout the process.

3.2.1. Gantt Chart

A Gantt chart is a tool to represent time committed to certain tasks. A horizontal timeline is made for the entire project scope. Tasks are listed vertically and horizontal blocks mark their time consumption and when during the project they are to be done. The chart also shows which tasks can be performed in parallel (Ulrich, 1995).

Structuring this project as a whole and tasks to be performed was important to optimize time and resources used. The Gantt chart was a good way to overview and visualize time and planning aspects.

3.2.2. Backwards Planning

Backwards planning means starting from the desired result or project goal, setting out the starting point and then structure the space in between.

As the goal of a new demonstration tool was pre-identified, backwards planning was a good way to set up the planning and schedule for the project, to keep to focus on the outcome and plan effectively according to that.

3.2.3. Diary Notes

Daily diary notes were kept during the entire thesis project to document accomplishments, activities, decisions and thoughts in writing.

Daily diary was chosen in order to see progress and also as the continuous documentation.

3.2.4. Process Flow Chart

A process flow chart describes a project process from start to end by symbols and links. The symbols and links mark out the elements of the process and what is included in the different stages of the process. The flow chart gives an overview easy to communicate, creates an understanding, documents and describes how the project should be done (Mindtools, 2013). The symbols are to some extent standardized, see image 9, making the communication and understanding even more clear (Cinergix, 2013).

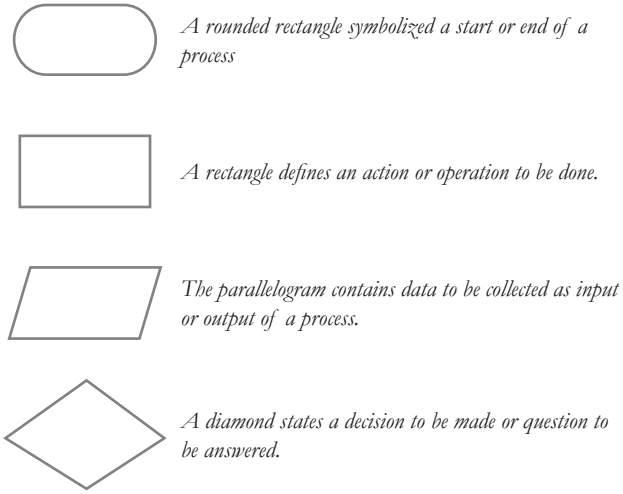


Image 9. Standardized Process Flow Chart Symbols

3.3. Data Collection

Data collection methods have given necessary theoretical knowledge about various areas in the project. The methods were more intensely used in the beginning of the project.

3.3.1. Literature Studies

A way to get background information or more insight in a subject is by literature studies (Bohgard, 2009). Articles, research studies, books and many other written documents can add knowledge. In addition to written documents similar information gathering can be done by watching documentaries and online seminars.

Depending on the vastness of the literature study it can be defined differently. In this case the method has come to be subjective and qualitative considering the difficulty in disregarding the subjectivity of the authors and the relatively low amount of sources.

The method was in the project used to get background information and an understanding for the area of the thesis.

3.3.2. Interviews

Interviewing is primarily a subjective qualitative method where people state their experience, opinion, thoughts, values and so on. Interviews can be categorized into structured, unstructured or semi-structured (Bohgard, 2009).

During this thesis project unstructured and semi-structured interviews were performed where open questions were asked and there were a possibility to direct the discussion towards what evolved as interesting during the interview. Unstructured interviews gave qualitative data, which is harder to compile but useful for explorative studies. The method was used as background information and setup was chosen to allow the experts to tell and acknowledge important parts that the project team was not initially aware of.

3.3.3. Observations

To find out how people act in a given actual situation observations can be used to collect data. Behavior is noted which the users might not even be aware of themselves. On the other hand, the natural environment might not automatically provide natural acts if people know they are being studied (Bohgard, 2009).

For this project direct unsystematic observations were done, meaning they occurred in a real environment with no specific aim, thereby being empirical and participative. They were also performed as an objective and qualitative method. Underlying reason for behaviors during observations was not gained, unless complemented with an interview. The observations were conducted to get initial knowledge and see actual behavior. Observations were also used as a comparison to verify theory with practice.

3.3.4. Benchmarking

Benchmarking is a way of comparing primarily processes and not products specifically even though products might be improved by improving processes. Looking at other companies within the same segment

is a way to see differences and trends on the market (Bohgard, 2009).

The benchmarking was conducted mainly to see how other hearing aid companies promote their solutions and what message they are sending as well as to identify the current trends in the field.

3.4. Analysis Tools

As a continuing phase to the theory studies, analysis methods have been used to evaluate the data collected.

3.4.1. SWOT

SWOT stands for Strenghts, Weaknesses, Opportunities and Threats. The areas are usually divided into four blocks in a rectangle. SWOT is used to identify and easily list these areas for an organization and it separates and gets participants to start thinking of how the organization or system e.g. looks or functions. Strenghts and weaknesses are seen as internal factors to the organization while opportunities and threats are depending on external factors. (SWOT, 2013)

SWOT was used as a quick way to state these factors for the company and the tool to be developed in relation to the market but also internally within the company. It breaks down what to enhance and what to improve.

3.4.2. Design the Box

This is a method useful to start off a project and make the team get a common view of what the result will be when the project might not be fully tangible, e.g. implementing a new organization system (Spolsky, 2002). The idea is for the team to together shape and design a physical box to represent the core of the project, e.g. with color, size, texture, name, slogan and so on (McMullin, 2007).

For this project the method was modified to instead explore expressions during a workshop. The box was to be redesigned to represent a certain expression.

Design the box was used to get a more tangible starting point when exploring expression in design. The method was considered very useful as it created something physical to work around.

3.4.3. User Profile

Studying users involved in the products or system, data can be compiled into user profiles stating specific characteristics and relationships amongst the user groups. User profiles should be made early in the project to set the foundation and reasons for development, redesign and evaluation (Bohgard, 2009).

Users are usually divided in to four groups (Ibid);

- Primary users are interacting with the product or system due to its actual purpose, e.g. user using a tool
- Secondary users use the product but not for its primary purpose, e.g. selling or repairing the tool.
- A side user is affected by the product but do not fit in the first two categories, e.g. a person being in the room next to where the tool is being used and thereby hearing or feeling the use of it.
- Co-users work together with the primary or secondary user but is not interacting with the product directly, e.g. using another tool in the same construction work.

Several persons can qualify as primary users for a product and one person can fit several user roles. A user profile is made up by six elements (Ibid);

- Background: user type, age, language and place of residence and educational background.
- Use: knowledge, mental model, experience, frequency of use.
- Influence and responsibility: opportunity to choose product used, influence on the situation and responsibility for the product.
- Emotional relationship: ownership, social aspects, products mental influence on the user.
- Type of interaction: cognitive interaction, physical handling, opportunity to use the product with disabilities.
- Activities, goals and motives: what the user do with the product, its goal and motivation behind the usage.

User profiles was compiled as a good way to define the different people connected to the product being developed. Besides it structured and sorted out who the product really is being designed for.

3.4.4. Clustering

Clustering is an effective way to structure large amounts of data to see common denominators and sort out relevant elements to be considered.

Clustering helped in sorting out the content of articles

in the literature study and it was used to find interest areas and structure the key aspects.

3.5. Creativity Methods

Creative methods have been used mostly during the ideation phase to start the product development and bridge over from analysis to concept and further evaluation.

3.5.1. Issue Cards

Issue cards are used as a way to freely draw or write insights, ideas or any other type of issue that comes to mind. They are used to trig interactivity amongst group members and are a simple way to work around something tangible than just having a verbal discussion (Tassi, 2009).

Issue cards were used to start interactions with people new to the project that was only spoken to for a short while. The issue stated on the card was used as a way to trigger thoughts and discussion.

3.5.2. Assumption Bursting

To define assumptions drawn about the situation the idea is to list and challenge them. Some things might be obvious or not even considered as possible to overcome or change. Listing assumptions and bursting them might loosen the limitations of the situation and give a new perspective on things (Assumption Bursting, 2010).

The method starts with setting the situation, and then listing the assumptions about it. Then the assumption is challenged by a bursting and step by step this continues (Ibid.). Eg.

Situation: we cannot sell our products over the Internet.

- *Assumption: we do not have the technology*
- *Burst: we could buy it*
- *Assumption: it is too expensive*
- *Burst: we could learn or look if there is a good price to get the service for.*
- *Assumption: learning will take too long and too much effort*
- *Burst: we do not know until we try and it might generate more value in the long-term perspective.*

The assumption bursting was good to challenge the own prejudgments and assumptions to not unconsciously limit or block certain aspects.

3.5.3. Moodboards

Boards can have many functions. It is a way to show what visual aspects are desired. It can be as a more detailed specification of elements to include or more loose as a source of inspiration and creativity. Moodboards connect to the main impression and atmosphere that one wants to achieve. Various things can be included in a board, e.g. details, surface materials, textures, colors, shapes, graphics and so on (Österlin, 2010).

The method was selected mainly as moodboards were a good communication tool when working with others, e.g. in a workshop or within the thesis group.

3.5.4. Personas

A more fictive variant of a user profile is a persona. A persona is a fictive person corresponding to the needs and requirements of the product, simply defining the person the product is being designed for. Collected data set the basis for the persona and several personas can be created to match the entire target group, which might not be homogenous. A good strategy is to focus on one persona at the time. The description of a persona should be complemented with a picture or illustration to get a visual description as well (Österlin, 2010).

Personas were used as it was a good way to combine all information sources and user aspects into a fictive person to discuss around. The personas were also used as a creative tool.

3.5.5. Storytelling and Scenarios

A way to connect the persona to the product is by storytelling. Storytelling brings out the personas experiences with the product throughout its lifecycle, it could be from watching a commercial to buying and using the product until it is discarded. The scenario should bring out the products effect on the persona, how is it experienced, what emotions does it arouse, in what situations is it used, what alternatives might be on the market and so on (Österlin, 2010).

The methods were used to put the product and its user in a context and situation, which is fruitful to tangibly see how, when and where the concept can be used and what purposes it actually serves.

3.5.6. Design by Analogy

Using analogies in design is taking inspiration from other things, situations, systems etc. to move forward in development processes. Inspiration from nature is a common example, e.g. looking at different types of wings when creating a sail. Other already existing products can be sources of inspiration also regarding material properties, expressions and so on (Linsey, 2007).

The analogy was a good way to make attributes or expressions more tangible and communicative for a specific product.

3.5.7. DFA

Companies providing a range of products need to have consistent design elements in order to create a strong identity within the product families. Connecting them to the company is important for customers' recognition and for enhancing the company brand identity. Also when developing new products it is important to consider existing design elements and product design history (Warrell, 2001).

Design Format Analysis, DFA, compares products to identified design elements and ranks them in order of consistency. The products to be analyzed are placed on one axis and the defined design formats on the other. The intersection of product and design format is then market for a filled circle for a strong correlation between product and element and a circle for a weaker correlation. The summed score will then tell which products have a strong identity and which formats best represent the company design (Ibid.).

DFA was done to identify the Baha design elements to make the coming demonstration tool fit well with the Baha system.

3.6. Visualization Methods

Visualization methods have helped to illustrate and develop concepts as well as to set a foundation and to build material for discussions with stakeholders.

3.6.1. Sketching

Sketching is a method to be used in several different levels of detail. Quick small sketches can be done in thumbnail size and these can be evolved to more detailed concept sketches in larger formats. By sketching, ideas can be illustrated and described visually in a way that words may not fully do (Österlin, 2010).

In the development process of a physical product sketching functions well to combine with other methods. It is also a great way to discuss around ideas.

3.6.2. Sketch Modeling

Making a sketch model is a quick way of sketching in three dimensions. Besides it is a useful way to try functions, shapes, structure, etc. The sketch model can be made full scale as a mock up to be tried in the thought of environment or in scaled versions (Österlin, 2010).

As the end result was to be a physical product, sketch modeling was a great method during the development process. Both in order to try grip dimensions and construction in early stages and realizing things simple to improve early in the process.

3.6.3. CAD

Using CAD-tools (Computer Aided Design) is a helpful way to visualize a product before making a physical model. CAD-tools also facilitate easily made drawings, three-dimensional views, calculations and movements of mechanical systems among other things (Johannesson, 2004).

In this thesis project Autodesk Inventor Professional has been used to make the final product as realistic as possible, both in terms of construction and visualization.

3.6.4. Rapid Prototyping

Rapid prototyping is a quick way to turn CAD-models into physical objects. By 3D-printing geometries no machining is needed which makes the process fast when trying out designs (Johannesson, 2004).

In this project the 3D-printing was done by layering that melts together in to the desired shape. Rapid prototype was used to quickly try out the interaction with the demonstration tool and to evaluate the physical and emotional aspects of the handling.

3.6.5. Function Modeling

A function model aims to test possible operations and tasks to be performed with the product. It is also a good way to verify construction and assembly. Focus is not put on visual aspects instead the functionality is

explored (Österlin, 2010).

The thesis group used function models to try out appropriate materials and assembly. The function model also showed how well the final product would suit the intended context and worked as a communication tool for explaining the project result.

3.7. Evaluation Methods

Evaluation methods have thoroughly been used to review content and served as a framework for the decisions made.

3.7.1. Morphological Matrix

Morphology is the study of shape structure and shape development. Having many factors and combining these will generate a large amount of variations. These variations can be sorted in a matrix to evaluate combinations (Österlin, 2010).

A morphological matrix was a good way to sort out which factors are met through each solution.

3.7.2. Pugh Matrix

Concept evaluation can be done with a Pugh matrix as it reduces the numbers of concepts in a quick and easy way and the selected concepts can be improved and refined. The concepts are listed on one axis and the criteria of the evaluation on the other. Besides a reference concept is listed which all other concepts are evaluated against (Ulrich, 1995).

The concepts are ranked as better (+) than the reference concept, the same as (0) or worse (-). This rather simple manner is done to get a hint of the ultimate solution. The scoring is summed and controlled to see that all concept features have been evaluated in a sensible way against the criterions. The concepts to take forward are finally selected based on score (ibid.).

A Pugh matrix was used as it was an effective way to include the current solution in the evaluation and make sure that the most valuable concepts are the ones brought forward. It is also a good method to go through concept features.

3.7.3. The Customer Journey Canvas

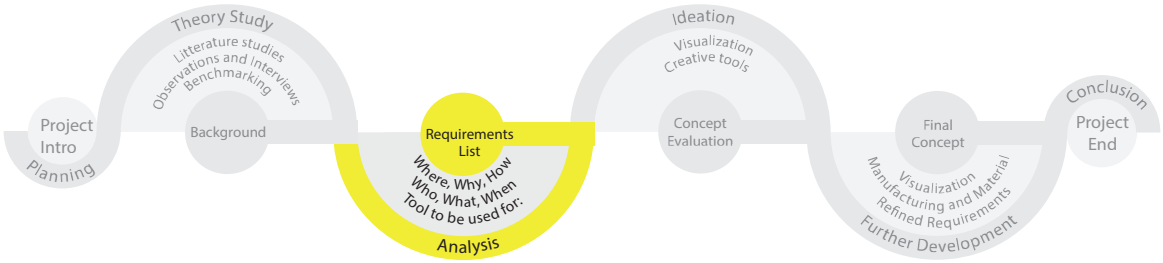
Marc Stickdorn and Jakob Schneider have developed the Customer Journey Canvas, which aims to give support when designing services. The tool maps not only the studied service, but also the pre-service and post-service stages. The tool should be used as a template, which could be modified to suit specific uses. The reasons for using the canvas could vary from mapping the overview picture of service processes to the exploration and evaluation of services, taking the customers' or other stakeholders' perspectives (CJC forum).

The tool was useful for mapping the insights from the analysis and supports in keeping the perspective of the candidate throughout the counseling experience. Besides it provided a summary and overview to the readers of the report.

3.7.4. User Tests

User tests are subjective and have been done in both participative and expert ways. In user tests people get to try out a system or product and give their opinion that is noted and considered e.g. under the further development phase.

User tests, in particular of sketch models, were done to establish the further development of the demonstration tool and to evaluate the product from a patient and professional user perspective.



4. Research and Analysis

As described in chapter 2.3, the process of getting a Baha is a non-standardized process employed by numerous clinics with different organizational structures. Thus the context of the bone anchored hearing aid care procedure is rather complex to define and describe. However, by gathering information from observations and interviews with professionals from different Swedish clinics, this chapter aims to provide a general understanding of the context and the requirements for a future demonstration tool.

4.1. Collection of Data

Several methods have been used to identify the requirements for a new demonstration tool. Information about the counseling situation, the Baha system and the expressions consistent with the company communication strategy have been collected and analyzed. The main part of the data collected have been of the qualitative type where deeper understanding have been gained trough fewer but more intense collection occasions.

4.1.1. Literature Studies

The literature studies have supported the work throughout the entire research phase. Initially literature studies were used in order to build up the understanding for a life with hearing loss and then the studies academically supported insights during the stage of analysis. The literature studies included reading journal articles, exploring books about design for experience, communication strategies and watching online seminars and educational materials regarding the Baha surgery and life with hearing loss. Findings from the articles were clustered to sort out relevant aspects to consider and to condense the information.

4.1.2. Interviews

Two interviews conducted at Sahlgrenska University Hospital in Gothenburg the 15th of November 2012, see appendix 3, and Sunderby Hospital in Luleå the 23rd of November, see appendix 4, set the foundation for the study of the context. In total four audiologists have been interviewed; a single audiologist working with adult patients was interviewed at Sahlgrenska, Gothenburg and a group of audiologists, one working with adults and two working with children, were interviewed at Sunderbyn Hospital, Luleå.

The intention with the interviews was to confirm the counseling process, how it was described in theory to how it was experienced by the professionals. Moreover the interviews with audiologists aimed to describe the general work and show the tools that are used during counseling sessions. Besides, the interviews aimed to develop the understanding of the different situations occurring, as well as an understanding of the main objectives, needs and preferences of the audiologist.

4.1.3. Observations

Two observations were conducted at Sahlgrenska the 6th and 20th of December, see appendix 5 and 6. The first observation was at a candidate's first time visit to the audiologist. The second observation was a revisit of a candidate who had tried the Baha on a softband for a month.

The observations aimed to provide information on how the audiologist actually works. The observed audiologist

was the same person as was interviewed, thus it was possible to compare how the session actually was held to what was told during the interviews. Besides, the observation was the main source of information concerning the candidates. Watching them indeed confirmed the by Cochlear predefined barriers, which the project aimed to address.

4.1.4. Workshop for Audiologists

Informal discussions with several audiologist and other professionals at a workshop for audiologists, 4th of December 2012, have contributed to the research and analysis of the counseling sessions. Through the day thoughts and reflections from audiologist with different levels of experience were collected. Thus the understanding of the professional users were further developed. The method of Issue Cards was used during the workshop to get in contact with the participants and initiate discussion around the topic of needs for a new demonstration tool.

Another reason for attending the workshop was a seminar by a Baha recipient, explaining his thoughts and journey from getting a Baha to living with it for many years.

4.1.5. Study of Expression

In parallel with the context exploration, a workshop on expression was prepared and held at Industrial Design Engineering department at Chalmers, the 13th of December 2012, see images 10 to 14. The workshop aimed to bring out ideas on how to generate an expression in line with the company strategy. From which, the desired expressions had been identified through use of the design analogy method on the core values; ease of use, reliable performance and aesthetic design.

The workshop was held to involve a larger crowd in exploring what was associated with the desired expressions and participants were asked to modify a white plain box by shape, material or by other means in order to match the requested expressions. The workshop structure sprung from the method "Design the Box" but here participants worked individually. The participants were furthermore asked to explain their ideas through illustrations or descriptions on small paper sheets.

The expressions looked for were inviting, honest, and selected. In the room three boxes where placed with an expression and additional moodboard each. The question asked to the participants was "How would you make the box more…?", followed by each expression.

The workshop was open during three hours over lunchtime where participants could casually walk in and join. The participation required about five to ten minutes and was conducted anonymously and all ideas were gathered in a big carton box. The setting was neutral and relaxed with white walls, music and color pens at disposal. When closing, 25 individuals had taken part in the workshop and their answers where compiled in an excel sheet. For each expression the ideas where listed in a table and it was noted how many times they reoccurred.

In addition to the workshop on expression, a Design Format Analysis (DFA) was conducted to analyze Cochlear's current product portfolio. The products studied were the sound processors and not the current supportive tools. Firstly, the sound processors were selected to assure that the demonstration tool would fit with the Baha system. Secondly due to lack of supportive tool offerings and consistency in supportive tool portfolio.

Images 10-14 clockwise: workshop participants, the set up of expressions and boxes, honest, inviting and selected, drawing, and writing thoughts and ideas with color pens on note paper.

4.2. Context Description

The following chapters will sum up the research and data collection and account for the obvious result outcome and also be a subjective analysis of how the context as a whole comes together and builds up a need of a new demonstration tool. The research shows that the general candidate journey consists of four phases, see image 15. The context description will focus on the counseling phase.

Image. 15. Counseling Phases

4.2.1. Users

Medicine technical equipment generally has two primary users:

- The patient who gets the treatment
- The health care personnel who direct the machine

Accordingly, for the development of a new Baha demonstration tool both the candidate and the audiologist will be considered primary users. The candidate interacting with the tool in order to get an understanding of the Baha system and the audiologist using the tool in order to facilitate the explanation to the candidate. Parents to children who might get a Baha will also be considered primary users but are not considered in this particular project.

Secondary users will for the demonstration tool be Cochlear who tries to get the Baha solution more desired. Potential co-users are interpreters, friends or family who might have joined the counseling meeting. Friends and family could also at times be considered side users.

Baha Audiologists

- Background

The audiologists are one of the two primary user groups. In Sweden the audiologist educational program is held at four various universities. The program holds 180 credits, which means three years of fulltime studies. The audiologist program is cross-disciplinary including technical, medical and behavioral sciences as described by the national admission office in Sweden.

Like in several other professions the level of experience of the audiologist working with Baha solutions depends on the numbers of patients treated. Some in the profession only work with the Baha solution while others have it as one solution among many other hearing aid solutions for patients.

The Swedish Baha audiologists are specialized in either Baha for adults, people above 18 years old, or children with their parents attending the counseling meeting, see appendix 3 and 4. When not having Baha patients frequently it is likely that the counseling procedure has to be reviewed before each new appointment, see appendix 4.

The audiologists could work at hearing clinics and hearing centers, in private or public sector. They could also work for the developers or within the industrial, school or children health services (KI, 2013).

- Use

The counseling work includes getting an understanding of the patient, explanation and display of the Baha system, individual adjustments, evaluation and journal writing.

The hearing experience is always tried out by allowing the candidate to experience hearing through the skull bone by wearing headbands or softbands, which the audiologist provides the candidate with during the meeting. The work of the audiologist also includes setting individual programs on the sound processor through computer software provided by Cochlear and feedback given by the candidate.

The frequency of performing Baha counseling varies greatly from audiologist to audiologist. E.g the interviewees from Sunderbyn Hospital had a patient frequency of approximately five candidates a year whereas the audiologist interviewed at Sahlgrenska claimed to have two counseling appointments a day. Depending on the frequency, the mental model of the counseling and Baha solution differ from rather vague to very clear.

The arrangement at the specific clinic also seems to vary. For instance, as overheard during the workshop for audiologists some clinics used to have special days only treating Baha counseling and Baha surgeries, however, due to re-organizations this set up was not longer possible wherefore a close collaboration and dialogue between the audiologists and surgeons were more difficult to sustain.

- Influence and Responsibility

The details on the counseling content depend on the candidate involved, current knowledge, interests as well as the preferences of the specific audiologist. Factors

like children being too young to explain their own situation with the presence and behavior of parents, as well as a potential presence of an interpreter to help language barriers effect the set up of and emphasis during the meeting.

- Emotional Relationship

The emotional relationship to the Baha system and counseling vary depending on experience. The interviewed audiologist at Sahlgrenska was confident and experienced in handling the Baha system and counseling procedure whereas the audiologists interviewed at Sunderbyn Hospital had a less confident relationship.

- Type of Interaction

The interaction to the system includes both cognitive use and physical handling.

- Activities, Goals and Motivation

The main objective for the audiologist during counseling is to help the candidate in gaining knowledge of the options available, which could improve one's hearing. The guidance is likewise to inform and provide facts and options and definitely not to sell the Baha solution. As a result of that, the trial of the hearing experience through head- or softband is the main argument for the Baha system. The goal is to give the patient an accurate picture how he or she would find the solution if moving forward in the process.

Baha Candidates

- Background

The candidates are the other primary user group. The group is heterogeneous, ranging from very young children to elderly people far above the age of retirement. Not only the age but also the previous experience of hearing is extensively diverse. In counseling of very young candidates, the parents are also considered primary users and are treated almost like candidates, although they are not.

- Use

Some candidates have lived for several years with other hearing aids, experiencing similar hearing as would be obtainable by the Baha. Other candidates have no previous experience from living with hearing aids and have only lived with impaired hearing without using any aids at all.

- Influence and Responsibility

For an adult the reflection and furthermore decision upon the hearing is done for oneself. For a child it is the parent, who tries to understand the effect the offered solution will have on the quality of life of his or her child, who mainly makes the decision.

- Emotional Relationship

Currently the Bahas are often considered when no other options are available. Either it could be due to that sufficient hearing cannot be obtained with other aids or that the candidate has tried other aids but experienced lots of issues so the situation has to be improved. Please see chapter 2.2 for information regarding the causes.

- Type of Interaction

The interaction with the Baha system is physical when trying the hearing experience on a softband. For getting an understanding of the system, the current interaction is mainly cognitive. For a parent, the counseling would be mainly cognitive; although one can try the hearing experience itself the hearing experience of its child cannot be completely obtained.

- Activities, Goals and Motivation

The counseling is for the candidate a step in deciding if something should or could be done in order to improve the hearing or the current situation living with hearing loss. Besides, as was identified during the observation at Sahlgrenska 6th of December 2012, see appendix 5, the main intension during a counseling session is for a candidate to understand why their current situation is as it is. That could be that the candidate mainly searches for an answer that lies in the diagnosis done by a doctor rather than the audiologist.

The main reason for getting a Baha is for a candidate to improve the hearing and the life quality e.g. when the candidate cannot live without hearing aids anymore or when having issues with other hearing aids.

4.2.2. Barriers – why refraining from Baha

When patients classify within the three types of hearing loss, previously mentioned in chapter 2.2, they become candidates for the Baha system, meaning Baha is a sufficient aid to their hearing loss. When patients choose to take on the Baha system they become recipients. Some persons might qualify for Baha but still chose not to move forward with the aid. There can be various reasons why possible candidates for a Baha do not end up with the solution. Refraining factors can origin from the healthcare sector or from the patient itself.

Professionals not being too familiar with bone anchored

hearing might not know when to recommend the solution or even think of it as an option. Bone anchored hearing aids are not as common as conventional hearing aids and therefore sufficient knowledge and comfort of providing information about Baha might not be available by the individual audiologist.

Regarding the patient there are five identified barriers by Cochlear (Appendix 2 and Design Research Report 2012). These are reasons for why the patient itself refrains from the Baha solution.

1. Aesthetics is a barrier to choose the Baha system as the candidate is concerned about size of the sound processor, that it always shows (especially with shorter hair) and is placed at different place than conventional hearing aids.
2. The surgery can be a barrier for patients that for some reason fear it, possibly based on previous experiences or assumptions made regarding its complexity and risks.
3. The implant is identified as a barrier as some candidates find it troubling that it comes out of the head and that something is implanted into the head.
4. Funding can be a barrier for candidates in some countries as insurance approval can be difficult to get. Policies can also vary in different counties in Sweden.
5. Perceived hearing outcome can be a barrier if the candidate is not convinced when trying on the softband. The softband experience is not good enough to make the candidate follow through with the Baha solution.

4.2.3. Observational Study

Two observations of the work of an audiologist at Sahlgrenska were arranged along the research and analysis., see appendix 5 and 6 The observations provided insights about the actual behavior of the audiologist and candidates during the counseling sessions.

The first observation was done on a first time meeting between the audiologist and a middle-aged woman experiencing issues with runny ears when using her conventional hearing aids. The woman had visited her medical doctor prior to the counseling.

It was recognized that the audiologist, during the counseling, uses gestures, shows brochures and one or more product samples in order to convey an understanding of the bone anchored hearing aid system. The discussion was general and no brand specific clarifications were done.

Although the by the audiologist explained intension is to provide an objective presentation of all the appropriate sound system choices, the observations at Sahlgrenska showed that the candidate might only get one option presented before the test period on a softband. Latter stated by the observed audiologist, there could be several reasons for only displaying one option initially. Relevant factors such as time restraints, e.g. when using an interpreter, the amount of processors in stock and if a right or left placed processor is required, effect the amount of displayed system options. The audiologist moreover explained that e.g. the competitor Oticon offers different processors for each distinctive placement side, whereas the Cochlear processor is universal for both sides of the head. The actual reason for only exposing and suggesting one processor at the observation was not clarified.

The dialogue during the 40 minutes counseling was a bit pushed and there was not much time for discussion. Potential reasons could be the delayed start of the meeting, the element that an interpreter was used or it did simply expose the general behavior of this very experienced audiologist.

At the second observation a revisit was observed. The patient, a middle aged woman, had tested a softband for a month and basically came back to explain that she was not ready for the bone anchored solution. The candidate could clearly see that her hearing benefitted from using the device, yet she was not ready to welcome a solution that penetrates the skin and is implanted in the skull. She further explained to the audiologist that it was not the surgery that frightened her. Instead it was simply the fact that something would stick out from her head.

Conversely to previous observation, the patient was the one leading the conversation during the counseling. The audiologist, the same one as during the first observation, primarily listened to the candidate and confirmed the feeling of the candidate by nodding and letting the candidate continue to talk. When the patient had finished her explanation and handed back the softband, the audiologist asked if she wanted to try it for a longer period. The audiologist furthermore explained that a doctor at Sahlgrenska holds tests on a new magnetic solution that would not go through the skin. Instead a magnet under the skin would make it possible to attach the processor. The candidate got very positive to the idea and instantly wanted to join

the study group. As she had experience from clinical studies, she knew that these are nothing to worry about, she said.

The meeting was very short and the audiologist clarified, directly after the meeting, that it is not her task to convince the candidates, solitary to display the options available. This correlated well with the perceptions gained during the conducted observations.

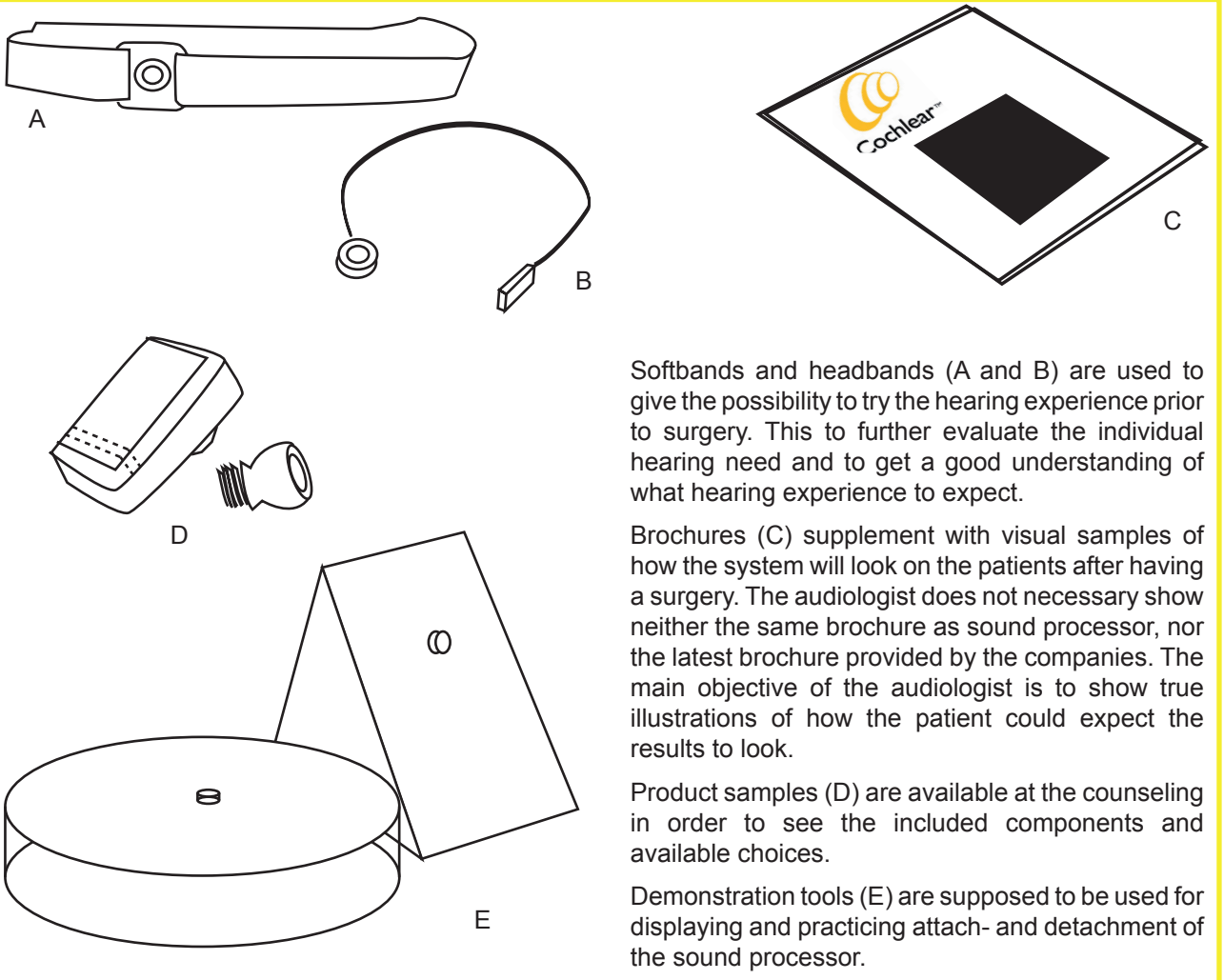
4.2.4. Demonstration Material During Counseling

The companies trading the bone anchored systems have each developed several demonstration tools that aim to be used during the counseling, see image 16. Observations at Sahlgrenska University Hospital have shown that besides facilitating the work of the professionals, the demonstration tools that are used try to enhance the candidate's understanding of the product offerings and their likely results. In addition to the mentioned functions, these tools also promote and certify the quality in which the audiologists present the companies' product offerings.

At the place for the observational studies, there were two product brands available. The two companies offered similar demonstration tools for product display and practicing use of the system, see the illustration and explanations in image 16(E). The cylindrical tool, shown in image 1, by Cochlear is the main reference product for this Master's Thesis.

The two demonstration tools are both made in Plexiglass. They offer a possibility to attach and detach the sound processors to abutment, yet they give neither tactile nor visual resemblances to the actual placement and visual appearance on a recipient. Simple shapes, a cylinder and a triangular prism, are used. Although none of the two tools give resemblance to the real use, the inclination on the triangular prism gives a slightly more truthful angle of display than the horizontal position on the cylindrical shape.

As seen from the observations and interviews, the



Softbands and headbands (A and B) are used to give the possibility to try the hearing experience prior to surgery. This to further evaluate the individual hearing need and to get a good understanding of what hearing experience to expect.

Brochures (C) supplement with visual samples of how the system will look on the patients after having a surgery. The audiologist does not necessary show neither the same brochure as sound processor, nor the latest brochure provided by the companies. The main objective of the audiologist is to show true illustrations of how the patient could expect the results to look.

Product samples (D) are available at the counseling in order to see the included components and available choices.

Demonstration tools (E) are supposed to be used for displaying and practicing attach- and detachment of the sound processor.

Image 16. Demonstration material used at counseling

reference tools are currently not actively used except for storing and occasionally showing product samples to the candidates.

4.2.5. Market Competition

Cochlear has identified the market competition as the following image 17, which includes companies and solutions that can be alternatives to their own Baha system (Pettersson, 2012).

Percutaneous bone anchored hearing aid is what the current Baha solution is today. The abutment goes through the skin and the sound processor above the skin receives sound vibrations.

Passive transcutaneous bone anchored hearing aid has the abutment part under the skin and thus the skin is never pierced. Sound vibrations are led through the skin, which muffles the sound.

Active transcutaneous bone anchored hearing aids have the abutment part under the skin and thus the skin is never pierced. The audio processor picking up sounds is placed above the skin. The vibrating part transferring sound vibrations is placed under the skin.

Non-surgical aids are indirect competition as e.g. CROS and BiCROS hearing aids can be used for the some types of hearing loss that Baha can improve as well. CROS hearing aids treats single sided deafness by transmitting sounds from the poorer hearing ear to the better ear. BiCROS does the same but also amplifies the sound if the better ear suffers from conductive hearing loss.

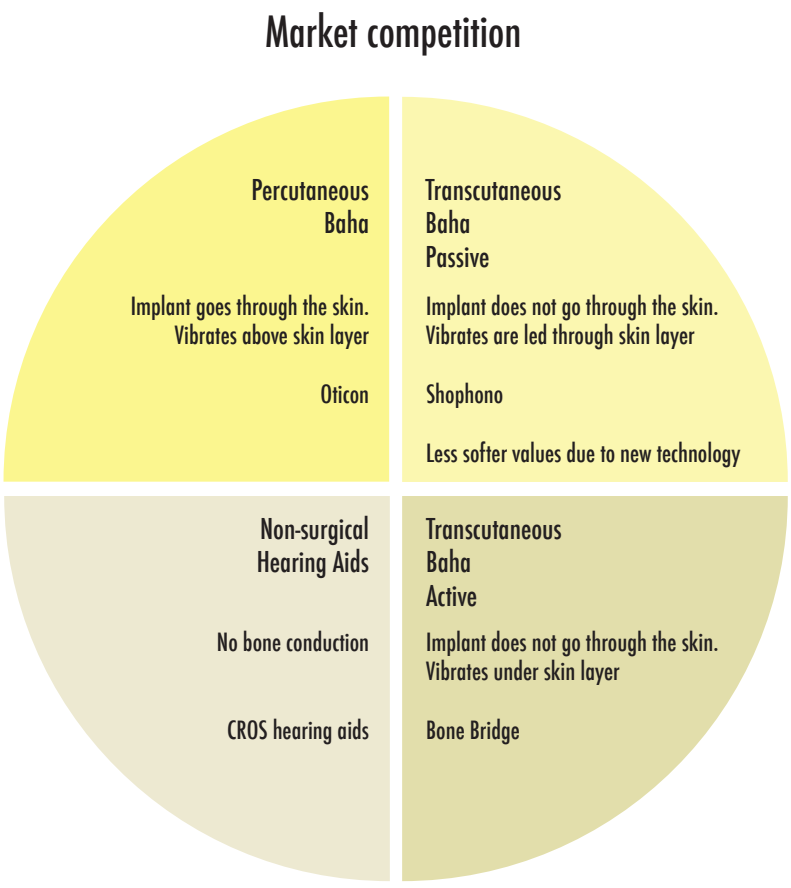


Image 17. Market Competition

4.2.6. Cochlear Strategy

By use of three core values; Reliable Performance, Aesthetic Design and Ease of Use, Cochlear wants to build a customer centered strategy built on meeting the customer needs within guiding principles such as simplicity, aesthetics, reliability and value creation (CBAS Communication Strategy, 2012). The strategy aims to increase the trust and love to the Cochlear brand and products, as shown in image 18.

The end users are the primary target group, whose needs all communication should build on. However the company speaks to the end users through professionals being Baha audiologists and surgeons. The target groups are divided as follows in image 20.

The strategy claims that the Cochelar's products are not sold through features. Instead the softer values and benefits that emphasize the company core values will build the foundation in the communication to all the addressed target groups, see image 19.

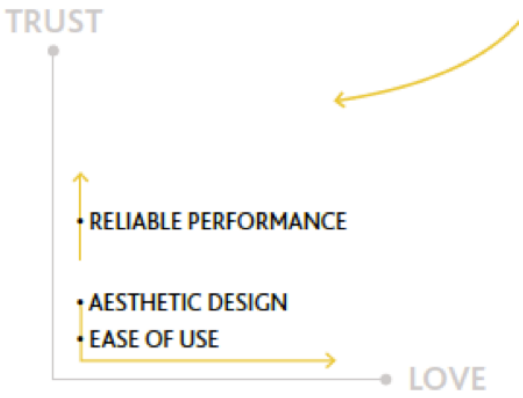


Image 18. Trust vs Love

Image 19. From Features to Message

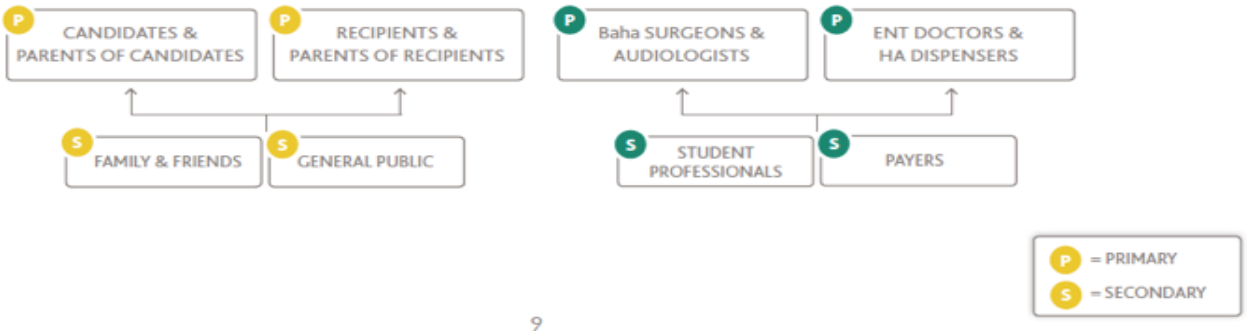


Image 20. Target Groups

4.3. Analysis Conclusions

The conclusions of the analysis have been drawn with focus in identified needs and requirements for the new demonstration tool. The findings are subjective yet verified with company representatives. All analysis areas are considered and finally concluded in a requirements list for the new demonstration tool.

4.3.1. Counseling Journey

As explained in chapter 2.5 Design Theory, numerous perceptions build up to one entire experience. The Counseling Journey Canvas, image 21 maps the main insights from the counseling context study and concludes the overall counseling journey as it is designed today. The Journey is divided in three phases; Pre-Counseling, Counseling and Post-Counseling.

Image 21. Counseling Journey

Pre-Counseling

Public Relations
- News on technical advancements
- Research articles
- See the product on someone
- Self Counseling Tool

Social Media
- Hearing Loss Communities
- Twitter
- Facebook
- Youtube

Word-of-Mouth
Patient stories
- Improved hearing
- Better life quality
- Issues

Past Experiences
Previous hearing aids
- Infections
- Runny ears
- Acoustic feedback
- Not Strong enough

Expectations
- Solve hearing
- Surgery is a big deal
- Not sure what Baha involves

Counseling

Journey

Look at System	Understand Function	Experience Hearing
Reflect Options	Review Hearing	Try at Home Baha kit
Try again Baha kit	Decide For me?	

Experiences
- Treatment and communication by audiologist
- Percieved hearing outcome - improved or not
- Aesthetics - discrete to acceptance
- Surgery - fear or not
- Implant - acceptance or not

Post-Counseling

Patient Relationship Management
- Adjustments on sound processor
- Rehabilitation post surgery
- Baha maintenance
- Updates
- Accessories and better solutions

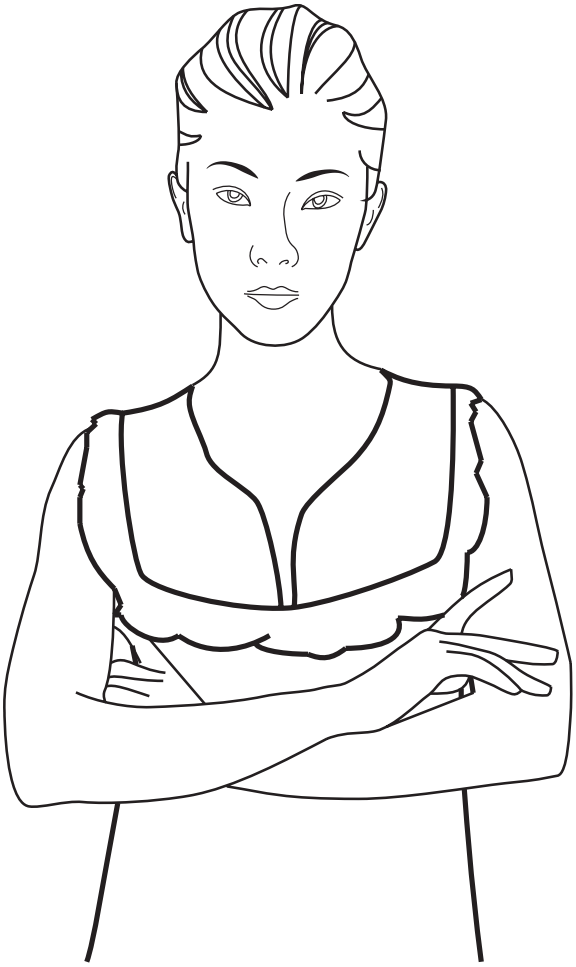
Social Media
- Hearing experience
- Complications
- Life with Baha - improved or not

Word-of-Mouth
- Hearing experience
- Complications
- Life with Baha - improved or not

Satisfaction/Dissatisfacton
- Satisfied with hearing outcome and life quality
- Dissatisfied with acoustic feedback, healing and aesthetics

4.3.2. Personas

The user profiles and observations set the foundation for three personas. Each represent a user segment for which the demonstration tool could balance up their drivers in regarding helping aids for hearing loss. Anna wants to stay herself, Kent wants to keep his harmony in life and Ruth wants her patients to be satisfied with their decisions.



Anna is 29 years old and works with sales at a company providing applications within construction. In her free time she likes to go out and spend time with her friends. Fashion and trends are one of her great interests.

Almost a year ago Anna was caught in a serious car accident. She got severe injuries onto the ear canal and the middle ear bones got damaged. This caused her hearing to become very reduced on one ear. Her profession involves customer meetings at noisy construction sites, which now are obstructed mainly because of her hearing reduction, restaurant visits with friends are also difficult.

Her hearing is reduced to such a degree that conventional hearing aids are not sufficient. Baha, a bone anchored hearing solution, would give Anna a much more improved hearing experience, which she has also experienced at a try out. Her hesitation concerns the aesthetics that comes with the sound processor and implant. To live with Baha would constantly remind her of the accident. She is afraid that she will not feel and look herself with an implant coming out and the sound processor attached to the head. She is also worried that people might treat her differently seeing her hearing aid.

Kent is 70 years old and as retired he spends most of his time at the house, in the garden or out on walks with his dog. With age his hearing has become reduced on both ears, yet a bit more on one ear so today he uses CROS hearing aids. He notices that he has a hard time keeping up in conversations with a group of people and that he does not hear when somebody calls his name or the doorbell rings.

Since the hearing reduction has occurred gradually Kent has partially adapted to it and developed own communication strategies. He turns his better ear to the sound source, reads on lips and avoids certain contexts he experiences as difficult. It is hard for him to have a reference as the reduction has occurred over time, his family and friend on the other hand notices and have spoken of the difference.

For Kent the Baha solution would be implanted on both ears. Yet there are some worries to deal with before Kent feels comfortable with particularly the surgery. Some years ago Kent had meningitis, which was experienced as very unpleasant, and he is now worried about what complications might arise from this needing to operate on the skull bone. Furthermore he has done a knee surgery where the outcome was less than expected and healing took longer than planned. With these experiences he is afraid that also this operation will not heal properly and that he might find it difficult to take care of the implant as the side of the head is hard to reach and see.

Ruth is 41 year old and has educated herself further to work as an audiologist after several years within the healthcare sector. She is located in a smaller county region where patients with all kinds of problems related to hearing loss visit her. Her role thereby involves knowledge of various hearing aids and possible interventions to pursue, from conventional aids to CROS, Baha and Cochlea implants.

Due to her long career within the healthcare sector she feels confident meeting patients and judging their emotional and physical state. Ruth thinks it is the rewarding part of her work as she is good at handling the patients core problem making them feel seen and heard, and she often gets positive feedback from the ones she meet.

Although she finds it exciting to develop a new knowledge area growing in the role as an audiologist it is also a bit nervous. Most types of hearing loss results in conventional hearing aids but when patient problems require other solutions she feels a bit lost. Ruth appreciates the neutral role she has as a healthcare professional and does not want to come off as selling products to the patient.

She does not work with the Baha system that often, and when she is to meet a potential Baha candidate she has to take extra time to prepare herself. She uses the company provided material when discussing with patients, but she feels like it is mostly a monologue by her during counseling. Trying to explain the system to patients she feels like she does not come through with the information and she feels pressured as the consultation time is only set to one hour at the most.

4.3.3. Trends

Throughout the analysis several trends important for developing a new demonstration tool, were identified. Considering the counseling in particular, the trend of communication characterized by emotion is growing. It was noticed that competitors successfully use soft values in their argumentation towards the candidates, e.g. on their websites. Besides, as identified by Cochlear (Design Research Report, 2012), ergonomic feel drives user preference to the design as has been shown e.g. in the Ponto solution by Oticon, in which the curves and ear-like shape suggest harmony. In comparison, the Cochlear BP 100 was perceived less ergonomic and more old-fashioned.

Another trend is the rapid technology development, particularly concerning the implant and abutment. Technology inventions have resulted in new competitors entering the field and will moreover make firms offer more than one type of option regarding implant and abutment combination to the candidates. Thus the candidate's number of options increase, which makes the work of the audiologist a bit more difficult.

Today the audiologists "sell" the Baha solution primarily by the "try before you buy it" approach, which by now only includes the trial of the hearing experience through a test period on a head- or softband.

Re-organizations of the healthcare clinics combined with the individual´s professional interests have increased the distance between the anatomical, audial and surgical knowledge and thus probably impaired the prospects for the candidates to get a holistic understanding of the system offer.

4.3.4. SWOT

Launching new products and tools, Cochlear's strengths concerns them having the most experience in the field of Baha, see image 22. In combination with their quality assurance thanks to throughout assessment before releasing new innovations, the Cochlear choice should come through as very safe to the recipients. New surface treatments also make the Cochlear surgical outcome less visible.

A potential weakness identified is that the design seems to be considered rather stiff compared to the more organic shapes in some of the competitors' designs. The stiffness can be difficult to incorporate with softer values aimed for in the company strategy and come through as friendly when presented with supporting products. Regarding the development of a new demonstration tool, economical limitations might also affect the number of concepts possible to realize.

Whilst many barriers make candidates refrain the Baha

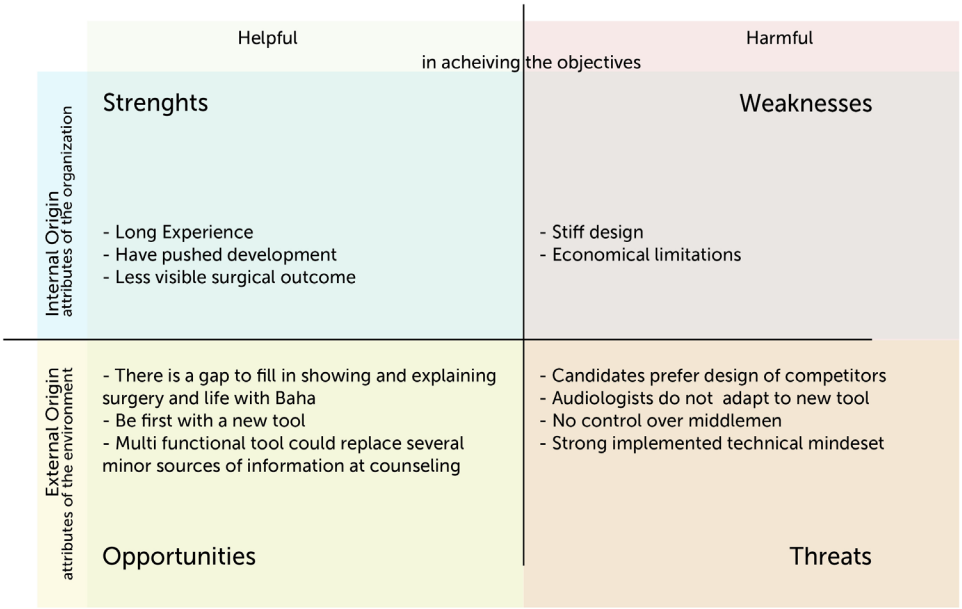


Image 22. SWOT Analysis

solution, the actual operation is very safe and although one could get infections, one could not actually worsen the hearing. Thus there is a gap to fill in explaining the surgery and life with Baha, then changing the perception of the action of getting a Baha from frightening to fairly inviting. As there would be a need for filling the gap, there is an opportunity to be the first one with a new tool, thus increasing the attention during counseling. Through development of a multifunctional tool, there would also be an opportunity to replace several minor sources of information, like different pictures and brochures in order to better bond to the candidate.

The general threats for introducing new tools for the counseling sessions are that although a new Cochlear tool is used, the candidates might not get committed to the solution. Secondly a threat would be that the audiologists do not use the new tool at all. It has been noticed, at the workshop for audiologists, that the audiologists do actually not use numerous tools offered by the producers and even if the audiologists do use the tool, Cochlear has no control of the actual conversation at the session. The lack of control over the middlemen might have great effects on the success of new inventions. At last, one threat is that the highly technical mindset at Cochlear might affect the audiologists' attitudes when talking to the candidates. Thus the softer argumentation expressed in the strategy threats to be dissolved through the deeply rooted technical mindset in the company.

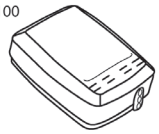
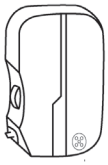
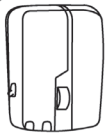
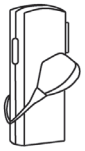
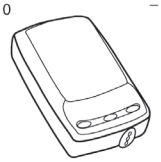
4.3.5. Design Format Analysis (DFA)

Table 1 shows that in general the Cochlear sound processors have very clean cuts and rectangular sharp shapes. No patterns or textures are used. Looking at the design format analysis it shows that the BP 100 and the BP 110 are the most consistent products. Least consistent is the Baha Cordelle mainly because it is body worn.

The most consistent design elements are sharp radius from side to front, four cornered shape, buttons only at side, decentralized division line at sides and symmetry of entire product.

The sound processors basically come in four different

Table 1. DFA

	Sharp radius front to side	4 corner shape	"Y" decoration	Sharp side corner	Chamfered	Air membrane visible on front	Unbroken sides	Buttons only at sides	Non-centralized split line at sides	Slightly curved sides	Symmetric	Slightly curved top	
BP100 	●	●		●	●	●	●	●	●	●	●		20
Intenso 	●	○	●					●	●			●	11
Divino 	○	●	●	●			●		●	●	●	●	17
Cordelle 	○	○		○			○		●		●	○	9
BP110 	●	●		●	●	●	●	●	●	●	●		20
	8	8	4	7	4	4	7	8	8	6	8	5	

colors (blonde, black, grey and brown) to match the hair. The surface is matte and shimmery. For the BP 100 a broader range of different colored side covers and fronts are available, the colors are not only natural but also include brighter shades.

Preferably the demonstration tool will use similar design elements as defined in the DFA, yet the tool need to have a subtle shape to enhance the importance and display of the actual Baha system and come through as pleasant.

4.3.6. Strategy alignment

In order to increase the strategy alignment the sound processor ought to be perceived more ergonomic and aesthetically up-to-date. Regarding the performance, the current products are perceived as reliable.

To better align the product offers to the Company Core Values, the new demonstration tool must try to progress the candidates' view of the sound processor experience to an ergonomic and preferred choice, whilst the design format still comprises sharp cuts and rectangular shapes.The interpretation of the company core values to the demonstration tool expression resulted in the requirement of the tool being inviting, honest and selected in its expression referring to the company core values ease of use reliable performance and aesthetic design.

4.3.7. Workshop Outcome

The conducted workshop on expression resulted in several characteristics complementing each requested expression, explained in previous chapter. The most frequently mentioned thoughts are listed in table 2 and some collected idea sheets are shown in image 23.

Table 2. Workshop Outcome

Expression	Characteristic	Occurrence
Inviting	*Round shape*	*10*
	Smooth shape	*7*
	Chiseled out/Concave	*6*
Selected	*Nice to hold*	*5*
	Elevated	*10*
	Indicated	*7*
	High-class material	*6*
	Precise form	*6*
	Beveled edges	*6*
Honest	*Transparent material*	*12*
	Organized dimensions	*7*
	Homogenous coloring	*5*
	Clean surface areas	*5*

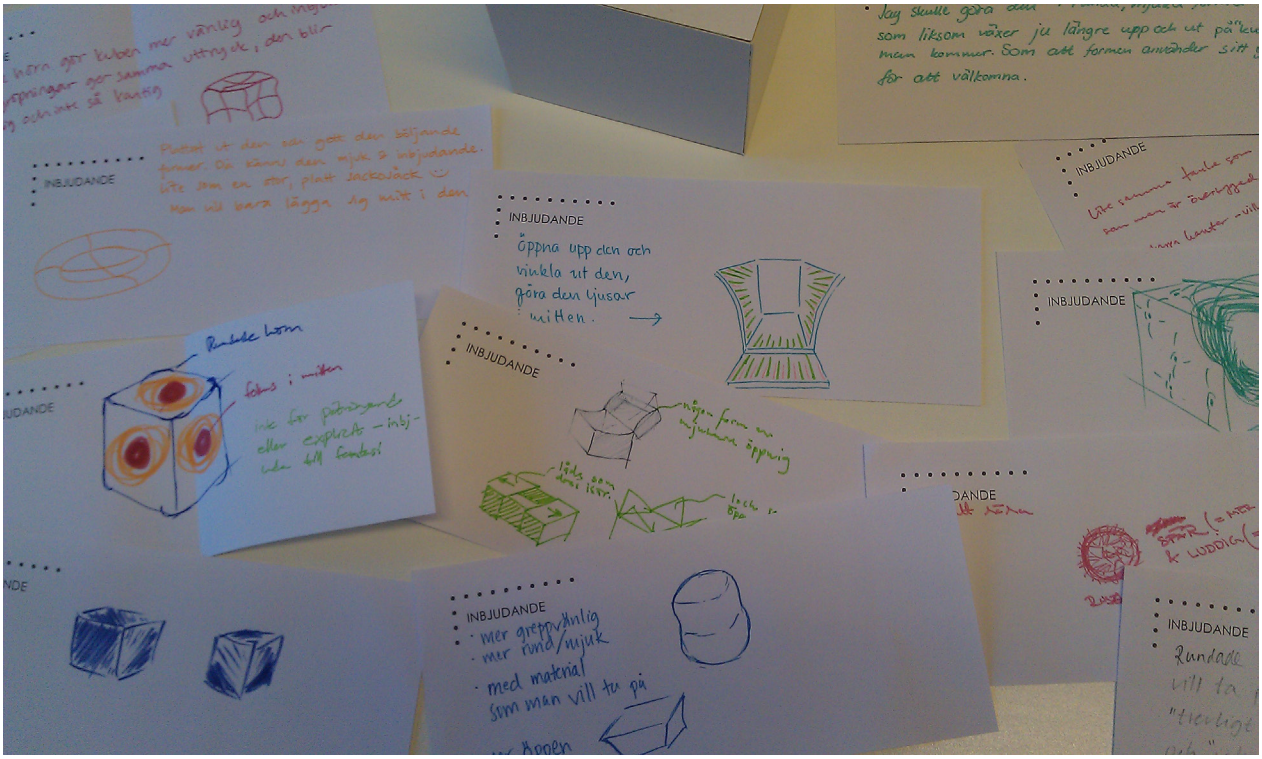


Image 23. Workshop on Expression

4.3.8. Need and Potential in a New Demonstration Tool

The impression is that there is an opening for a new tool that would be used by the audiologist for showing the Baha system location on the head. Especially for showing the visual looks and for explaining the ear anatomy and sound travel. Yet the group is sensitive to material that could be perceived like commercial. Their main interest lies in the hearing experience and they are not employed for convincing the candidates. Instead they are employed to inform and show the options that could help the candidate to improve their hearing and experienced quality of life.

Today the explanation of the Baha system is according to the research exclusively done through the display of real example pictures and sample products. Thus no tactile feedback and relation to the body is conveyed to the candidate, who does not build up any further relationship to the system than the one conveyed through the hearing experience trial via the head- or softband. Use of tactile stimuli in addition to audio and visual stimuli would certainly be an opportunity to address the reasons for refraining the Baha system and instead build a relationship and affection for the aid.

The interviews and observations show that the reference product, the plexiglass snapping tool, is not used as intended today. Snapping on and off the sound processor is done on the softband to get a realistic feel. The current snapping tool puts the sound processer in a horizontal position, which is not comparable to the final outcome after surgery. The snapping tool becomes a storage place for the sound processor.

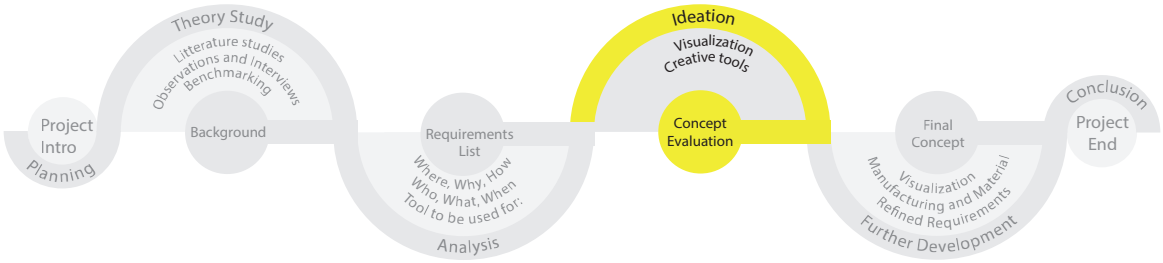
To essentially be wanted and used by the audiologists, it is of major importance that the tool is perceived as an honest display in terms of transferring a realistic understanding of the system instead of a dream solution or a brand advertisement.

4.3.9. Demonstration Tool Requirements Specification

To conclude the research and analysis results, please find the compiled list of requirements for the new demonstration tool in table 3.

Table 3. Requirements List

Function	Requirement	Demand / Preference
Implant and abutment structure	Expose insertion to skull bone	Demand
	Display operational area	Preference
Visual appearance	Demonstrate the system positioning	Demand
	Express Cochlear company core values	Demand
Healing	Display expected results on skin area	Demand
	Invite to conversation around process	Demand
Function	Describe individual options	Demand
	Allow attach- and detachment of sound processor	Demand
	Facilitate explanation of hearing function	Preference
	Fit upcoming Baha system solutions	Demand
	Provide intuitive use	Demand
	Possible to clean with antiseptics	Demand
	Facilitate practice opportunities for professional surgeons	Preference



5. Concept Development

With the theory and analysis as a foundation focus was set on concept development. The concept development has involved input and discussion with e.g. professionals to verify and bring various perspectives to the project. By several creative methods and evaluation sessions, the development phase came to consist of two generations of concepts.

5.1. Ideation Execution

Several methods have been used during the ideation. Creative methods, visualization tools and various evaluations have made the project move forward by variation, iteration and selection.

5.1.1. Dissecting Own Prejudgments

Assumption bursting was used to set the focus on the project as a whole and to put all interpretations and impressions in writing. By working with the preconceptions the implicit boundaries were loosened. The assumptions were listed within four areas; the candidates understanding of the Baha solution, the use of a new demonstration tool, the connection of a tool to the human anatomy and the design of a tool to make it a pleasant experience. Personal assumption where then challenged with bursting suggestions. Examples of assumptions and bursting suggestions are listed in table 4. A full review can be found in appendix 7.

5.1.2. Multiple Iterations

The foundation for idea generation and communication was done through sketching and discussions around the sketches. Several idea sessions were conducted rather efficiently. An iterative process was used and both thesis group members changed and continued on ideas planted by the other. The ideas then grew without getting an ownership, which consequently facilitated an objective approach towards all developed ideas.

By use of different work material, e.g. paper and clay modeling, the mind started going and gradually made the ideas more tangible. Exploration of basic shapes and curvatures was done without any specific method or direction. Abstract models were made in many variations, e.g. solid, thin, connected to the sound processor or just solitary. All sessions were documented by taking pictures, see images 24-34.

5.1.3. Path Idea Generation

Using the workshop outcome, chapter 4.3.7, as the common comprehension of the expressions, more tangible concepts were now generated with focus on communicating the expressions and fulfilling the requirements list.

After an individual brainstorming and sketching session all concepts where gathered and clustered. Three paths (display, packaging and anatomy) merged out of this clustering.

The display concepts show the Baha system in a display-like way, connecting the tool to be used at e.g. a fair. Extra attention is at fronting the product in a simple and effective way.

The packaging concepts focuses on the expression selected, giving the tool an identity and attitude with e.g. special surface finish, abstract shapes, and also by making the tool more interactive.

Table 4. Samples of assumptions and bursting suggestions

Use of demonstration tool

Assump: The audiologists will not use the model. It comes through as too selling when it comes from a company.

Burst: The model is mainly for the patient as an educational tool and to have a conversation around with the audiologist.

Assump: For patients without any prior knowledge the model needs to be simple and clear

Burst: To show “everything” creates more questions and an increased understanding

Assump: The patient does not need to know everything, at least not all at once with a too complicated model.

Burst: The audiologist can deliver the information in different turns, even with a complete model. Maybe it is better to know too much prior to proceeding with the Baha solution than that the info comes after.

Understanding

Assump: Today candidates do not fully understand the Baha solution.

Burst: The candidates do understand but the company wants to create a closer relationship.

Assump: A closer relationship will make customers choose the company.

Burst: The relationship still needs to feel trustworthy and professional.

Assump: A physical model can feel trustworthy information wise and emotionally meet patients by expressive design.

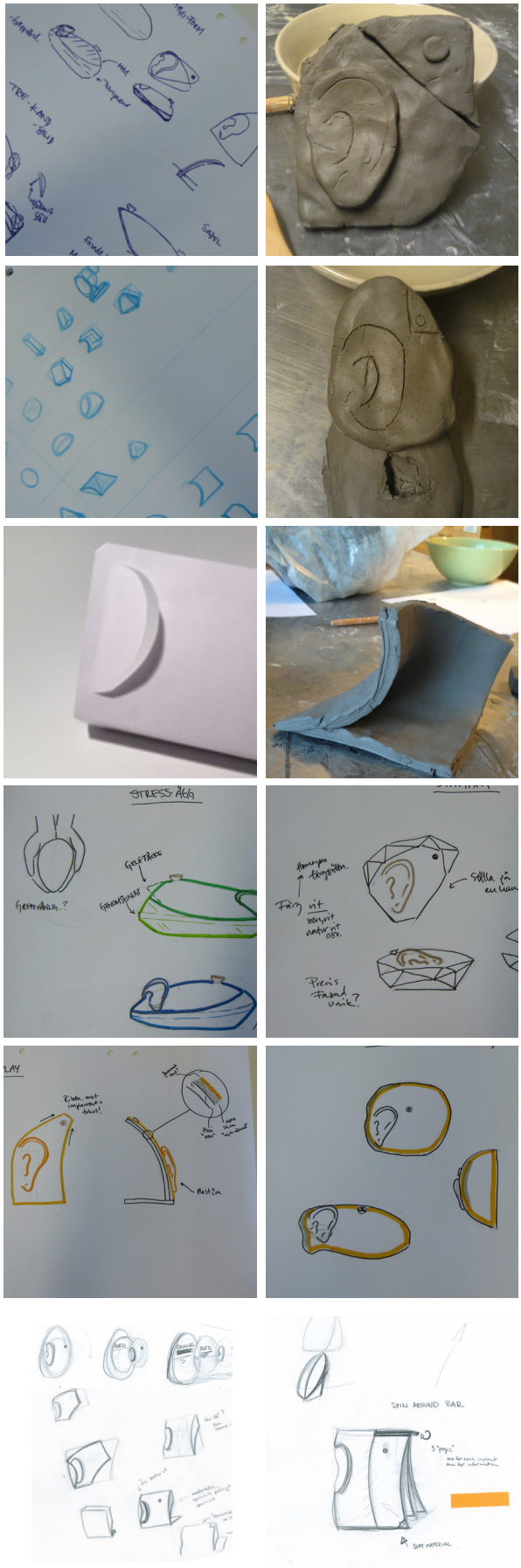


Image 24-34. Ideation Samples of Sketches and Models

The anatomy concepts explore how practice opportunities for surgeons can be incorporated in the demo tool to make the final product a two in one solution, as this was an initial suggestion. Yet material and modular requirements will be stricter and are at this stage hard to estimate.

To further establish and investigate these three paths inspiration was gained studying the display of art pieces and packaging at department stores.

5.1.4. First Generation Concept Selection

With the three paths display, packaging and anatomy in mind, ideas were generated in the form of sub solutions drawn in thumbnail format. Focus was on quantity and getting any form of idea down on paper. Ideas could regard shape, how to solve modularity, interaction ideas and so on. To reach final mid-stage concepts, the requirements list was refined and thoroughly verified against the concepts.

All sub solution thumbnails were then sorted in a morphological matrix, see image 35, where the ideas, divided into the three paths, were placed on one axis and the requirements and expressions on the other axis. The thumbnails were placed where they fitted in, both concerning the y- and x-axis.

By the evaluation, valuable solutions for each path were found. The best sub solutions for each path were then marked by how well they corresponded to the requirement it had been placed under. Also appreciated aesthetic features were marked. These marked thumbnails were then clustered into more tangible full concepts for each path. The paths evolved to be; display like tools, handheld tools and demonstration tools focusing on anatomy. Some of the ideas can be found in image 36.

In total the matrix evolved to seven full concepts. A Pugh matrix, in which the requirements were weighted, was used to evaluate these concepts towards the current Plexiglass cylinder. In addition an estimation of the concepts affordability in terms of monetary cost and environmental friendliness was estimated. Finally three concepts were selected and presented to Cochlear in a mid-stage meeting.

Image 35. Morphological Matrix

5.1.5. Refining the Requirements List

The requirements list was evolved in order to comprise costs, transportation, packaging and storage possibilities, which had shown to be important factors for the company's decision-making. The refined list of requirements with the thesis group ranks, based on the analysis conclusions, were advised and distributed to Cochlear in an Excel sheet, in which Cochlear were asked to add the company prioritizes. The compiled requirements list with thesis group and company weights were then used as a basis for the final concept evaluation and selection.

5.1.6. Second Generation Ideation

Another ideation stage was arranged with the merging of the first generation of concepts. Individual sketching, simple model making and CAD-modelling were mixed with group sessions. Ideas were followed by group discussions and finally the first generation concepts had merged into one demonstration tool idea that was believed to better match to the new and refined requirements list.

5.1.7. Second Generation Selection

The demonstration tool idea was evaluated towards the refined requirements list, in which all previous concepts also were included. The scores of the former concepts were compared to the score of the further developed concept. A decision was made and refined models and CAD-renderings of the selected concept was created. These were communicated and discussed with Cochlear. The refined concept was well accepted by Cochlear and the decision regarding the chosen concept was definite.

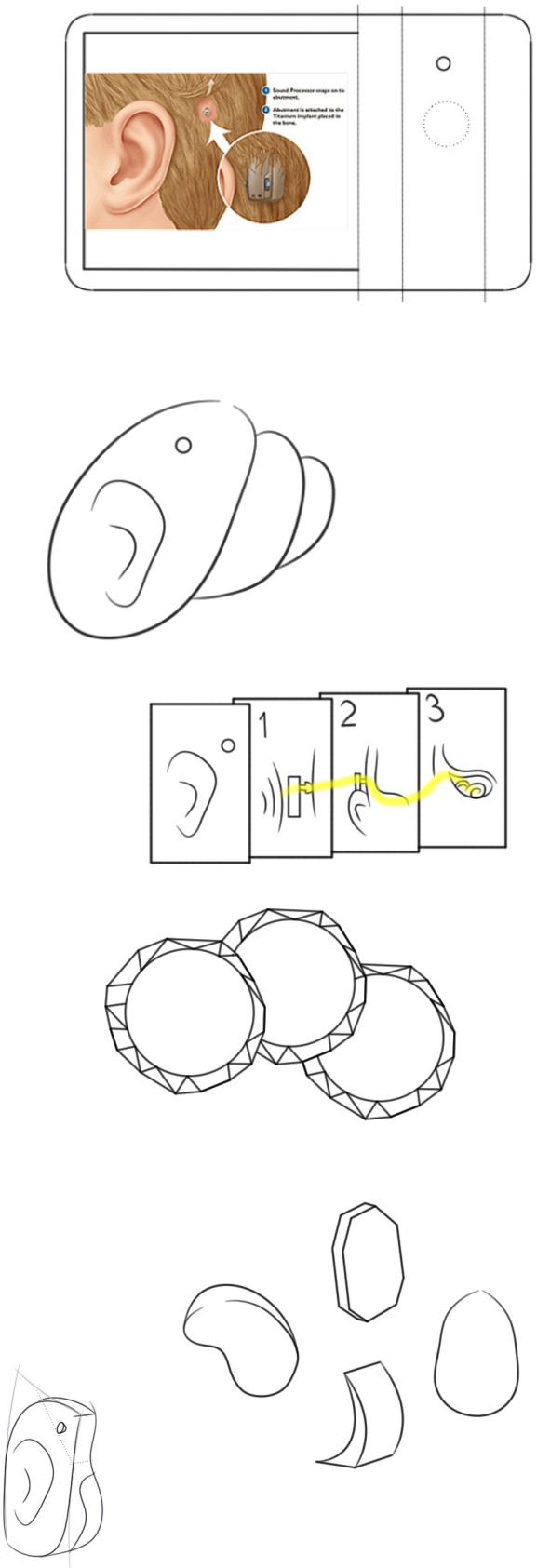


Image 36. Some of the evolved from the three paths; Display like tools, Handheld tools and anatomy tools

5.2. First Generation Concepts

As a result of the first ideation three concepts emerged. The three stretches away from each other to bring out different focus areas and ways of representation. The idea was to present the three paths and concepts to Cochlear to see what they value the most and what direction continuing work should take.

5.2.1. Pugh Matrix

The outcome of the Pugh matrix is represented in table 5, one concept for each path was moved forward with. The "notepad" was ranked highest in the display path, the "chamfered egg" in the handheld path and the "reduced anatomy" in the anatomy path. Refined sketches and physical sketch models finalized the three final concepts for which the names Functional Display, Informative Cut-Trough and Emotion Trigger were used.

Table 5. Pugh Matrix

Requirements:	*Current tool	Foldable	Notepad	Display	Chamfered Egg	Twist	Anatomical	Reduced Anatomy
								
"show insertion into skull bone (x2)"	N	2	2	2	2	0	0	2
"show position in relationship to ear"	N	1	1	1	1	1	1	1
"show expected result on skin area (x2)"	P	0	0	2	0	0	0	0
"invite to conversation"	N	0	1	0	0	0	0	1
"presentation of induvidual options (x2)"	N	0	2	2	2	2	0	2
"allow attach/detachment (x2)"	F	0	0	0	0	0	0	0
"be modular"	N	0	1	1	1	0	0	1
"selected"	P	1	0	-1	1	1	0	0
"inviting"	N	0	0	0	1	1	0	0
"honest"	N	-1	1	0	-1	-1	1	1
"hygiene (cont. req.)"	F	0	0	0	0	0	0	0
"intuitive in conseling communication"	N	1	1	1	0	1	0	1
"facilitate practice opputunities for professionals"	N	0	0	0	0	0	1	0
Sum:	-	4	9	8	7	5	3	9
**Affordable*		F	F	P	P	P	P	P
**Environmental friendliness*		P	F	N	F	P	N	F

**N=No, P=Partially, F=Fully*

5.2.2. A - Functional Display

The idea of the functional display is to make it easy for the audiologists to show what Cochlear has to offer and what choices can be made to suit the candidates' individual preferences. Similar to a product catalogue pages can be flipped and placed together with a skin like material to show the ear-to-Baha relationship and the abutment together with a bone and skin like surface. A possibility is to add pages to e.g. show the variety of sound processors, colors etc, see image 37.

The physical sketch model, see image 38, is made out of kapa board for the basic shapes. It also has a top layer of a plastic-coated fabric to function as skin. The ear is cut and bent out of the display to make it simple yet functional. The abutment choices are placed on a page each.

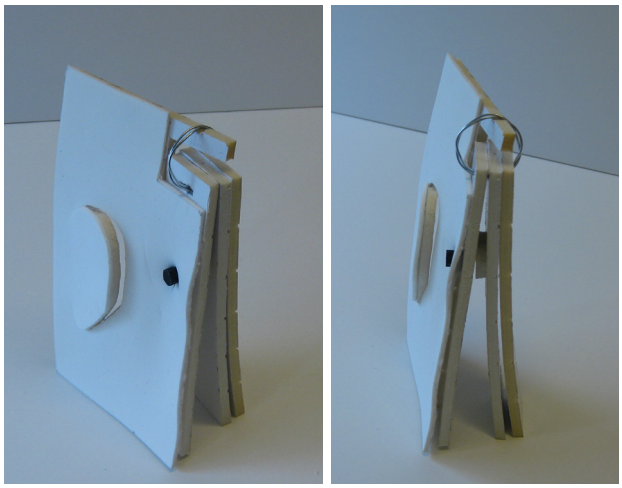


Image 38. Sketch model of the functional display concept

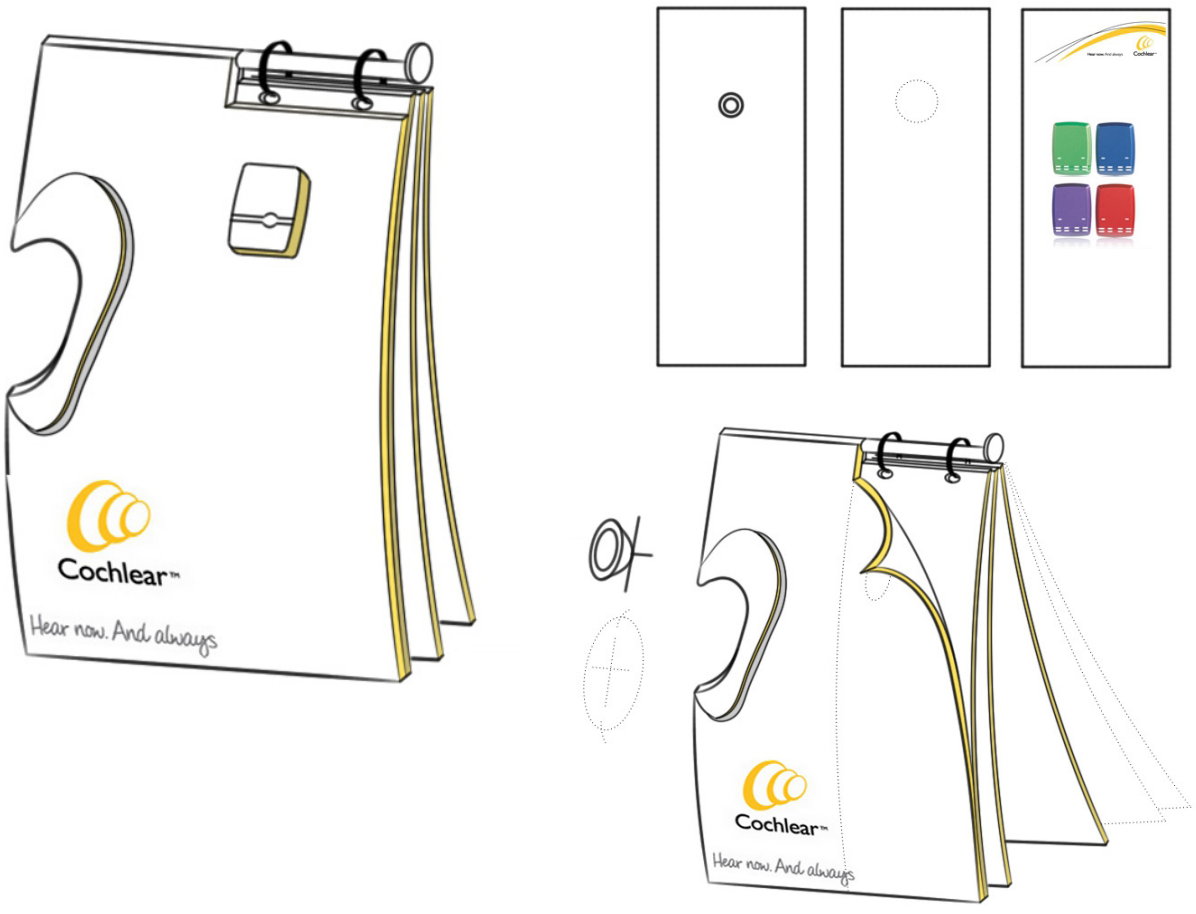


Image 37. Functional display concept

5.2.3. B - Informative Cut Through

This concept, see image 39, is designed to blend in with the context of a hearing aid clinic and aims to explain for the candidate how hearing with the Baha-system works. The audiologist can with help of the ear cut through show how sound is transmitted, where problems are today and what will become better with Baha. The demonstration tool address the barriers of implant and surgery by giving an honest impression with e.g. the reference marks and a clean simple design of the ear anatomy.

The side of the tool where the implant is fitted is to have a natural curvature similar to the side of the head where it in reality would be placed. The tool's head-like side consisting of a skin and bone part is changeable to be adaptable for future designs. Either the skin layer could be fitted into the base of the head, or put together with the bone into a solid piece.

The sketch model, see image 40, was made out of kapa board, a fabric with a plastic coating and the ear anatomy, which is printed to show the functionality.

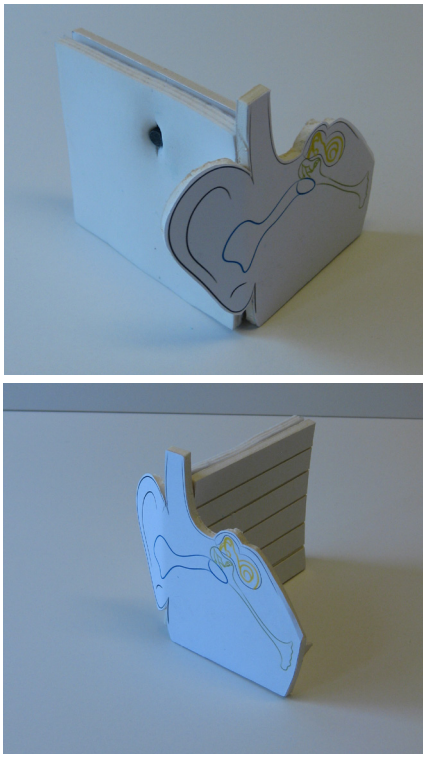


Image 40. Sketch model of the concept

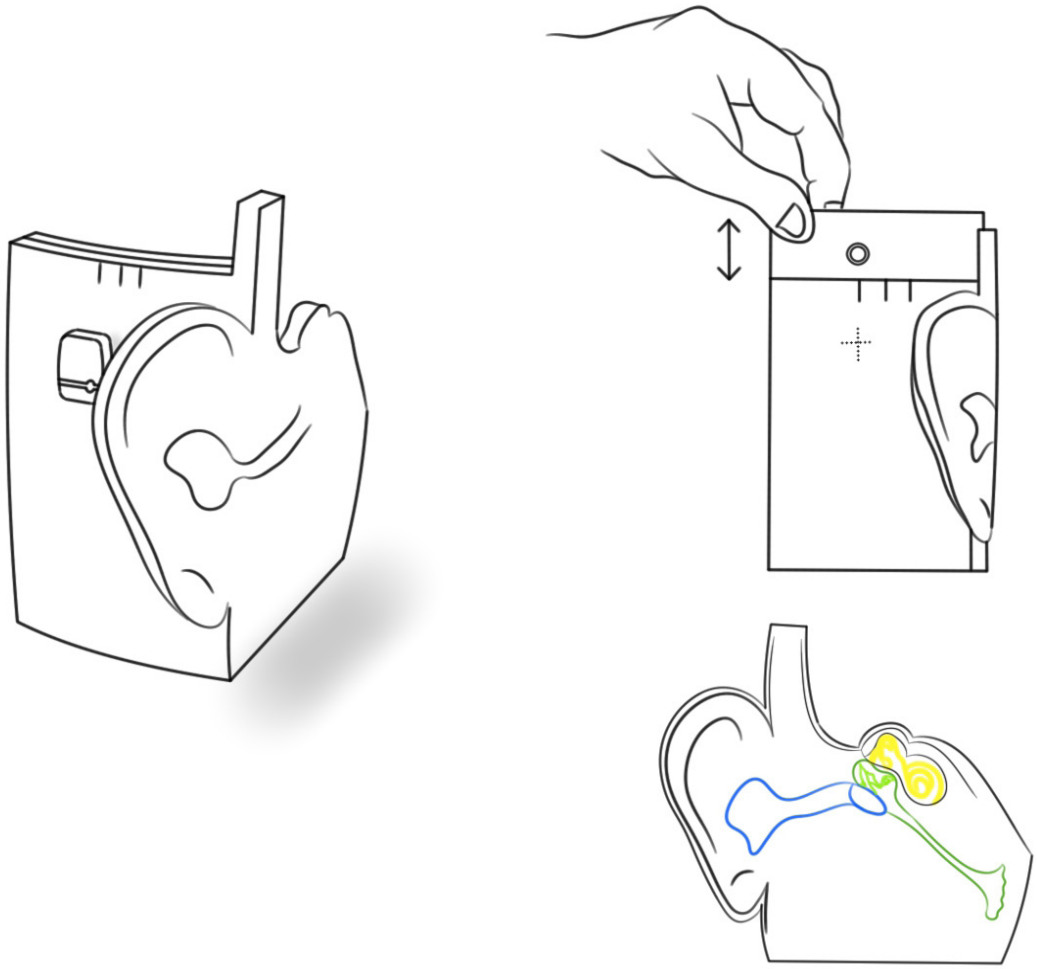


Image 39. Informative cut through concept

5.2.4. C - Emotion Trigger

The third concept, see image 41, focuses more on the feelings of the candidate and aims to trig emotions. The sharp yet simple design enhances the design of the sound processor putting it in an appropriate context, giving it an identity and by that overcoming the aesthetic barrier. The concept is handheld and is made to create a more personal relationship via the asymmetric interesting grip and new interaction possibilities.

A cutout is done around the implant making it a replaceable piece. The front cover is possible to slide up and provide storage for additional pieces of future implant designs.

The sketch model, image 42, is made of filler covered polyurethane foam for the grip and ear base. The front is kapa board covered with a plastic-coated fabric.

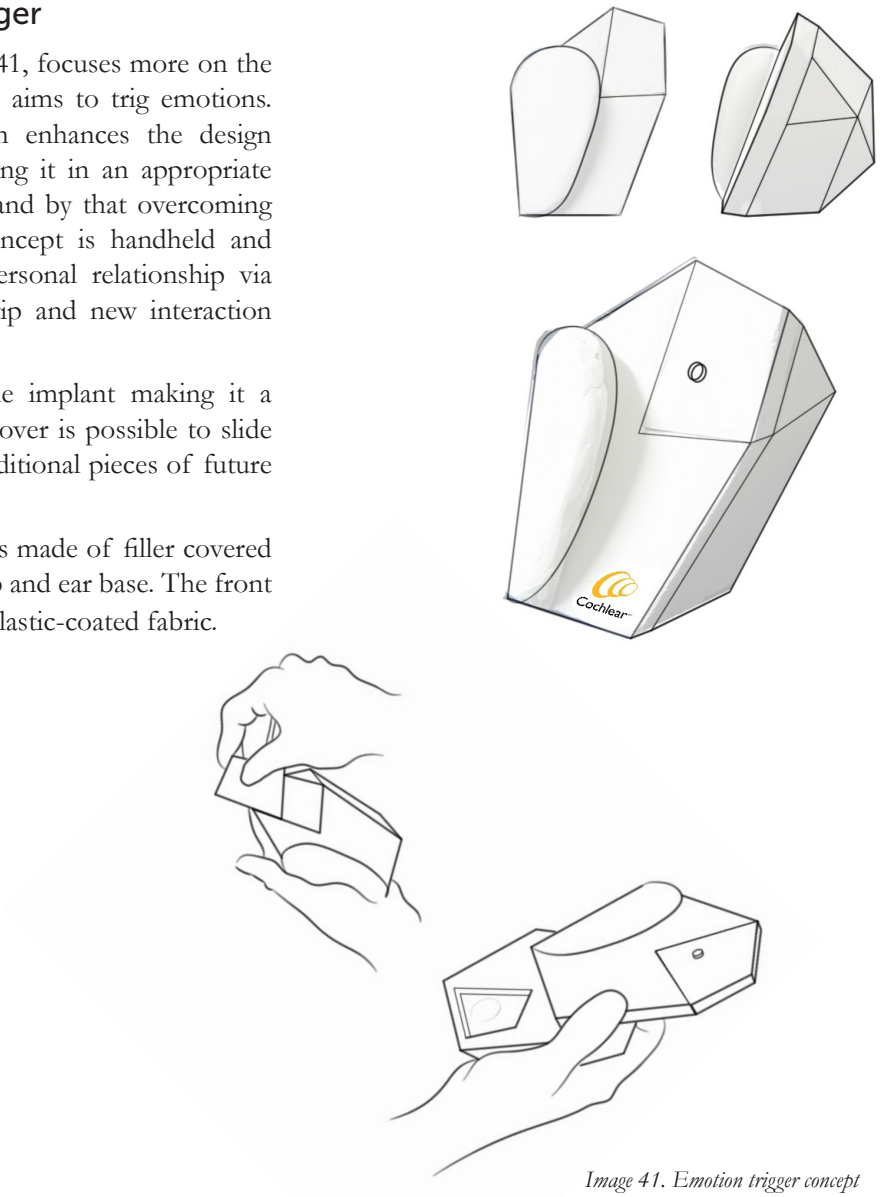


Image 41. Emotion trigger concept

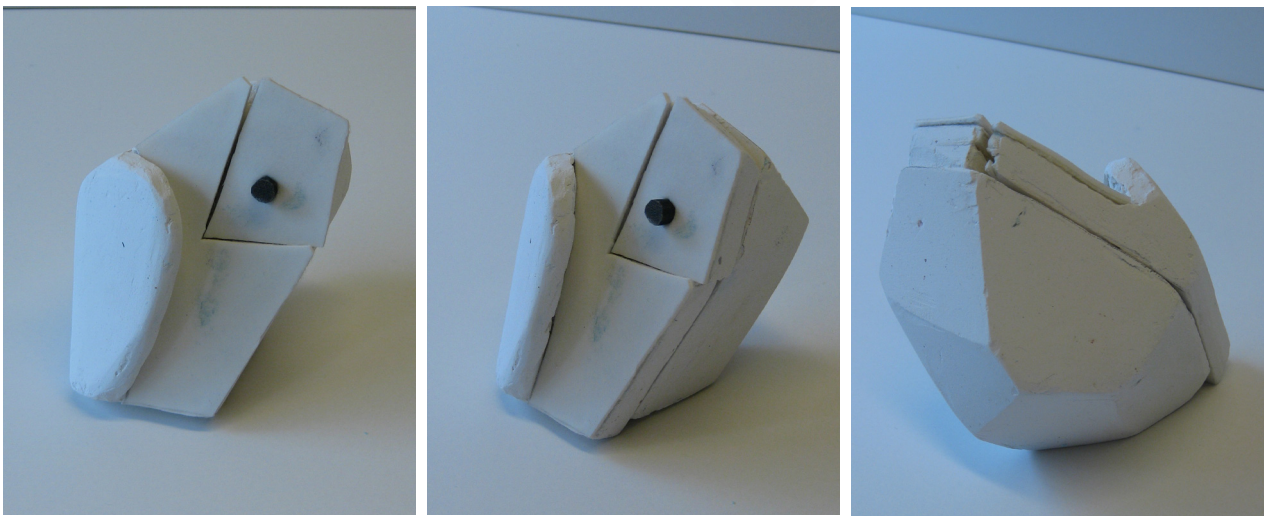


Image 42. Sketch model displayed in three different views

5.2.5. Concept Selection Results

Four Cochlear representatives attended the mid-stage meeting. The participants in the meeting appreciated qualities in all concepts.

The functional display was considered most feasible. The high flexibility in terms of changing between the displayed options as well as the clear but simple visualization of the ear, were very liked features.

The display of the anatomy in the Informative Cut Through concept was highly valued by the participants and ultimately communicated as a must-have requirement in the final concept, no matter which path was to be chosen. The simple construction and anticipated low manufacture cost would also make it possible to distribute the tool to every clinic, which would be beneficial. The participants also favoured the simplified graphics used in the concept, as an abstract and simple design puts focus on what is the most important.

The Emotion Trigger was considered the most complex concept and both manufacturing feasibility and the attach- and detachment function were doubted. Although the interaction was well accepted and liked, the concept was understood as less realistic than the other two concepts.

Regardless path chosen, image 43, a request from the participants was to make the demonstration tool communicate the implant as fitting to both current abutment and future solution. E.g. by making the implant fixed into the bone whereas the abutment and future solution could be altered. The participants did also want the skin to be completely unbroken when displaying a transcutaneous solution, which triggered changes in the Functional Display and Informative Cut Through concepts.

Conclusively, one concept could not be chosen for further development. Instead it was suggested to merge the Functional Display and Informative Cut Through into one concept and increase the feasibility of and functionality in the Emotion Trigger.

5.3. Second Generation Concept

As a result of the second generation ideation a refined requirements list evolved and a concept better corresponding to the requirements was moved forward with.

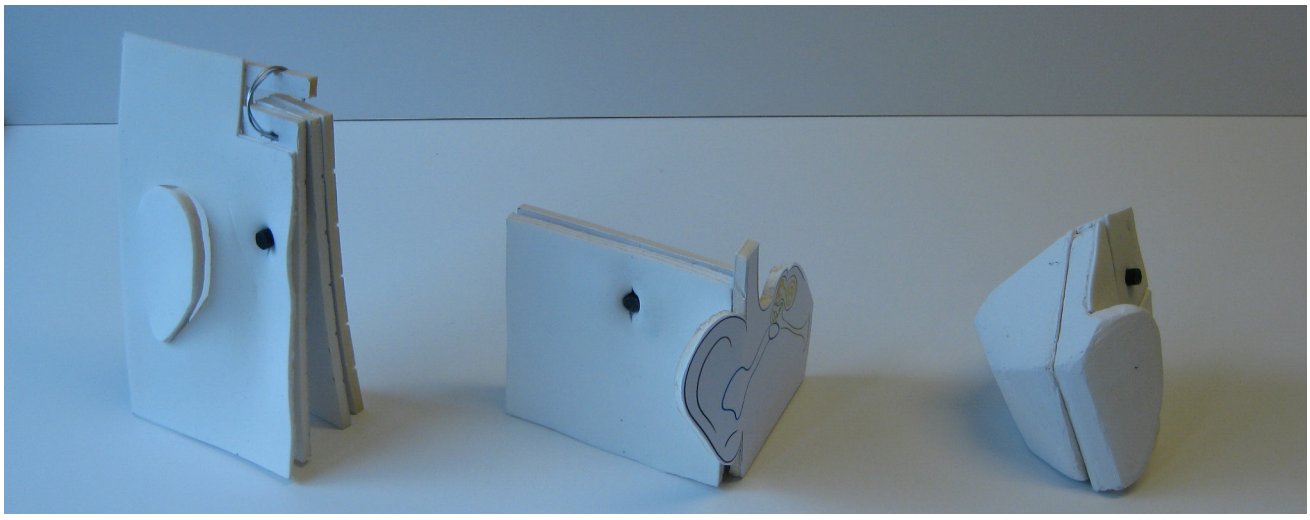


Image 43. The three concepts

5.3.1. Final Requirements List

Both the project team and the Cochlear weights proved the new demonstration tool concept to be better than the previous three concepts. Table 6 shows the final requirements list comprising the thesis group's and Cochlear's ratings of the different concepts.

Table 6. Final requirements list

			Thesis	Cochlear	Requirement Fulfillment				Thesis Weighted Score				Cochlear Weighted Score			
	Requirements	Specification	5 = absolutely necessary 4 = to high extent ... 3 = neccessary 2 = to some extent... 1 = not neccessary		Display	Cut-through	Emotion trigger	Advanced Concept	Display	Cut Through	Emotion Trigger	Advanced Concept	Display	Cut Through	Emotion Trigger	Advanced Concept
Functionality	Allow attach and detachment of SP	Stand specified force (pull/push)	5	5	●	●	●	●	5	5	5	5	5	5	5	5
	Show SP positioning in relation to ear	Appr. 60mm from centre of ear	5	5	●	●	●	●	5	5	5	5	5	5	5	5
	Show anatomy of ear	Yes/No	4	4		●		●	0	4	0	4	0	4	0	4
	Provide understanding of implant structure	One implant + abutment or magnet	4	5	●			●	4	2	0	4	5	2,5	0	5
		Show implant in skull bone	4	5		●			2	4	2	2	2,5	5	2,5	2,5
	Be visually appealing	Smooth surface finish	3		●	●	●	●	3	3	3	3	0	0	0	0
		Fine tolerances around implant	4			●	●	●	0	4	4	4	0	0	0	0
		Fine split lines	3		●	●			3	3	1,5	1,5	0	0	0	0
	Score								22,0	30,0	20,5	28,5	17,5	21,5	12,5	21,5
Strategy Alignment	Connect to the core values of Cochlear	Aesthetic design	4	4			●	●	2	2	4	4	2	2	4	4
		Reliable performance	4	4		●			2	4	2	2	2	4	2	2
		Ease of use	4	4				●	2	2	2	4	2	2	2	4
	Score								6	8	8	10	6	8	8	10
Flexibility & Upgradability	Be compatible with future designs	Current and magnet solution	5	5	●	●	●	●	5	5	5	5	5	5	5	5
		Possible to add further updates	3	3	●	●	●		3	3	3	1,5	3	3	3	1,5
	Possible to adapt to clinics product range	Only display options availble	4	2	●	●	●	●	4	4	4	4	2	2	2	2
	Support interaction between tool and	Audiologist	5	3	●	●		●	5	5	0	5	3	3	0	3
		Canditate	4	3			●	●	0	0	4	4	0	0	3	3
	Provide intuitive use	Marks and indications of possible actions	3		●	●	●	●	3	3	3	3	0	0	0	0
	Hygiene aspects	Easy to keep/stay clean	3	2					3	3	3	3	2	2	2	2
	Score								23,0	23,0	22,0	25,5	15,0	15,0	15,0	16,5
	Total Score								51,0	61,0	50,5	64,0	36,5	44,5	35,5	48,0

5.3.2. Refined Concept

The advanced concept is a multifunctional demonstration tool that supports active use during counseling. It is easy to modify when it comes to changing in between the display of implant options.

As shown in image 44, the refined concept has an informative visualization of the ear anatomy and a realistic display of the sound processor location. The shape is mirrored and flipped horizontally, which means that it just needs to be turned over in order to easily change between the displayed implant options, as shown in image 45. At the same time as one implant option is displayed, the other option could be covered by the ear anatomy part that is attached to the side. Thus the concept offers the audiologist a possibility to only display the appropriate options to each candidate.

Like previous concepts the refined concept allows easy attach- and detachment of the sound processor. By having a grip, the concept stimulates interaction that can trigger reflection and build acceptance to the system.

The grip surface and softness create a feeling of trust. By being easy to use, having a simple construction and providing reliable performance through facilitating direct communication, the product identity is believed to fit the Cochlear Core Values. Use of the design elements, such as having sharp radius from side to front and having division lines only at sides, make the concept fit well to the product portfolio. Envisioned materials and modules are roughly presented in image 46.

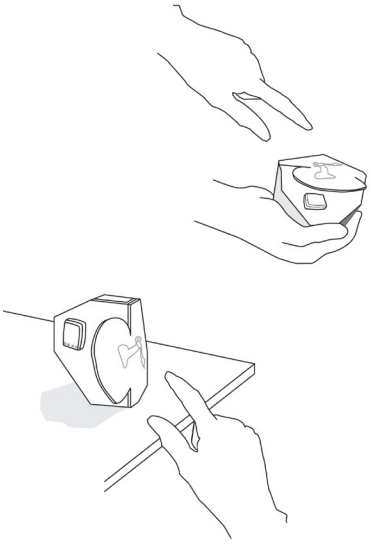


Image 44. Visualization of ear anatomy

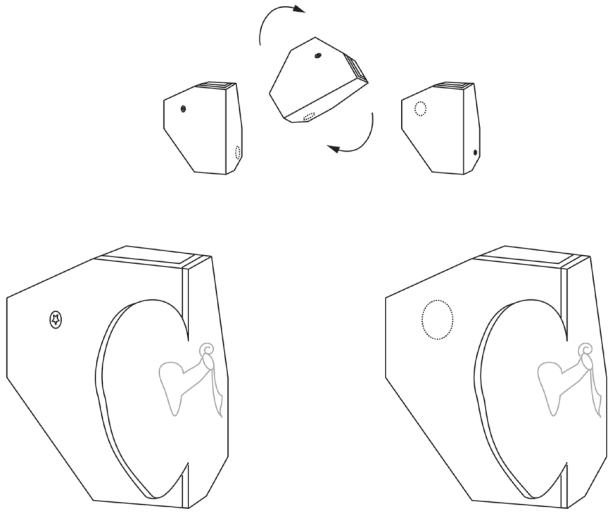


Image 45. Flippable shape that enables covering of the non-used implant option

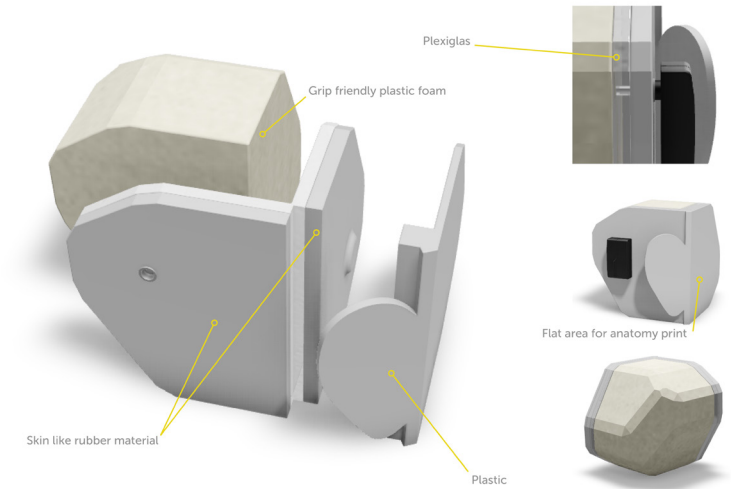
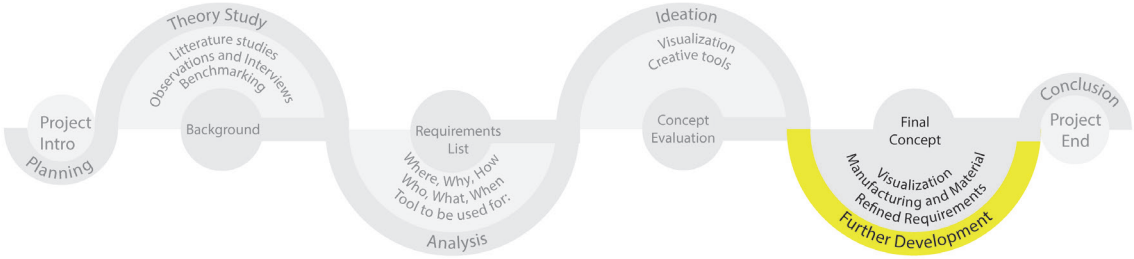


Image 46. Modules and materials



6. Further Development

Deciding the main concept to move forward with lead to the fifth project phase of further development. Details and refinements were processed and materials and manufacturability further assessed. The chapter will go through evaluation and decisions of the final iteration stages.

6.1. Further Development Process

The process of the further development was done in collaboration with both Cochlear representatives and evaluation groups to reinforce decisions. The grip part did to a large extent set the design of the other parts, which is why a major part of this chapter will regard the grip.

6.1.1. Manufacturability Considerations

A meeting was held with Cochlear in order to discuss the feasibility in producing the final concept through use of their current suppliers. Succeeding the consultation a new ideation session was held in order to advance and specify the construction of the bone and skin assembly to the grip. The ear anatomy piece was likewise developed in order to slim the design and reduce manufacturing expenses. Suppliers were contacted in order to investigate the manufacturability and possibility to allocate the building of a prototype within the time of the project.

6.1.2. Ergonomic and Aesthetic Assessment of Grip and Display

Physical models, image 47, of five variations of the grip shape were developed in order to study how it affected the perception of the ergonomics and aesthetics of the demonstration tool and the displayed sound processor. The design and ergonomics were quickly evaluated in hands-on assessments. Several aspects, table 7, were carefully reviewed in the internal evaluation of the grip alternatives.

Five persons with great variation in palm size were furthermore asked to try the three concepts that got the highest results in the internal evaluation. Following questions were asked to the participants:

- Which alternative do you find most pleasant to grip? (In hand/Placed on a table)
- Looking at the alternatives, which sound processor do you feel the most for? Why?
- Which model gives you the best total impression?
- Do you think you would actually grip the models when first seeing them? Which ones would you most likely grip?

The participants got a brief introduction to the counseling set-up. More details were provided if the evaluator had further questions. All participants were highly cultured in ergonomics and design rules but inexperienced in the field of Baha.

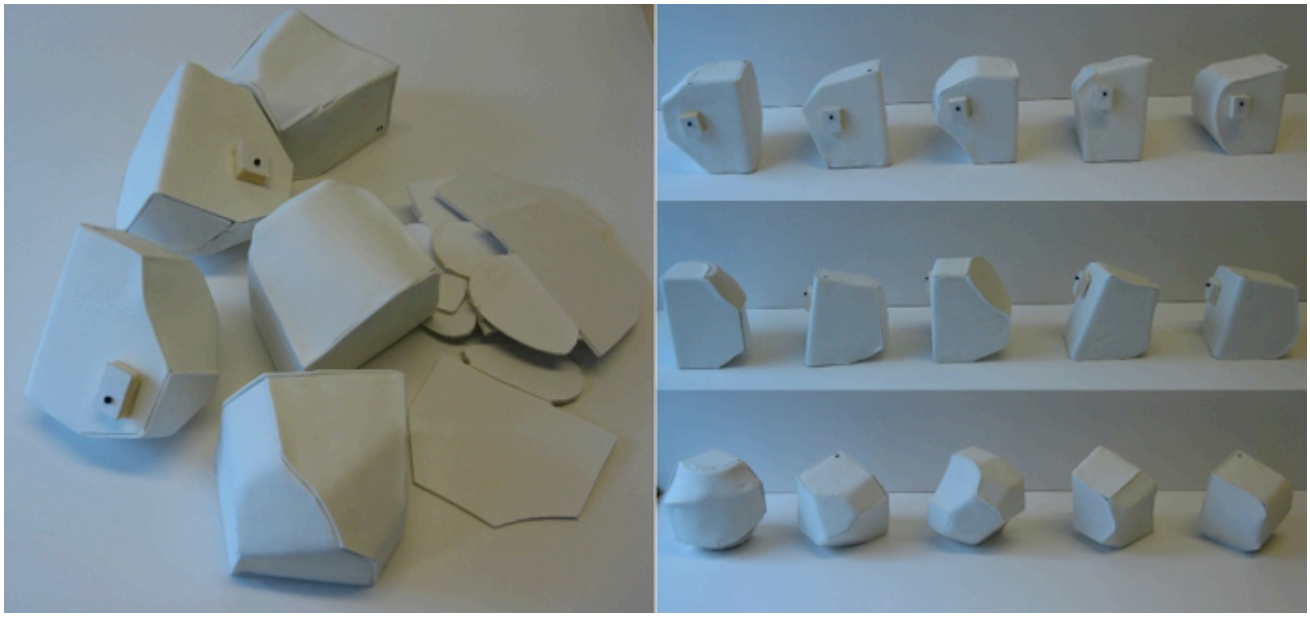


Image 47. Ergonomic and aesthetic assessment

Table 7. Evaluation criteria for grip

Grip evaluation	
Implant display	
Anatomy display	
Ergonomics	- Possibilities for left and right handed - Resting in hand - Grip on table - Stability
Clean and simple aesthetics	
Honesty regarding placement of sound processor	
Feeling of (sound processor) being selected	
Grip invitingness	
Compatibility to future designs, e.g. if using softer curves in sound processor design	

6.1.3. Grip Optimization

The earlier created CAD-model was used in order to alternate the radii, angles and curvatures on the selected grip. Three visually satisfactory variations were selected and rapid prototypes, 3D printed models, were created in order to choose the visually, functionally and ergonomically optimal combination of radii and angles.

The three printed prototypes were evaluated internally in order to decide on the final grip. Consensus within the thesis group was considered sufficient to take the decision. Manufacturers of pressure balls and car interior were contacted in order to confirm the manufacturability and to provide initial price estimations.

6.1.4. Audiologist's Response to Concept Idea

An evaluation session, together with the audiologist at Sahlgrenska, was held in order to validate the concept's desirability. The 3D model, image 48, with bone, skin and anatomy prototypes in kapa board and paper, were brought in order to easily describe the purpose and use. Besides a concise three slides presentation was brought in order to communicate the overall construction idea as well as the benefits of the concept.

The thought of materials and surfaces were discussed and semi structured questions were asked. These to validate the importance of adding some functionality, e.g. in terms of detach- and attachment of grip and visual display of the implant depth. Some additional follow-up questions on the first observation were furthermore asked in order to find out the generated results of that specific appointment.

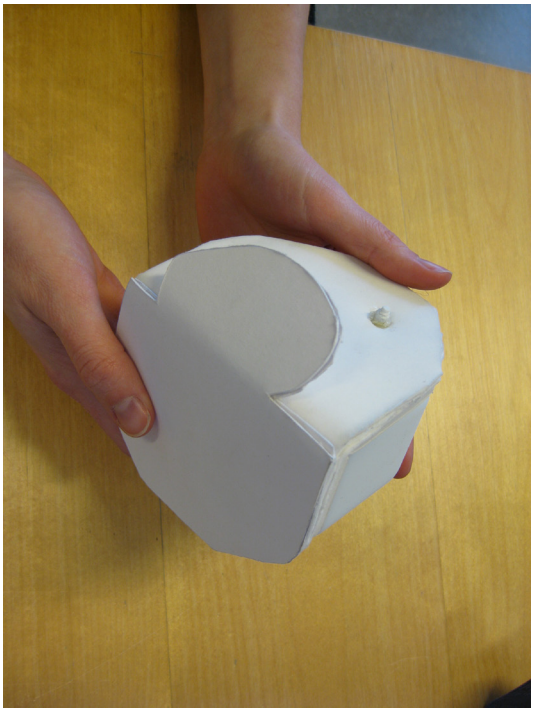


Image 48. Model displayed to audiologist

6.1.5. Final Iteration

Multiple grip variations were developed and visually evaluated in Inventor to create more even transition surfaces and higher curvature levels. The bone and skin constructions were also evolved in order to match the new radii, simplify the manufacturing and make the solution visually more appealing. The anatomy part was advanced in order to have a neater look and to easily provide attach- and detachment to the sides. In addition a solution for attach- and detachment was chosen and modelled.

In order to verify the level of visibility concerning the implant depth and prove the practicality in the transparent bone part idea, a screw was threaded in a laser cut piece of Plexiglas. A laser cut piece was used since normal cut edges have proven not to provide enough visibility through the cuts.

A last iteration was held wherein the construction was revised in order to minimize the number of required operations, especially regarding the manufacturing of the bone part. This as a result of an evaluation session held at Cochlear, confirming the project status. The dimensions on implants and depths of bone and skin were also refined in order to match the upcoming Baha implant dimensions.

6.2. Refinement Results

The results within the different aspects of the refinement phase described below make up the final demonstration tool presented in the following chapter. Results of the further development will contain outcome of tests and evaluations as well as estimations and verifications.

6.2.1. Evaluation Through Mockups

Among five mockups evaluated, grip number one, three and five were the three alternatives that got the highest scores in the internal evaluation, image 47. In the final assessment, all participants had the most preference for the same alternative, namely concept three.

Both size and shapes were preferred in the third concept and although slightly big, the grip was experienced comfortable to hold and pleasant to look at. The slightly curved side provided better grip and also made it look like something one should pick up and hold. One of the participants used the word exciting as a reason for the total preference in grip number three. By one of the assessors, the possibility to put the grip in an angle when placed on a table was an appreciated feature.

6.2.2. Manufacturability

Though some changes were needed, the general concept was considered feasible when first explained to Cochlear. In the refined design, both the skin and the bone went from one display side across to the other, see image 49. The new construction will be feasible to produce although one could wish to reduce the required manufacturing operations. At least for the bone construction, which had to be both cut, heated and bent although not very visible in assembled mode. The elastomer skin part was assumed to be possible to stretch around the corner without being pre-heated. The design on the anatomy module was also changed. The new part would be created from a flat and thin sheet of plastic, which would be slightly bent around the corner. The estimated production volume is 2000 possibly up to 5000 depending on the market demand.

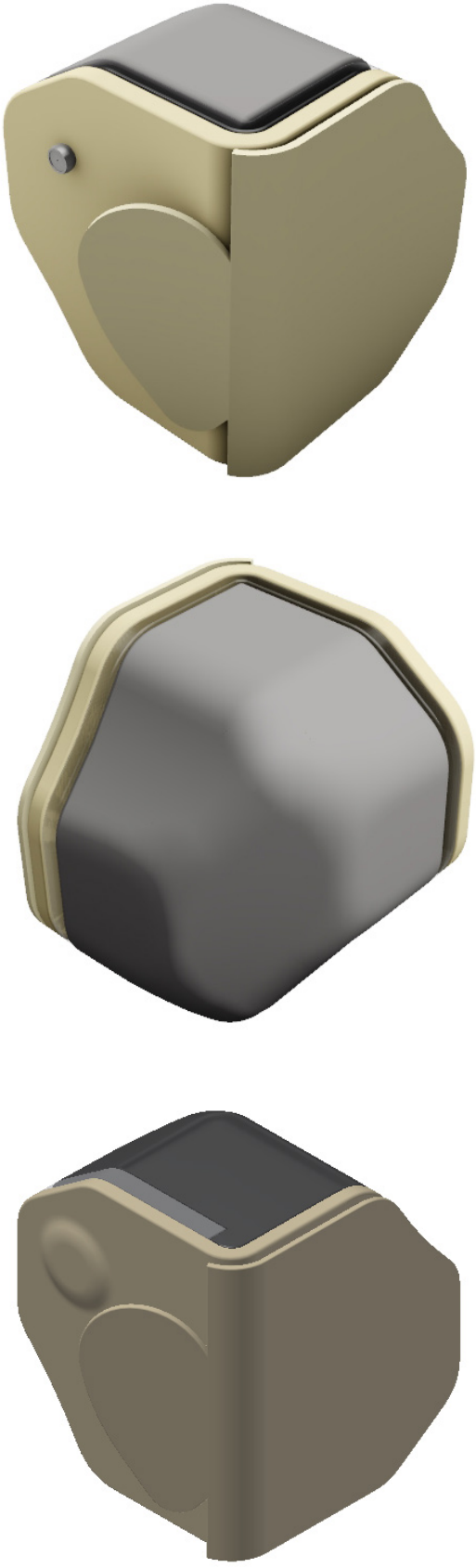


Image 49. Refined concept

6.2.3. Grip Design

The ideal concept comprised moderate radii and angles, generally 20 mm radii were used on the grip. Stability, visual appearance and ergonomics were favored by its combination of radii and angles. The shape also provided a stable display in an angle, which would be useful when practising attach- and detachment of the sound processor.

The demonstration tool can be held in various ways both in the hand and against a table due to the multiple flat grip surfaces and leaning areas. A main hand grip is to hold the tool with the left hand and practice snapping on and off the sound processor with the right hand, this due to most people being right handed.

The printed 3D-models, image 50, displayed some visual issues regarding the fillets on the back, thus another refinement was done in CAD after having selected the optimized angles and radii. The contacted company, who imports pressure balls and company giveaways from Asia, confirmed the manufacturability and a price of 13 SEK per grip, including transportation and tooling.

Image 50. 3D-printed model

6.2.4. Audiologist's Verification

According the audiologist, the refined concept and 3D-model was experienced a little bit big in the hand. Yet she appreciated the realistic size and 1:1 scaled anatomy displayed by the demonstration tool. The audiologist considered the concept innovative and clearly fulfilling her needs during counseling. The evaluator also claimed she would certainly use the concept during counseling. She moreover thought the candidates would definitely grip the model if it was displayed at counseling

Additional feedback from the evaluation session:

- Attachment and detachment of the grip would be wanted in order to take a close look at the implant only if the depth of the implant is not clearly described in the assembled mode.
- Soft tissues and bone should preferably not be detachable. According to the audiologist it would wear out too quickly due to frequent use.
- Important to show an inward bend(reduced soft tissue area) around the implant since that is an outcome of the surgery as it is today, otherwise the model would not be right.
- The anatomy has to include Cochlea, Auditory Nerve, Stirrupbone, Hammer, Anvil, Eardrum, Pinna and the Auditory Canal. Text would not be necessary.
- The material has to stand antiseptic agents. The tool should easily be cleaned together with the sound processors.
- The look is more important than the accuracy and the tactile feeling of skin, as the candidate would anyway be aware it is a model.
- The grip should have some resistance, not be too soft, to remain undamaged when frequently used for detach- and attachment.

6.2.5. Suitability of Transparent Plexiglas as Bone Material

As image 51 suggest, the laser cut provides high visibility of the threaded screw and Plexiglas could be confirmed an appropriate bone material in the final concept. The very high visibility also reduced the importance of making the grip detachable from the bone module, which was otherwise wanted by the audiologist.

6.2.6. Final Iteration

The final iteration resulted in a neat design. The anatomy piece is easy attachable by magnets, hidden by the ear on the side displaying the Baha system option and under the anatomy segment on the covered side.

The two system options furthermore have different dimensions, which means that the anatomy part must be attached at different distances from the general skin position. Having a slightly thicker magnet on the side on which the implant goes out a little longer from the bone solves this, see image 52.

Consultation at the company site resulted in latterly changed height and length of the bone piece. Two parts reducing the bending operation, which would make the expected bone part price lower, now make up the bone symbolization. As a result of the changed bone piece shape, the grip was expanded to cover up for the new bone design. The changes on the transparent bone areas increase the complexity of the grip shape. Yet the impact on the grip part price is expected to be rather low since new tooling was required anyway and the material itself is not very advanced. The function of the demonstration tool will remain unchanged. Having cut transparent pieces displaying the implant options facilitate explanation as they lower the risk for candidates interpreting the grip as a representation of the brain. The cut bone will moreover maintain a neat and professional aesthetically attractive look.

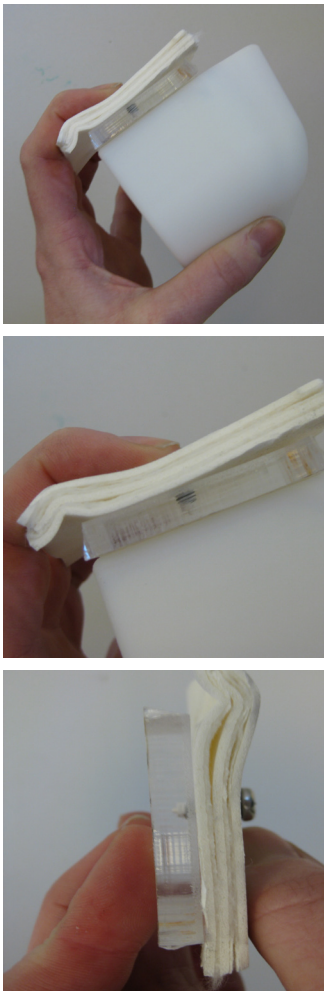


Image 51. Laser cut Plexiglas transparency

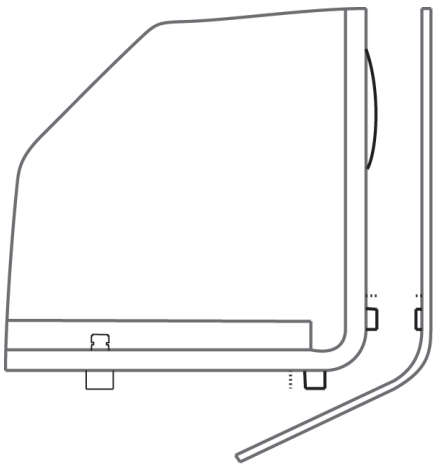
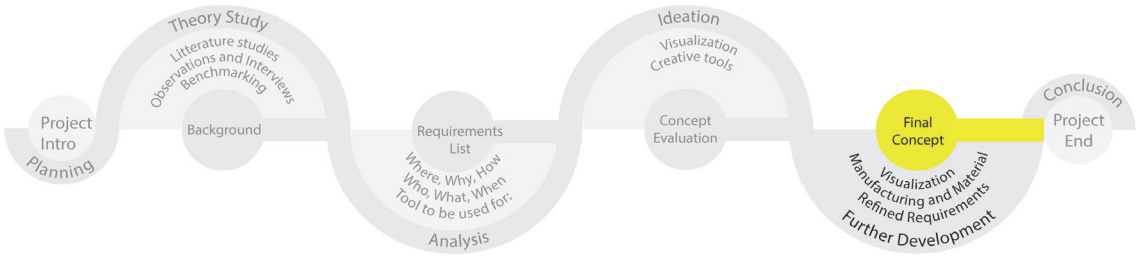


Image 52. Anatomy part attachment



7. Final Results

This chapter will present the final result of this thesis project, a demonstration tool evoking curiosity and de-dramatize candidate barriers. The tool aims to be a central conversation topic during the consultation and present the Baha system in an easy manner.

7.1. Concept Idea

The final result, see image 53, aims to make the candidate more involved in the counseling situation by interaction. The idea is to give an intuitive understanding of what living with the Baha solution will mean and to show the simplicity of the system. A tool has condensed and clear information areas that will make it easy for the audiologist to come through with the appropriate facts and aspects.

The demonstration tool consists of four main parts; a grip, two plexi pieces symbolizing bone thickness, a skin cover surface and an ear anatomy part. The grip, bone part and skin surface are all fastened together. The ear anatomy part is movable with help of magnets in order to show current and future Baha abutment solutions in relation to the ear, one at a time.

Image 53. Back and front view of the final result.

7.1.1. Candidate Experience

By the outer curvature under the sound processor, the tool will encourage to pick it up as a first expression to the candidate, see image 55. The soft grip, seen in image 54, will then enhance the interaction and be an interesting feature, creating focus and attention. Its shape, being mirrored and horizontally flipped, also enables both left- and right-handed grip possibilities to the user.

The interaction then moves over to attaching and detaching the sound processor from the abutment. The candidate can place the demonstration tool perpendicularly on a table surface and support it by putting the hand on the grip side. Or the tool can be leaned on an angle for better view, thanks to the chamfered parts of the grip.

The demonstration tool facilitates understanding of the three parts of the Baha system:

- The see-through function of the plexiglass part symbolizing the skull bone thickness will show how far into the bone the implant will go, thereby eliminating the association to brain surgery.
- The surface part functions as the skin and will show the transition from skin to abutment.
- The outer ear anatomy part will create a relation between the ear and the sound processor showing size and placement of the Baha system.

Making the candidate interact with the tool will create a more tangible understanding and room for reflection during the counseling. The tool will also facilitate an easy-going transition to questions and conversation around the Baha system and procedure.

7.1.2. Audiologist Experience

The demonstration tool consists of two separable parts, one main part and one ear anatomy part which easily snaps on and off the main part by magnets. The main part has two flat surfaces for two different Baha abutment solutions and is possible to turn 180 degrees around a horizontal axis. By snapping the ear anatomy part onto the desired surface on the tool the audiologist can hide one abutment solution, if only one is appropriate for the candidate, and show the other in relationship to the ear.

By using the ear anatomy cut through illustration, see image 56, the audiologist can explain where the candidate has problems today and how the Baha solution could improve the situation. It also makes a clear connection between how the Baha functions and the parts of the system; implant, abutment and sound processor.

The demonstration tool has flat surfaces in plastic materials, which make it easy to clean and disinfect with antibacterial wipes. The relatively small tool makes it easy to store or just keep on a desk area.

Image 54. Side view of tool grip

Image 55. Pick-me-up curvature

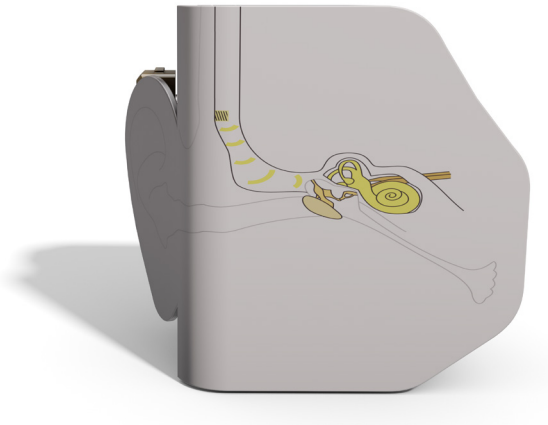
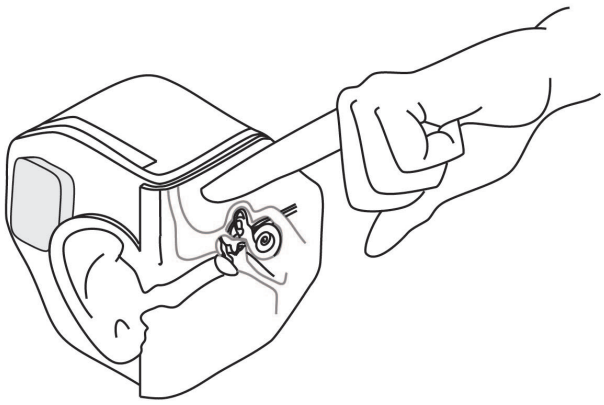


Image 56. Anatomy illustration

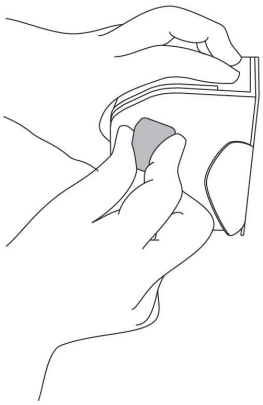
7.2. Counseling

Three scenarios will tell the story of how the personas Kent, Anna and Ruth, presented in chapter 4.5.2., will interact and experince the demonstration tool during a consultation. The demonstration tool challenges Kent's and Anna's questioning of the Baha by being explanatory and interactive. Ruth uses the tool to reach through to her patients and create a mutual understanding.

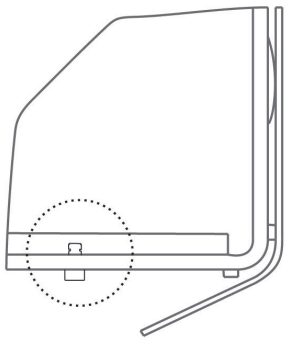
Kent is at his first meeting with the audiologist. He explains that he does not know that much about bone anchored hearing aids but he understands they involve surgery, which makes him skeptical. He doesn't quite understand how BAHA is different from what he uses today and he does not want to get involved with something difficult.



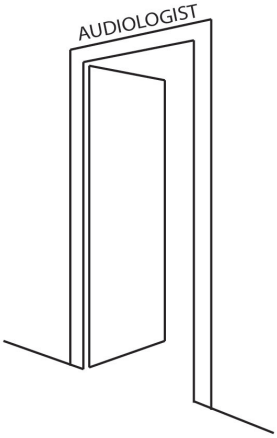
The audiologist brings out the demonstration tool where Kent can see the BAHA system placed by an ear. On the other side is a cut through of the ear anatomy where the audiologist explains where Kent has problems today. The audiologist describes how BAHA uses bone conduction and what could be improved for Kent.



The audiologist explains how the sound processor can be removed. Kent puts the tool on the desk and tries snapping the sound processor on and off in a vertical angel while stabilizing the tool with his other hand. Kent thinks the implant looks tiny besides the ear and the model gives a clean impression with the pale colors.



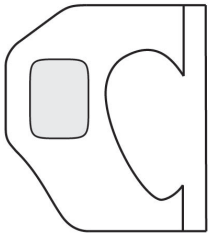
After trying the BAHA softband the audiologist goes away to collect a kit to take home for Kent, to see how the softband and sound processor can improve his everyday life. While waiting Kent picks up the tool wondering how far into the skull bone the implant actually goes. He can see it doesn't go all the way through the plexiglass. He thinks to himself maybe it is far fetched to be worried and connect complications to his previous meningitis.



Anna is back to the audiologists after having tried the soft band and sound processor for four weeks. Her hearing experience was much improved, which she discovered already at the tryout during the first meeting with the audiologist.

The first meeting was a bit emotional for Anna and she could not really take in all the information. Now that she has tried the system at home she has settled a bit more with what it involves.

Her hearing is clearly improved and she feels calmer and need to struggle less with sounds she perceives. It feels nice that there is an aid to relieve the accident consequences. Yet she has only used the softband at home, as it shows too much which she is not comfortable with.

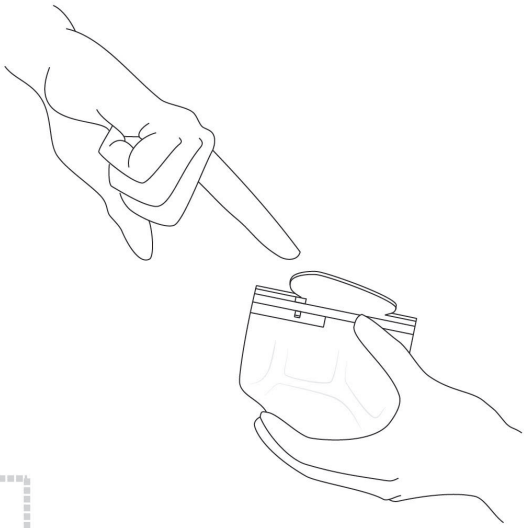


Back at the audiologist Anna sees the demonstration tool again. Now she reflects a bit more over its appearance. The sound processor looks rather stylistic on the tool, like it has some sort of identity, and not so large compared to the ear.

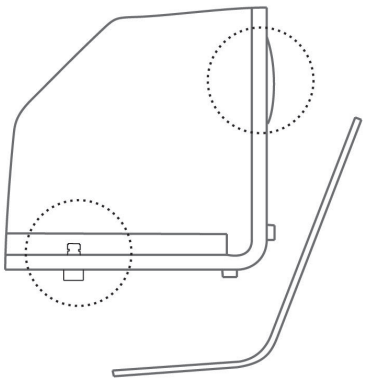
Holding the soft grip gives a warm feeling, and the BAHA solution seems pretty simple the way it is presented. Maybe it is not such a big deal compared to how much it will improve her hearing experience.

Wearing her hair down the sound processor will not show. And wearing it up the sound processor looks similar to a mobile communication device. Maybe the implant is not such a big deal, it does not seem very harmful looking at the tool.

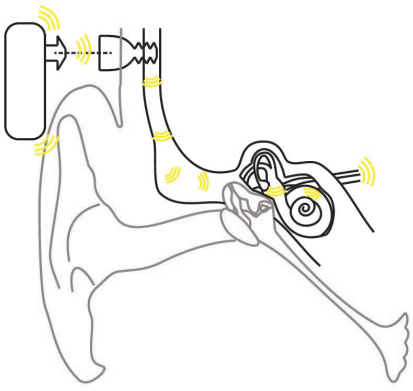
Ruth is getting ready for another counseling this afternoon, this one concerning a BAHA hearing aid. Meeting the patient she registers a nervous person, who is short-spoken and difficult to reach at first.



To get the candidates attention Ruth hands over the BAHA demonstration tool for the candidate to hold. While the patient holds the tool Ruth easily describes where in the ear the current problems are and why BAHA would be a better solution. She moves over to describing the three parts making up the BAHA system and the candidate nods and comments on the implant not going all the way trough the skull bone.



Ruth shows how to snap the sound processor on and off and lets the candidate have a try at it. She also moves over the ear anatomy part to the other side of the tool as she estimates both BAHA solutions to be possible for this particular candidate.



After having collected the home trail kit she returns to the counseling room finding the candidate snapping the sound processor on and off. The candidate looks up saying how fascinating it is that sound can travel through the bone with such small means.

7.3. Construction

This section will describe the construction of each individual part of the tool as well as the assembly. The complete demonstration tool has the outer dimensions of approximately 90x85x100mm (LxWxH). The entire tool is possible to turn, meaning it can be turned 180 degrees around a horizontal axis and look the same, to display two abutment options. The product strives to work with flat materials to reduce manufacturing costs. This applies to all part except for the grip as a great value is seen in the interaction it creates. A design simple to clean and materials resisting disinfectants have been considered to match the medical context.

7.3.1. Grip

The grip is 100 mm high and 80 mm wide at the most. The dimensions were set with consideration to an estimated area to fit an ear with an appropriate distance to a sound processor. The grip is then chamfered with rather flat surfaces to allow grip areas for the palm and fingers. Rounding's on the back chamfers has a 20 mm radius which was tested to be the most comfortable. The curvature under the abutment and sound processor has a radius of 150 mm to provide a comfortable larger grip surface and still make the grip stand on its own, giving a stable demonstration tool. Space is left on the grip's two main flat sides for the bone parts, see image 57.

The recommendation for the grip is to use microcellular elastomeric foam. It has a small cell size giving a greater resistance to gripping reducing wear and tear yet being elastic with a closed surface to make the grip easy to clean. Foams of EVA or EPDM are suggestions. EVA, see chapter 2.6.1, is still cheap in comparison to more common polymers and is possible to recycle. A possible manufacturing method could be expanded foam moulding as it is rather cheap. Using this method also allows for a complex shape without any extra operations adding costs, as the main cost will be the tool itself and not so much depending on shape.

7.3.2. Bone

The two parts representing the bone thickness, 7 mm, are 71 x 45 mm and shaped to fit the grip profile and have drilling holes for the implants, see image 58. The parts have as clear sides as possible to see through to the implant. The parts have been made as small as possible to reduce material but still provide the function of seeing the implant.

Recommended material for the bone part is PMMA or Acrylic, also known as Plexiglass, see chapter 2.6.4. A clear material that when laser cut gets a good visibility through the cuts. A more environmental friendly choice of material would be PLA, see chapter 2.6.3, yet it is much more expensive.

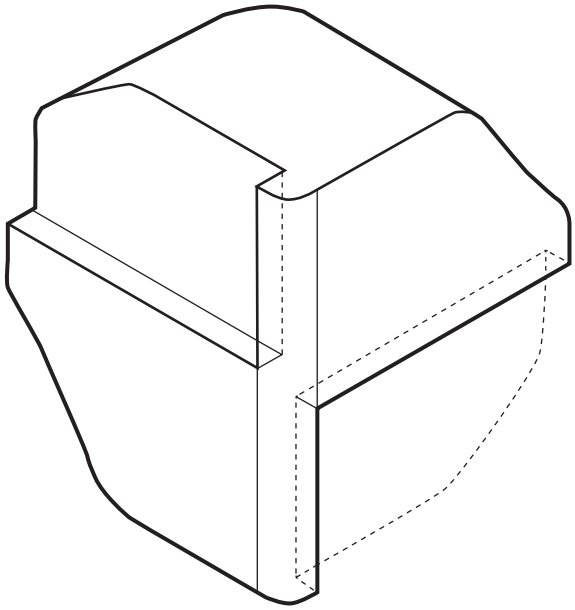


Image 57. Grip

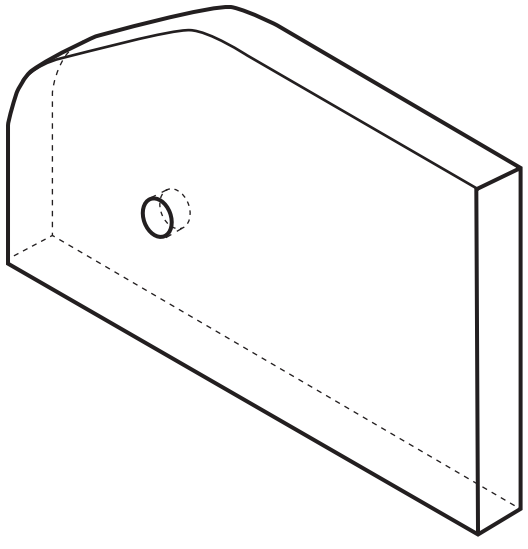


Image 58. Part representing bone

7.3.3. Skin and Soft Tissue

The part symbolizing skin and soft tissue will be in one piece covering the flat sides of the grip. The part will have a thickness of 5 mm and is soft enough to bend around the grip corner. A hole on one side will be made to let the percutaneous abutment come through, see image 59.

The recommendation is to use a rubber or silicone like material to get a smooth surface resembling skin. Suitable material would be TPE, see chapter 2.6.8 or SBS, see chapter 2.6.7. Dryflex, a styrenic thermoplastic elastomer, has been looked at due to appropriate tactile and visual qualities. TPE would be the more environmentally friendly material and the SBS the more economical alternative. The part would be cut out according to the grip profile.

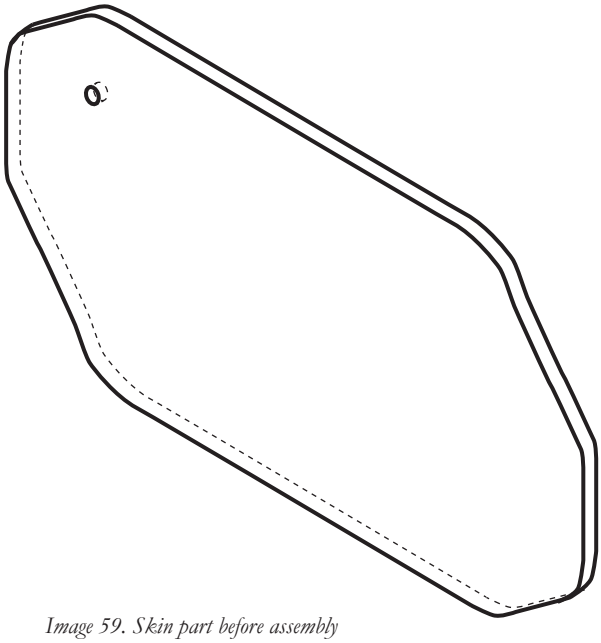


Image 59. Skin part before assembly

7.3.4. Ear Anatomy

The ear anatomy part is cut out to match the grip profile of the implant side not intended to show, the 150 mm radius curvature of the part is thereby on the upper side. The ear is in an estimated one to one scale, about 70 mm long and 40 mm wide. The part is printed with ear details and an anatomy illustration of a ear cut-through showing the outer, middle and inner parts of the ear as well as some skull bone, see image 60.

Recommended for this part is to have a rather thin sheet, about 2mm. The shape is created using a cutting or milling machine. Appropriate material would be PE see chapter 2.6.2, or PP, see chapter 2.6.5, probably more so PP as PE is not so easy to print on and the price span for PP is lower, yet PE has a higher recycle potential. The part is moreover heated to get the desired curvature on the edge.

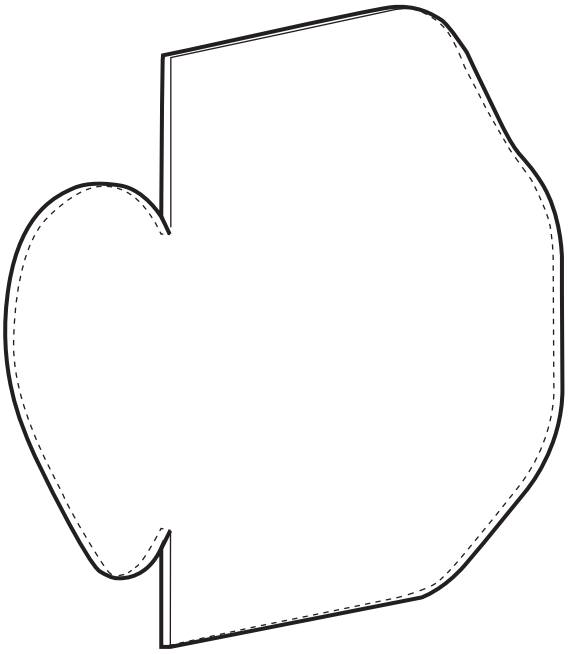


Image 60. Skin part before assembly

7.3.5. Assembly

The grip and bone will be fastened together with double coated tape. The same goes for the skin onto these parts. A strip of magnetic material will be placed on each side of the skin, close to the corner, to be covered by the ear. The depth of the magnetic material on the skin surface will correspond to the height of the abutment sticking out above the skin, meaning they allow attachment of the ear anatomy part at different distances from the skin. On the backside of the ear anatomy part, a magnet will be placed to fit the magnetic material on the skin. Thereby the ear anatomy part can be moved to show the different Baha solutions, see image 61. Entire construction is described by image 62.

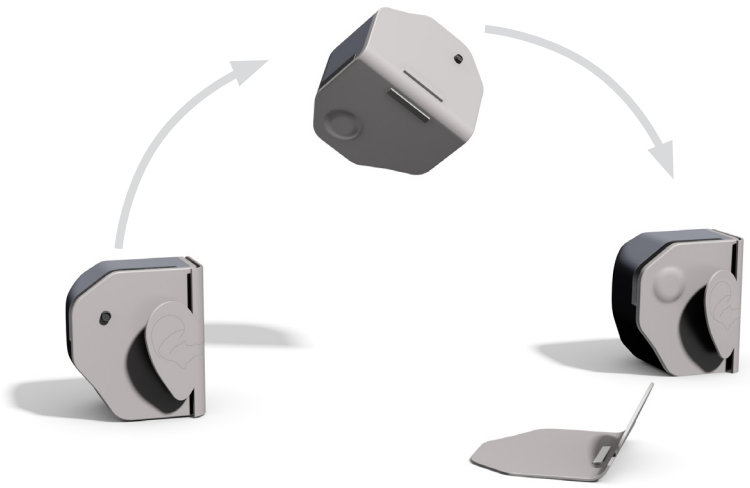


Image 61. Flip to change between displayed Baha solution

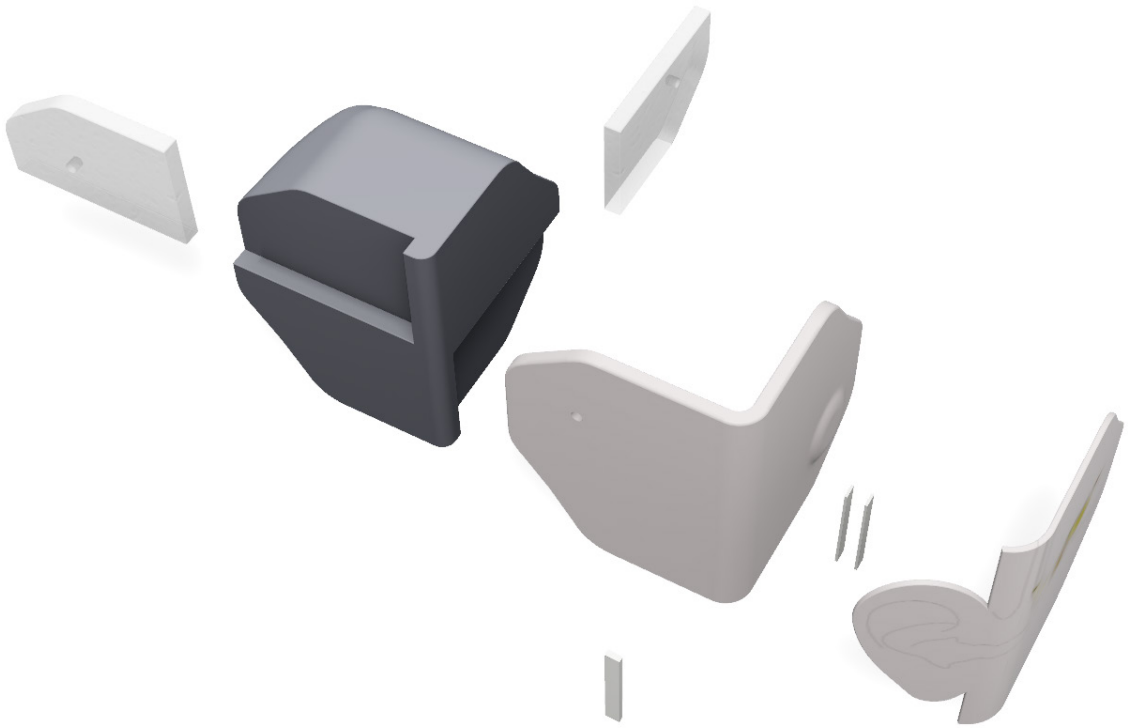


Image 62. Exploded View

7.4. Verification

This sections accounts for verifications made of the design and manufacturing. To show that the final concept has substance to it, measurements have been compared to anthopometrical theory and materials and manufacturing methods chosen have been discussed with active companies within the prototype industry.

7.4.1. Anthropometry

By making a handheld product the aim is to increase the patient interaction and activity during the counseling. The project scope has only stretched to investigating the Swedish context by user tests although the target group of people with hearing loss is diverse as it spans across the globe affecting both genders and all ages.

To further verify the grip proportions in addition to user tests, anthropometrical measurements can be used. An appropriate measure to be looked at is hand length and maximal functionality spread, meaning a handgrip stretching approximately from the thumb to the ring finger. The anthropometric data origins from various sources, yet mainly British adults, and is collected during the early 1980's (Pheasant, 1996). The table 8 below states the hand length and maximal functionality spread of the fiftieth percentile female and male as well as the standard deviation.

Table 8. Hand Anthropometrical measurements

	50% Female	50% Male	sd
Hand Length	174	189	9
Mean Value	181.5		
Maximal Functionality Spread	127	142	11
Mean Value	134.5		

Since the standard deviation is rather low is it seen as sufficient enough to use the above given numbers as most of the population spans around this measures. Another aspect of the standard deviation being low is that is allows for design for the average individual (Bohgard, 2009), in contrary to design for all, mentioned in chapter 2.5.1., which commonly involves possibilities of adjustments. The grip is not possible to alter or adjust but compromises between fitting the presentation of the Baha system in an appropriate way. Still the grip is possible to hold by most candidates.

The length around the grip areas is approximately 120mm. Even though the grip seems to fall within the values in table 8 in theory, users with small hands experience the grip as a bit too large. However the grip should rest in the hand and no considerable force is to apply. The material removed on the curved side surfaces also reduces the grip a little. Within the aspects to account for, reasonable consideration to functionality for users and the Baha system to be displayed has been taken and verified.

7.4.2. Manufacturing

Cutting out the bone, skin and ear anatomy part are relatively easy and cheap operations needing common standard tools. The manufacturing of the grip is a bit more complicated, that doesn't necessarily need to be expensive but it can be hard to find a manufacturer.

The master thesis group found two examples of manufacturers confirming that the grip part can be done. The part would then be casted or molded requiring some sort of tool. Yet it remains to see in what specific material and quality. The price varied quite a lot, from 13 SEK/part including tooling to 50-65sek/part exclusive of tooling which is estimated to 25000-30000 SEK.

Other companies suggested redesign of the grip as they could not make it in one solid part. That would be an option but probably requires more assembly operations and parts to elaborate with. Further research is needed within the area not only regarding manufacturing but also manufacturers, price, tooling and so on.

7.4.3. Function Model

A function model (made of recycled EVA foam for the grip, plexiglass for the bone part, foam plastic for the skin and a solid plastic sheet for the ear anatomy part) verified the construction and functionality of the tool design, see images 63-67. The model worked satisfactory and verification at the audiologist showed that the concept fit well to the context as it much resembles the visual appearance aimed for. The audiologist appreciated the aid and would like it developed and spread to the clinics.

Attaching the grip to the plastic foam turned out to be a reservation, so tape has to be carefully chosen to certify fixation. Moreover the plexiglass creates an optical illusion of the drill hole, which has to be elaborated with. Further verifications and tests are suggested before final assembly can be decided. Possibly another fixation method has to be used and total weight will probably be a trade off against simple manufacturing.

Image 63-67. The demonsration tool in use (snap, hold etc)

Image 68. The demonsration tool placed in a healthcare clinic context.

Image 69. Counseling office

7.5. Context, Color and Shape

The demonstration tool is designed to fit into a healthcare context in which pale and light colors are used to verify a clean and safe environment. Disinfectants are commonly used and products are designed to make patients cope with their current state. The consultation often occurs in an office-like environment where the audiologist and candidate are seated by a desk. The final result fits the surroundings but is still different enough to evoke attention among other equipment at the clinics, see image 68 and 69.

The shape of the assembled demonstration tool is soft with smooth rounding's yet distinct with the flat chamfered surfaces. That way there is a bridge between the sharp, minimalistic design of the sound processors and the softer values desired to communicate within the new strategy. The longer curvature under the abutment makes the tool signal to be picked up and is also a comfortable surface indicating where and how to hold. The upper corner is cut off to frame the sound processor and give it a designated area as well as to provide another grip surface.

The grip has a darker grey color to match Cochlear's color scheme. A darker tone is chosen as the grip is to be held by various persons for shorter time periods. Thereby the color will most probably not look dirty to such a large extent.

The skin and ear anatomy part has a lighter grey tone to be neutral and facilitate visualization of the anatomy illustration. It still has a sufficient amount of black to it to handle frequent use but gives a lighter presentation background area for the sound processor. The skin part has a smooth surface to feel clinically clean and reduce manufacturing operations. The ear anatomy part is also flat to allow the illustration printing and also be obvious in the symbolization of the ear.

Working with grey scale will match the variations of sound processor colors. Standard sound processor colors blend in with different hair tones but there are also brighter colors. As the tool is a supporting product giving focus to the actual Baha system grey scale will not steal any attention yet blend in well and create a sense of unity. Besides the transparency makes the entire system visible to the candidate, see image 70.

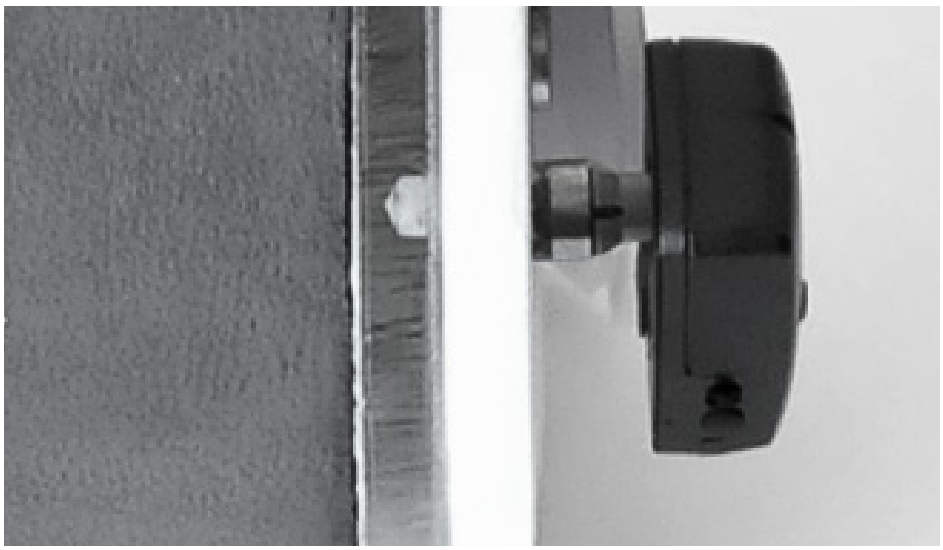


Image 70. Implant close-up

7.6. Life Cycle Estimation

To look closer at the life cycle of the demonstration tool a brief estimation has been done. This estimation will evaluate previously made choices and how they influence the sustainability of the three main life cycle stages the product will go through, see image 71.

7.6.1. Pre-use

To reduce the products impact on the environment the most eco friendly materials are chosen. Not only will striving for reduced and simple manufacturing operations save money but also energy.

7.6.2. Use

The demonstration tool is made as an informative and intuitive product to use by professionals. That means there is a greater control over the product compared to e.g. a single use give away meant for patients to take home. The tool parts are wear resistant to be used for several consultations a week involving being held by patients.

The demonstration tool is easily cleaned and disinfected due to its flat surfaces and is simple to store. The estimated lifetime of how long the tool will be sufficient and useful is around five years. New technology coming in five years might require an updated tool although bone conduction with the current solution might still last another ten years.

7.6.3. Post-use

At end of life the tool parts are recyclable or can be incinerated to recover energy. Separating might be difficult due to double sided tape although possible.

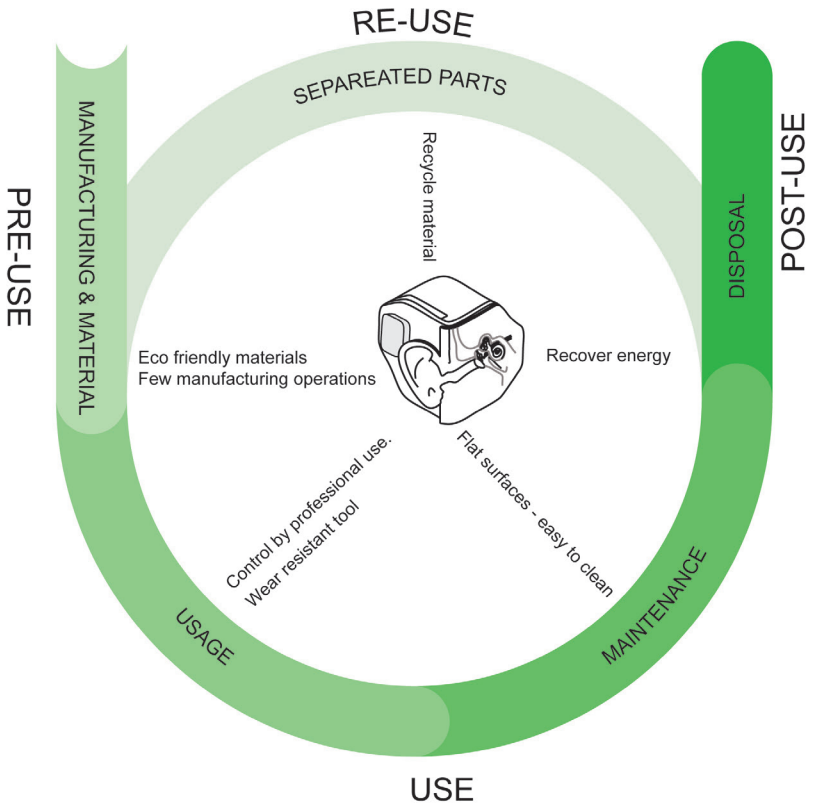


Image 71. Life Cycle Estimation

8. Discussion

The discussion will start with sustainability aspects of the developed demonstration tool. Working with medical technology social sustainability is the driving factor, the thesis group has not had the chance to address it to the desired extent within the scope of the project whereas it will be further elaborated with here. The final result will then be dealt with and then executions of the methods and their sub-results will follow. Finally a brief overall discussion of the master thesis will bridge over to project recommendations and conclusions.

8.1. Sustainability

The social aspect of sustainability might be the most affected aspect by this tool. Having a reduced sense, being hearing in this case, has a great impact in a persons life and could either reduce the ability to do certain tasks, both work related and during the free personal time, or make the person refrain from e.g. certain environments. Besides it greatly affects the people around the person with impaired hearing. The loss for society is great and costs in all aspects will be less with a healthy population. The fact that the Baha system is a solution perceived as an improvement, yet still refrained from due to the identified barriers means that there is a gap to fill to achieve greater social sustainability. If the tool overcomes the barriers, the social sustainability and quality of life would be increased and in the long run society would benefit from the increased understanding and presentation of the Baha system that the tool provides.

Eco aspects have been considered throughout the project yet it comes down to a trade off between desired properties, price and the environmental aspects. Several possible alternatives would make the demonstration tool more eco friendly. Yet these alternatives have to be further investigated to know for sure from start to end of the product lifecycle, e.g. a material eco friendly in itself might require a lot of energy to extract, manufacture and so on. Yet from a company side it often comes down to the economical aspect. In this case the product does not make any profit in itself but is a supportive product to increase sales of the company's other main products. This causes a driving factor to be cost. The value of the product should be there but the cost of the product still needs to be low as it is more of a giveaway to clinics. Another way to put it is that the value needs to be very high in order to defend an increased cost. Common materials and manufacturing methods are often the cheapest, yet not always the most environmental friendly as new innovations usually cost more until they stabilize in the market. Thereby a tradeoff between economical and environmental factors arises. In this particular case it is likely that the company will choose the cost effective alternative, although the master thesis group would go for the environmentally sustainable choices as a future strategy to change prioritization in product development.

To account for further sustainability discussion, the eco strategy wheel, see image 72, has been used as a reference point. Following discussion will cover for the aspects covered in the strategy wheel.

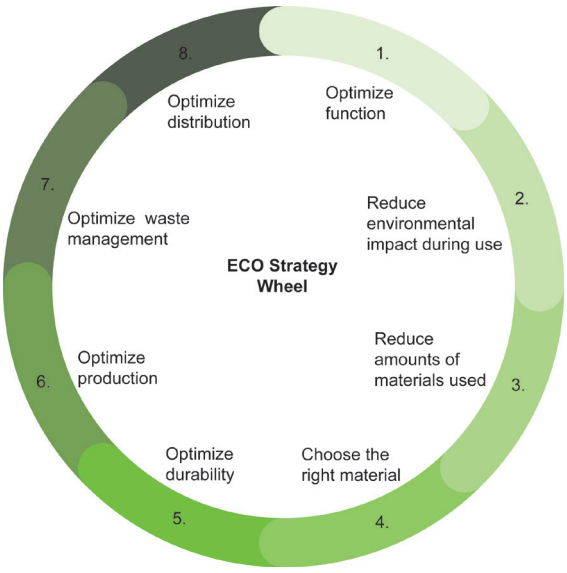


Image 72. The Eco Strategy Wheel

1. Optimize the function

The product function has been developed with the focus of being informative and simple. With uncomplicated manners the product shows the Baha system and the ear anatomy. Only one part of the product is movable in order to reduce possible operations, and thereby possible errors. Discussions can be done around the snapping function of the tool. Snapping the sound processor on and off an implant, which is fastened onto the side of the head, will create a certain angle and hand movement. The operation will not be possible to see unless using a mirror so most likely the movement will be done by movement pattern recognition. Using the tool, the abutment and sound processor will be possible to view at a good angle but not very similar to reality.

2. Reduce the environmental impact during use

The demonstration tool does not require any energy during use nor will it leave any waste due to use. The only addition is the disinfection needed between patients. It is not any large amounts of disinfectants needed, but still a frequent use will add up.

3. Reduce the amount of materials

The tool contains multiple materials. These are chosen with regards to get the desired visual and tactile properties. In a reduced aspect the grip, skin and ear anatomy could probably be made from the same material but with different structures, e.g. foam in various stiffness. Choosing a material possible to make transparent could add the bone part to this group, and reduce the number of materials. Making e.g. snap attachments, casted or shaped into the different parts, to fasten them to each other would discard the magnets and tape. On the other hand that would require a more advanced manufacturing that would increase costs.

4. Choose the right material

In the construction chapter, see chapter 7.3., recommendations for more eco-friendly materials are done. Still it is hard to estimate these aspects and how likely the material is to recycle even if it can be done. More eco-friendly materials could probably be chosen; on the other hand this might require more advanced or difficult manufacturing methods demanding more energy.

5. Optimize durability

The durability of the products sufficiency is estimated to about 5 years, meaning the estimated time until new products will appear on the market. To make the tool last during these years, relatively durable materials are chosen and only one part is detachable. E.g. the skin could have been possible to remove from the implant to show it better, yet due to advice from audiologists that it would wear out too fast it was not chosen for the final concept.

The product concept is made for use in a professional context. This is to get a greater control over the product use and durability, as to e.g. have made a concept with giveaways to patients.

One way to make the product more durable is to have made it possible to replace existing products in the tool with new releases. This has been considered but was found difficult, as it would result in many loose parts or additional tools to make the replacements. Then audiologists would have to be educated in how to make the replacements and the possibly replacements would not be done, instead resulting in products being shown in a non-representative way.

6. Optimize production

The manufacturing methods are rather simple and uncomplicated except for the grip part. On the other hand expanded foam molding is an effective process once running. All manufacturing methods require energy and rather complex machinery. In addition the product needs to be assembled, either manually or by some sort of assembly equipment. This needs to be further investigated, yet a rough estimation is that the volume of the tool is still so low that manual assembly is the most reasonable option.

7. Optimize waste management

The materials are pure in themselves and thereby, if choosing the environmentally friendly options, possible to recycle. One issue is that the parts are taped or glued together to make up the assembled tool. Tape and glue waste might be left and is an obstacle to deal further with. An improvement would again be to design fasteners in the same existing materials.

It is also difficult to control the end of life disposal and how clinics that receive the tool will deal with it. Even if advice on how to dispose or recycle the tool is given it is hard to know if they are followed. One idea is that Cochlear would collect tools when they need to be replaced, either because of an update of products or if the tools have been worn out. Cochlear could then develop a procedure on how to take care of the products and make sure it is done correctly by doing it themselves.

8. Optimize distribution

The all over thought is to distribute the demonstration tool globally to all clinics working with Cochlear's Baha solution. As the tool is solid it is hard to optimize further in terms of packaging. On the other hand it is relatively small and will not take up so much space or weigh too much. No parts are extremely fragile so not much extra wrapping or special packaging material is needed.

Since the volume is so low all demonstration tools will most likely be produced at the same place. Thereby transportation will be an issue. All types of transportation will have an impact on the environment more or less. Looking at a global perspective the product will be scattered out across the globe in smaller quantities. If other products are transported as well the demonstration tool could join that batch. Distribution and logistics have to be looked at further by experts within the area.

8.2. Final Result

The final result is a concept that enables the user to handle the tool without previously being familiar with neither the tool nor the Baha-system. The ease of use and simplicity qualities are highly valued in the final design, still as the construction requires multiple operations and materials, one could argue if it could be made even more clean.

The intention has been to create a flexible tool that displays the Baha system in a truthful manner. In order to do so, emphasis was put on keeping the Baha-system either standing straight or slightly angled during display. Although this in some way corresponds to the truth, it does not correspond to the true position on the user. The thesis group could not completely relate looking at the system and having it attached behind the ear. It has also been a challenge to make a tool corresponding to both left and right hand usage. The fact that implant can be placed on both sides and snapping the sound processor is not seen in reality makes it even harder to translate the experience to a demonstration tool. Anyhow the movement patterns have to be learnt and recognized when implanted. As the experience when using the tool cannot be completely compared to having a Baha system implanted to the skull, one could also question the need of keeping it similar to reality and the context it is used in. Medical models have been studied but refrained from since a pleasant experience and value added to the conversation has been higher ranked than accurately resembling body parts. What if focus had been shifted to only concerning the feeling? Maybe wood or other inartificial materials could have triggered intended feelings although not being conventionally related to the context.

Although the solution is simple to use, both for audiologists and candidates, the concept is still dependent on the interest of the audiologist. Not only in order to keep it visible during counseling, but also to actually trigger initiatives from the candidates. Possibly, audiologists want to keep control of the counseling session and by that refrain to use the tool as it could encourage questions, which are not directly connected to the audiologist expertise area, which could make the time management more challenging. To build up the confidence in using the new tool and address potential barriers it is recommended to provide e.g. a descriptive folder, which briefly explains the intended use of the tool, to the clinics by the launch of the new demonstration tool.

Grip size has been compared to anthropometrical measurements to verify the ergonomics in the final design. The idea was also demonstrated to the audiologist, who previously had been helpful during the data collection. The audiologist liked the solution and claimed that she would definitely use it, yet the tool has not been tried out at real time counseling sessions. Instead personas and scenarios have been used to visualize the aspired use. It is recommended to keep a few completely functional prototypes at counseling sessions during some time to verify the accuracy in the

predicted use. This would be done both in order to identify potential improvements in the design and to see e.g. how the candidates react to the tool and how much the audiologists are willing to use it. Their willingness will depend on how accurate the tool is. The final result is designed for two new coming abutment solutions. The surgical result on the patients is less visible than the current Baha system. The thesis group stress that not until the audiologists are convinced of the two new surgical outcomes, will the demonstration tool without soft tissue reduction be shown to the candidates.

Both candidates and audiologists are considered primary users of the demonstration tool. Still merely audiologists have shared their opinions along the project. In an ideal situation thorough studies, like interviews and concept trial sessions, should have been held also with candidates. Initiatives to get in contact with current Baha users have been taken, but unfortunately without any success. Perhaps interviews with them could have contributed to better understanding of the candidates' needs and drivers. Besides exposing them to the study when being in the middle of the Baha counseling journey would not have been fair. Still the material provided by Cochlear should cover the barriers and provide the required understanding of the candidates' needs and wishes.

8.3. Sub-Result

The research and analysis result is a heavy weighted part in the project when it comes to the needs and requirements as the outcome. As a first conclusion the need and potential in a new demonstration tool was very important in order to verify the actual needs of a new tool based on what existing flaws and gaps to be improved.

The results of the research and analysis phase show that there is potential for a new tool, although it can be difficult to know what potential. In this project it is about matching three main stakeholders, Cochlear, the candidates and the audiologists. The result can be questioned in terms of underlying information e.g. if the methods used are sufficient and conducted in a correct manner. Within the scope of the project, regarding time and getting in touch with stakeholders, adequate effort has been made even though a greater success in finding more stakeholders for qualitative studies had been wished for.

The requirement list has been verified by Cochlear throughout the project and was to some extent set from the beginning. Developing the list and making the requirements more detailed for the specific tool has been rather easily done, although some requirements have been hard to narrow down and make measureable.

Making something visually appealing was specified by core values and current design format elements. Still personal taste, context and how design features interplay affect the perception and experience of the final result in a way that is hard to predict.

Difficulties have also been experienced regarding the criteria falling in under "nice to have" when working with requirements. As industrial designer seeking for that extra aha-feeling for the user when handling the product, many of these criteria can arise. Ways to direct the use of the tool or impression of it can be difficult to incorporate smoothly into the requirements.

The result of the ideation came to be three paths, which gave a good foundation for further discussion with Cochlear. Having the requirements list as a framework to stick with, it was soon realized that there could be various outcomes still fulfilling the requirements. Making the paths a bit extreme was a good way to challenge what is really important for the demonstration tool. However it was important to stress in the presentation and discussion situation that changes and alterations were possible.

The sketches and sketch models presented as a result of the ideation were relatively simple with the motivation that functionality and understanding was more important than appealing aesthetics. Also a model perceived as too realistic can be harder to discuss around and instead of focusing on what can be developed focus is put on incorrect details. On the other hand too undeveloped sketches and models can be hard to get a relation to. For the one who have gone through the ideation some things might be taken for granted or adjusted unconsciously, which is complicated to communicate to someone else new to what is presented.

The concepts for the three paths had to go through another iteration, in which the final result idea came out of making it easy to alter between different Baha solutions and foremost making a tool easy to handle for both audiologist and candidates. Since Cochlear probably does not want to educate the users nor can they really control the use of the demonstration tool, an intuitive simple solution was needed.

8.4. Method Execution

Planning

The ambition has from the start of the project been to stay within the assigned timeframe of twenty weeks. That is why planning was done starting from the end date moving towards the start. The Gantt chart was useful to consider what could be done in parallel and in what order. The chart has been followed surprisingly well throughout the whole project regarding the main phases although some activities were done more spontaneously than planned in the chart. The diary notes that were kept daily are something highly recommended. It made it obvious that things actually had been done and what had been done, as it is hard to forget and lose track over such a relatively long time span.

Data Collection

Literature studies and watching filmed material is always a good start to get an initial grip of a new knowledge area. Yet it was hard to know what to focus on and what would be important to the project. Technical functionality of the Baha system and medical outcome might not come through as used in the end result yet has been important to know in order to get a holistic perspective as "true" as possible.

Interviews and observations have been very valuable for this project and the product to be developed. In an ideal situation more interviews and observations should have been done to account for the variation of candidates and audiologists. It was only possible to stay in close contact with one audiologist, who was very experienced working with the Baha solution. However considering the majority of audiologists in Sweden are not as familiar with the product their opinions are missed out on for the development. Regarding patient interviews there was no chance to conduct such. Attempts to get in touch with Baha recipients through non-profit organizations, communities and such were done yet without any success. No personals connections existed and member lists are hard to get a hold of due to secrecy.

Observations gave good comparison to what was said to be done and what was actually done and also showed how patients acted and was exposed to in the counseling situation. A greater variation would have given better data, as both times the candidate was a woman 60-70 years of age. Meeting younger candidates and those with less experience of previous hearing aids would probably have given a more realistic target group, also considering other countries have a different healthcare system where economical issues might make deciding what hearing aid solution to adapt a more definite choice.

Looking at market competitors through benchmarking was especially useful when it came to communication strategies and physical design of product. At first it was hard not to consider the design of the actual product but throughout the project, and in particular at the recipient lecture during the Cochlear workshop, the advantages of having a less organic designed product came through. With that insight benchmarking could then be used to see what strategies other companies use for their products and how Cochlear's solution could be fronted in an appropriate way.

Analysis

Coming to the analysis of the theory study the challenge was to see what needed to be summed up and what conclusions there were to be drawn. Sometimes too much focus was on Cochlear as a company, e.g. when doing the SWOT.

Working with design formats and expression the DFA was good to really state characteristic design elements, but what was most helpful was the workshop "design the box." Not only did it bring out a "common opinion" that easily could be documented in a chart but it also involved more people in the project without them knowing in detail what it was all about. It was a great way to practice how to explain things and slim information down to its essence. Also learning how to engage participants and making a casual event meaningful was a great experience. Involving a larger crowd also brings new energy and perspectives into the analysis as one easily gets lost sometimes and loses track of what is done and how to see things.

The interviews and observations in combination with theoretical material gave a good understanding of which the audiologists and candidates are, in other words the users of the coming demonstration tool. It is always good to think through and structure this information in the steps of user profiles although it can be a bit difficult when the group can be rather diverse. In relation to the amount of persons working as audiologists and the candidates appropriate for Baha the data collection is scarce. On the other hand invaluable information was gained in comparison to not have met the users in reality at all.

Creativity Methods

Creativity methods were a good way to get the mind

going, trying to find common denominators with challenging assumptions. However it felt difficult being in a completely new area of bone conducted hearing and the roles of candidates and audiologists to know what denominators to find and what assumptions to draw that actually would lead somewhere. Methods performed that have not directly contributed to the final result can still have played an important part in the project without it being fully realized as they initiate other activities closer related to the goal of the project.

Using personas gave a great compliment to the user profiles and an opportunity to account for the potential of a larger target user group than what is today. Scenarios and story telling are good to show where the demonstration tool can fit in and be used in a tangible way. These methods where most useful towards the end of the project to argue for the product developed and not so much used during the project, as they might should have been.

Visualization Methods

Sketches were a great way for quick communication within the master thesis group, yet sketch models were even more useful when communicating with company representatives. That was also the feedback given during mid-presentations as the sketch models created a foundation for discussion and made it possible to show changes and development suggestion. Sketch models were also a good tool to use for rough evaluations and estimation regarding visual and tactile aspects.

Evaluation

In all evaluations regardless of project type it is tricky to set the right criteria and know if these are being ranked and evaluated in a true and correct manner. Sometimes gut feeling might lead the way towards a desired answer and weight connected to the criteria and how the criteria is formulated might be incorrect. For this project the morphological matrix was good when matching sub-solutions with a path and a criteria. Still many solutions could probably fit various paths and criteria with a little modification. On the other hand this matrix was an initial evaluation and further development was to be done which made nothing definite. The Pugh matrix was an efficient way to compare the new concepts to the existing solution and even though only small differences appeared it made a differentiation.

8.5. Overall Project

Regarding the project as a whole it has been very inspiring to immerse into the hearing aid field, which in the beginning was completely new to the thesis group. The thesis group is very satisfied with the project outcome, which design they find intuitive, informative and attractive to look at. Hopefully Cochlear will take the concept further to be ready for production, embracing the tool and the idea of increasing patient activeness to overcome barriers.

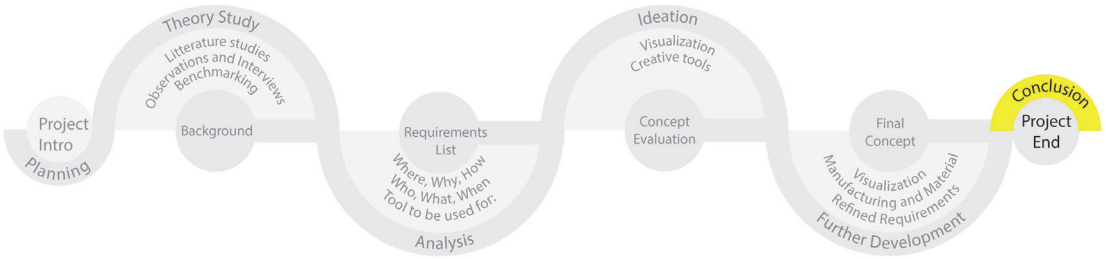
The collaboration with the company has been great and they have been very engaged. Great information exchange has taken place and care has been taken along the entire project.

Sweden has been used as the single research market although the tool intends to be used worldwide. Studying merely Sweden made it hard to grasp the full market range. Therefore some additional verification with clinics and patients in other countries could possibly suggest some revisions and add more value to the users.

8.6. Recommendations

These five bullets summarizes the main aspects of further development proceedings:

- The master thesis group stresses the importance of increasing the interaction between the candidate and the Baha system during the consultation as a strategy to overcome identified barriers. Thereby it is strongly recommended to launch the product as a handheld tool.
- The displayed skin area around the abutment on the tool needs to be verified against actual surgical outcome and audiologists' opinion. Most likely they will not use the demonstration tool towards candidates if it does not resemble their comprehension.
- Regarding continuous work more information gathering is needed concerning materials and manufacturing to reach a final quote and be ready for the production stage. Initial contact has been made with possible manufacturers and this information can be handed over and further elaborated with.
- If introducing the suggested concept of the demonstration tool it is recommended to include an information leaflet, directed to the clinic and audiologist, concisely describing the use and intention of the tool.
- If the grip part of the developed demonstration tool would be an obstructing factor to the extent that the entire tool will not be produced, a modification of the second-generation concept is suggested to proceed with. Excluding the grip and keeping the bent plexi part will still be informative in the same way yet loosing the interaction relationship building with the system.



9. Conclusion

This chapter will complete the project by providing the answers to the initial research questions, restated in bold font below.

How could a new demonstration tool communicate an understanding of the surgery and daily care with the Baha system?

Being the central element during the counseling conversation the tool can, by making the whole system visible, simplify the communication between the candidate and the audiologist. A handheld product is more likely to create a relationship and prerequisites for the patient to take a more active role during the meeting.

Understanding of the Baha system is facilitated by an intuitive design with no language barriers to be adapted for a global market.

How could a new demonstration tool facilitate an attractive presentation of the products through; display of the Baha system, explanation of features and benefits, functional training in using the system and communication of the company core values?

In order to be attractive in a healthcare context the demonstration tool is honest in the way it presents the aid system by visibility and giving necessary information about the ear anatomy connecting to the Baha system function. The tool's subtle colors and shapes puts attention on the actual Baha system to explain.

By being designed to be simple and intuitive to understand and use, the tool more so neutrally explains the Baha system. Because bone anchored hearing aids and surgery are sometimes assumed as complicated but are in the aspect of medical technology simple the Baha system is presented in an equally simple way.

Functional use by snap-training is encouraged by multiple ways of grip interaction.

The demonstration tool offers a possibility to get to know the performance of the Baha system and how it can suit the individual preferences. It is also easy to use, fronts the sound processor design in an attractive way and is not only a display but also an interactive tool, which sums up to all the Cochlear core values.

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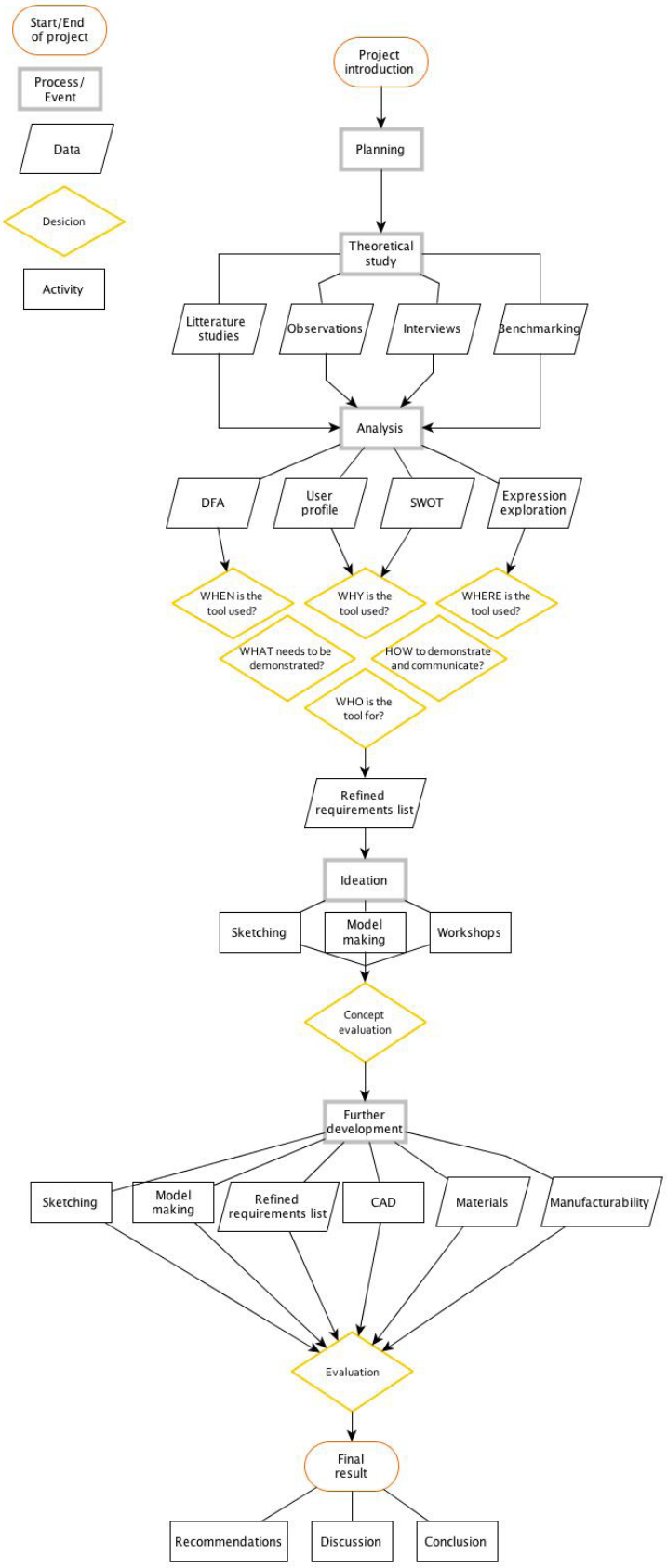
Appendix

Appendix 1 - Process Flow Chart



Appendix 2 - Cochlear Visit, Got, 2012-11-06

Meeting 1 Adi Nilsson

Target groups - professionals: surgeons and audiologists

Private: candidates and recipients

Candidates, "potential users", are people who found they have hearing loss and could be helped by Baha.

Recipients live with the Baha implant, "end users".

Key issues

1. Spreading the knowledge and awareness about the Baha solution. (Finding out about the solution, awareness is low today.)

2. Getting involved emotionally (most important issue, fact based selling arguments today)

Address the journey from being a candidate to a recipient; currently 5 out of 10 decides to go forward with the solution after being in contact with the product. "try it before you buy it"

Solution consists of implant – distance and sound processor

Difference in clinics, used to operating with the implant; many patients, or not so used to the solution; 1 patient per month.

Audiologists learn very little about bone anchored hearing implants during their studies.

Cochlear's strategy: 4 goals

- Increase referrals - remit patients, spread info
- Raise conversion – increase the amount of people saying yes to an implant
- Enhance user experience – "be hassle free"
- Support sales

Love marks – emotionally engaging, loyalty beyond reason

Core values:

Aesthetic design

Reliable performance

Ease of use

Benefits – lifestyle – simple - (core values)

70% is over 55 years

10 % are children – parents important communication

10000 new users each year

competitors take about 3000 users

=13000 recipients – 5/10 candidates says yes – 26000 possible

Always use illustration instead of pictures, more fair picture with a kinder language.

Search tip: Baha activation

Meeting 2 Henrik Fyrlund

Sound processor goes to 8000 Hz, speech is within 1000 – 3000 Hz, focuses on speech frequency.

Counseling journey,

1. BC-direct - hearing test by audiologist: Measures hearing threshold - unaided and with softband (Where our product fits in???)

2. Decision; is this something for me?

3. Book surgery

4. Healing takes about 6 weeks

5. Second visit to surgeon - test stability of implant with ultra sound,

6. if 5 ok, meet audiologist for activation

(if bad bone quality the surgery will take place in two steps)

Materials:

PEEK - plastic for sound processor attachment part, and for magnet. Biocompatible

Titanium - for abutment and implant

Three programs possible to install in digital sound processor e.g. outdoor, music, noisy environment.

Baha has sound uptake from all angles, can be installed e.g. from forward direction if in a conversation (BheindTheEar – aid mic is upward)

Cochlear has a counseling tool kit consisting of:

- All analog and digital sound processors
- Different colored cases
- Soft band
- Diadem
- Prototypes of "headphones" and "BTE-thing"
- Snap trainer

Manufacturing in Switzerland - soft band and sound processor attachment part

Manufacturing in Denmark - magnet

Types of hearing loss:

SSD - single sides deafness, dead cochlea, implant in deaf side

Conductive hearing loss - most common, outer ear and/or middle ear damaged, cochlea works. Can have problems with both ears, will have stronger hearing on the side with the implant.

Mixed hearing loss

Reasons for turning Baha down:

Cost (sverige, landstinget betalar) – solution: approx. 40000kr

Surgery: approx. 60000kr

Surgery – risks

aesthetics

Negative experiences

Difficult to heal implant, "open wound"

Surgery

Cut out edgy "U", open, remove periostitis layer=results in skin reduction (nergröpning: aukustiska fördelar, processor närmare huvud, dock "kal flack")

new surface treatment is currently tested (HA-coating, Hydroxyapatit) since a month ago, to be continued. Improve skin regrowth

At least 20 db reduction, sound processors in span of 45, 55 and 65 (with extra battery) db

Before sound processors were analog - with regulators for adjustments

Now they are digital with software for programming

Extra device: remote control, mic, audio streamer for tv

Snap trainer - approx. 100 kr, help to put implant in relation to body.

Patients possible to make own choice: glasses – contacts, and hearing aids… Rare within the medical sector

Meeting 3 – Nick

Selfcounseling, Ten categories:

- Intro
- My hearing
- Hearing and Hearing loss
- Choosing a solution
- How implants works
- Getting an implant
- What to expect
- Expectation exercise
- How will I look?
- Next steps

Have developed an interactive online tool to be launched in January.

Scenario based - personas and fictive stories

SSQ – expectation exercise

Appendix 3 - Visit to Sahlgrenska Univerity Hospital, Got, 2012-11-15

Interview with Ann-Charlotte Persson, an adults audiologist working with Baha solutions at Sahlgrenska. One out of in total 4 audiologists and two surgeons working with Bahas at Sahlgrenska.

Experience

- Has been working with Baha solutions for more than ten years

- Has a high counseling frequency with approximately 4 counseling sessions a day, two days a week. Some other audiologists at other clinics might according to her just have five candidates a year.

- A-C Persson has counseling for adults that mean candidates above 18 years old.

Consultation

There are generally two entries to a first time visit at the specific clinic, either through an external referral from a doctor or that the hearing defect is discovered within the clinic.

Generally, a Baha solution is discussed when the currently used hearing aid is not longer working properly. E.g. when having issues with eczema. A test period is then offered in order to try out the hearing experience through the softband and

- Counseling meetings include both first time visits and revisits where the Baha sound processor has been tried on a soft band for about a month.

- Each meeting is scheduled to one hour. Nonetheless, the time of the actual meeting varies a great deal depending on the knowledge of the candidate and if it is a first time visit or a revisit.

- Generally first time visits take about 40 minutes for Ann-Charlotte Persson, to conduct and then the remaining 20 min could be used for preparations and journal writing.

- The material she uses during counseling are mainly the showing of implants and abutments and visual material such as real pictures. Currently she uses the old brochure version, as the new one looks too flashy.

- The candidates also get the opportunity to try a sound processor on a softband or headband during the first time visit.

- After the meeting, the candidates are asked to try the sound processor on a softband or headband, at home during about a month in order to try out the hearing experience as well as to learn how to handle the sound processor and practicing the different hearing strategies. The test period could be prolonged if the candidate wants to try different brands.

- Subsequently a decision is taken whether to move forward in the process or not.

- The snaptrainer is not used during the counselling. Instead Ann-Charlotte Persson shows the attach- and detachment and then she let the patient try on the softband. There is no meaning by trying on something that is not representative for the real use, she said.

- Ann-Charlotte Persson cannot notice any particular difference when it comes to the kind of counseling needed for the various ages of the adults that she advises. Similar questions arise regardless the age of the candidate.

- A-C Persson believes the communication strategies are the most important parts for her to explain to the candidates. Communication strategies could for instance be where to place oneself in a room in order to lock out disturbing sounds, take advantage of the direction etc. All candidates have to practice and adjust their strategies according to A-C Persson, no matter if one has used a hearing aid previously or not, one has developed successful and less successful strategies that could be improved.

- The candidates generally want uncomplicated and easy to handle solutions, according to A-C Persson. The candidates who have had conventional hearing aids before are more interested in specific functions and want to get e.g. more base sound. Many patients have had conventional hearing aids before, but there are also patients who had tried other types of solutions previous to the Baha counseling.

Audiologist knowledge

- The counseling work could be described as a breakpoint between psychology and the profession as an audiologist. One needs to have a sense for the patient's state of mind before initiating the counseling meeting. The intuiting is often done directly when welcoming the candidate in the waiting room. Sometimes one does not get it right and initiate the meeting in the wrong way however it is often quite easy to adjust during the session.

- If the candidate is not ready for getting to know the solution directly, a suitable initiating question could be "How do you experience your current situation?" Otherwise, the general opening question is "How much do you know about bone anchored hearing aids?" and then she adjusts the succeeding counseling depending on the answer.

- Some candidates are not ready for counseling and should rather meet a psychologist before the audiologist should start with counseling.

- In the profession Ann-Charlotte Persson wants to provide information and facts, not purchasing material.

Candidates Perceiving Baha

- Candidates are a little bit frightened of the surgery, yet the hearing is the most important factor and thus prioritized to fear of surgery and cosmetically aspects.

- Most candidates prefer Oticon to Cochlear on the first visual impression and then due to the sound perception.

- It is seldom that patients do not want to try the Baha on a softband.

- Some patients do not want to continue due to fear of surgery or previous experiences. Then there is an option to continue with softbands.

- The feeling of the buttons and sound quality affect the hearing experience that the candidates have.

Candidate's experiences

- Issues that patients have with the Bahas are according to A-C Persson that the implant might fall out from the skull. If a patient changes his or her mind, there is always a possibility to remove the implant. The skin and skull bone will then get healed.

- The majority of the patients uses the Baha the entire days and keeps it in a box besides the bed. Since the usages of the Bahas are logged, the audiologists know exactly at what times the candidates has used the Baha's. The processors offer a standard program and the possibility to add manual programs. The standard program is most frequently used, whereas the manual programs are mainly used in combination with e.g. a telephone-cable.

- The candidates who have not had hearing aids before get a strong emotional experience and get happy when trying the Baha on a softband whereas people with previous experience of hearing aids do not reach as strongly.

Observation

- Two brands are available at the clinic, Cochlear and Oticon.

- Both brands have similar materials for displaying the products.

- The corresponding "snap trainer" that Oticon developed is also made in Plexiglas and is shaped as a prism, displaying the sound processor n an angle.

Appendix 4 - Visit to Sunderbyns Hospital, Luleå, 2012-11-23

Interview with Maria Rosengren and Lisa Sundström children audiologists and Annika Eliasson adults audiologist.

Experience

• Lisa has worked as an audiologist for 34 years, approx. 12 years with Baha

• Maria has worked for 6 years as an audiologist and with Baha

• Annika for 21 years and the past 6 years with Baha

Difficult to estimate frequency and amount of treatments, they have now gotten 4-5 referrals in a short time at the children department. At the adult section they see about 10 patients a year and of those 5-6 are new referrals.

At the children's department many suffer from atresia, that is deformations of the ear canal; it could be missing or be blocked, or microtia which is absence of the outer ear.

Consultation

They see the patients at Sunderbyn but the operation is performed in Umeå. There is a plan for two doctors to start performing the procedure on adults in Luleå.

Usually patients see the audiologists after referrals from the Ear (Ear-Nose-Throat) department. In a few cases the patients are sent for another type of aid and the audiologist realizes Baha could be an option. For children they can also come straight from delivery (BB) if they don't pass the hearing screening.

Adults

For adults the patients see the audiologist (Annika) one time before possible surgery to get info and try the sound processor. She starts with asking what the doctor has told them to get a picture of the patient's knowledge and continue from there.

After that she shows the snap trainer to show the product and demonstrate snapping on and off and cleaning. The patient can try on the snap trainer but mostly on the diadem, does almost never use soft band, and the diadem is almost always only worn at home.

Shows the latest brochures (with illustrations) to explain, she tells them briefly about about the surgery, because that is mainly the doctor's (surgeons??) task. If the doctor who sent the referral has not told them properly about Baha she has to repeat. The usual case is that the patients know about the Baha solution when she meets them.

After the first meting with the audiologist they see the doctor for the next meeting to make a decision for surgery or not and perform surgery. Next meetings (could be several) with the audiologist are after surgery to try the sound processor.

Children

For children the audiologists first meet them to do a hearing evaluation. At a second meeting the Baha is introduced if it is an option.

The children have to be about 2 years old to have thick enough (and stiff enough??) skull bone to perform the surgery. Until they have the surgery they use the sound processor with a soft band and have regular meetings with the audiologists.

The children only use soft band because it stays on better and does not give as severe hollowness, due to soft skull bone, even though the soft band still do, where as the SP is moved around on adults to give a good sound it has to be moved around on children to avoid pain and hollowness.

The audiologists to not use the snap trainer at since the implant and abutment is not relevant. Instead they show everything with the soft band including snapping.

No idea to involve snap trainer. Does not give a fair or relevant picture for children.

They also show a brochure from Entific medical systems during explanation (the company cochlear bought??)

Along with regular soft band use a bag for caretaking comes, how to clean the sound processor switch batteries and

so on??

Audiologist knowledge

Seldom try out Baha for SSD, instead takes Cross as an option (even though they see an expanding group to be potential Baha candidates)

They have to sit down a while before consultation to repeat knowledge of Baha and see so that the program to adjust the SP functions.

Adjusting the SP is done by BC-direct signal to the computer. Difficult to work with children here, as they can't be asked, which results in adults getting better adjustments.

They all three feel more secure working the BTE or ITE aids.

Candidates Perceiving Baha

Parents what to do surgery for their children to hear, but rather hearing improving surgery like opening the ear canal or reconstructing the middle ear.

Children often take of their soft band, like in school (in public??), because they are ashamed.

Older children might not want to perform surgery, rather just use soft band and take it of when they don't want it.

Parents and younger adults see the aesthetics as a concern.

Barrier to refrain from getting the Baha is fear of the surgery or feeling they are fine with what they have.

Candidate's experiences

Mostly older people have trouble with cleaning, which leads to bad healing. Also at geriatric care they don't know how to take care of the implant/don't want to, (Oticon has talked about new surgery techniques which would improve this, same as Cochlears???).

The over all impressions of the audiologists are that people have different experiences with Baha.

If the candidate has had a hearing aid before the hearing experience with Baha is not revolutionary yet could be appreciated as a better alternative solution. Some feel it is enough with what they have, especially SSD, have learned to live with it and do hear well on one ear.

Most candidates want to trough with the surgery.

A few do not use the SP even though they have done the surgery. E.g. SSD, if they have an acute problem they don't care to improve. Yet hard to know why they don't get into routine of using the SP as they don't show up to audiologist meetings.

Children do almost never get sad when experiencing Baha, instead get really attached to hearing quickly.

Conclusions

Baha is a good thing.

Improvements could be to spread out the pressure to avoid marks in skull bone of children.

It is sensitive to feedback, wearing hat in the winter especially in Luleå. Especially for children moving around.

A tool like a skull with cross section display and showing the implant in the skull bone could help counseling. Needs to be related to reality.

Appendix 5 - Observation Sahlgrenska, Got, 2012-12-06

Nära samtal med patient via tolk, tight gruppformation. Gestikulerar lite för tydligare förståelse

Patient med tolk

Har haft hörapparat innan men har problem med rinnande öra

A-C förbereder datorn

Inväntar tolk

1315 – mötet startar

Du förstår inte svenska ….

Hur länge har du varit i Sverige ….

Har du gått i skola? praktik, dagis i köket

Är det roligt? Ja

Då ska vi se hur du har det med öronen

Har du hörapparat i båda öronen? Ja, ena bara ibland

Fuktar det? Ja

Hur är det på vänster sida? Fuktar det där också? Nja, inte så mycket

- Konstaterar att höger är ett problem

Doktorn har skickat hit dig. Har ni talat om Baha? Vad berättade han?

Det e något bak på benet. Nu hör jag ingen bakom mig

Kandidat visar och berättar.

Hur går det på praktiken? Vi är två. En kroatisk kvinna hjälper till

Hur fungerar det hemma? De måste prata högre

Bor du med vänner familj? De måste prata högre

Hur är det med TV tittande? Måste läsa texten

Bor du i lägenhet eller hus? Lägenhet

Har du ringklocka, hör du ringklockan? Hör inte alltid så har olåst dörr

Visar allt material på en gång: Cochlears broschyr, implantat (oklart vilket, möjligen Cochlears?), Oticons ljusprocessor samt softband. Visar på illustration av förstorad öronanatomi hur ljudet leds vanligtvis och via benförankring. Visar foto på person med implantat från Cochlears broschyr. Förklarar lättsamt och konsist. Föreslår provning relativt direkt.

OK, när det gäller benförankrad apparat så ska jag förklara lite först. Det apparaten gör är att den leder ljudet via skallbenet. Din hörapparat leder idag ljudet via hörselgången. Ibland har man bekymmer med fukt när man har en vanlig apparat. Då kan en benförankrad apparat hjälpa. Apparaten sätts bakom örat så att örat kan vara fritt. Du ska få prova

Vilket öra?

Höger. Jag tror vi ska prova på band. Jag ska hämta en apparat

- Lämnar rummet och tolk samt patient får prata ostört

Lämnar rummet för att ge patient andrum och tid för reflektion samt att formulera frågor.

Varför rinner det? När jag lägger mig så behöver jag en tuss. Det rinner och kommer lite blod

Det vet jag inte men det vet doktorn. Du får ringa och fråga. Såhär ser apparaten du ska prova ut

Måste jag ha bandet?

Ja när du provar eftersom ljudet ska gå via skallbenet

- Fixar med inställningar
- Patient kollar lite i Cochlear broschyr

Väljer Oticon åt kandidat, kandidaten får inte själv göra valet.

Nu kommer jag sätta på bandet. Jag sätter på bandet först så tar vi apparaten sen. Sedan kommer jag göra ett hörseltest. Säg ja när du hör signalen. Ska se till att inte förstöra frisyren.

Haha, har ändå alltid mössa på mig

Den kommer sitta åt litegrann. Gör det ont? Nej

Nu kommer signalerna

…

….

Visar av och på-snäppning snabbt under förklaring.

Hör du något? Mycket högt

Blir det bättre så? Är det lagom styrka? Är det skillnad? Stor, högre och tydligare

Är det fortfarande för högt? Kanske lite

Programmerar ljudprocessor

Vi provar lite lägre. Tycker du att du hör lika bra på höger och vänster?

Det vet jag inte med den andra apparaten hör jag väldigt dåligt

A-C sätter på bandet och justerar, sätter sedan fast ljudprocessor

Vi provar med detta

Fungerar det bra kan du fortsätta med band eller operera in ett implantat.

Behöver man byta batteri?

Hörapparaten kräver byte av batteri det är samma på båda

Implantatet ser ut såhär. Det här är implantatet

Genomför hörseltest

Det här syns utanför. Och det här sätt utanpå

Vad är detta? (pekar på bilden i cochlear-broschyren)

14.40 Kandidat verkar bli glad när hon hör tal genom ljudprocessorn.

Det är olika modeller

En fördel med Baha är att det inte kommer rinna

Det var därför jag pratade med doktorn

Du behöver inte bestämma dig idag. Testa ett tag så bestämmer vi en ny tid

Vill du prova längre så går det. Måste jag ha denna?

Nej bara bandet. Nu ska du ta av dig bandet. Jag hör inte

Jag stängde av

A-C visar lokalisering av implantat på sig själv genom att peka med fingret genom håret.

Lossa på hörapparaten

Där är en batterilucka. På kvällen öppnar du den och ständer av

Det är ett lite större batteri

Visar implantat och infästning samt ett foto på det (Cochlear broschyr).

Det fungerar som på vanlig hörapparat. När batteriet börjar ta slut så piper det

Brukar du höja och sänka volymen? Ja

Förklarar vilken del ljudprocessorn fästs på.

Du höjer och sänker såhär. Den sätts på lite från sidan

Är du aktiv i någon förening? Nej

Då får du se till att använda den när du träffar vänner

Du får med dig det här och det här

Hur många program har du i apparaten idag? 3

Kandidat lyfter upp sladd för programmering via dator.

Ok, den här har ett program ..bra

Det finns ett stand by läge om du snabbt vill stänga av (tex flygplan)

Håll inne tills du hör två pip då stängs den av. Gör likadant om du vill slå på den

Kan du läsa bra svenska? Jag har många släktingar

Undrar du något mer? Jag förstod allt. Jag är fortfarande besviken på att det rinner

Kandidat tar av softband och får snäppa av ljudprocessor, återkoppling hörs.

Jag tror jag får använda den på vänster öra. Jag tror att jag behöver träffa doktorn

A-C visar hur man sätter av och på samt hur batteri fungerar.

Nu ska vi bestämma tid. Jobbar du alla dagar i veckan?

Jag kommer, jag kommer

Vad tror du om 17de januari? Jag kommer

När? Närsom

Visar volymknapp

Vid 13? Det blir bra

Vi beställer tolk då med

Repeterar hantering snabbt

13.50 Visar Oticon broschyr samt ljudprocessor

Patient är passiv under konsultation, lyssnar på info och provar utrustning.

Appendix 6 - Observation Sahlgrenska, Got, 2012-12-20

Basfakta

Patient med rinnande öron

Tveksam till operation

Har provat intenso (starkare varianten)

Vill troligtvis ha längre testperiod

Patient kommer in, hälsar och sager följande:

- Jag är inte redo, det har varit fantastiskt map hörseln men jag behöver inte höra allt
- Kul att veta att det finns
- Jag kommer gärna tillbaka
- Jag har testat på och av, hör bra men det gör ont. (har testat diademet, gör ont vid infästning)
- Upplevde du någon nytta?
- Ja det är klart, jag hör mycket bättre men man vänjer sig vid att inte höra
- Hur gör jag om jag vill komma tillbaka? (kan tänka sig detta alternativ när hörselnedsättningen blir mer kritisk)
- Du vänder dig hit eller till doktorn
- Vad heter det här?
- Benförankrad hörapparat
- Jag kommer komma tillbaka, jag vet att det fungerar men är inte redo nu
- En doktor här håller på med ett magnetiskt alternativ helt innanför huden. Man fäster sen med en magnet utanpå. Den går att ta av..
- Å det kan ju vara något, vill inte att det ska vara något hål
- Kan man vara med i studien? (bedrivs av Måns Egg Olofsson och Bo Håkansson, 1 patient opererad än så länge).
- Jag ska notera att du är intresserad
- Det skulle kännas bättre med något som inte syns, inte sticker igenom huden
- Jag har jobbat på Astra, kliniska studier är ingenting
- Jag är inte redo, nu, sådana här saker tar tid (måste mogna i beslutet)

Intervju

Väljer apparat tex med avseende på lager, höger/vänster apparat, samt styrke-klass

Oticons implantat är kompatibelt med båda företagens ljudprocessorer – fördel att man kan byta mellan märkena efteråt.

Map läkningstiden så ”läker det så läker det” någon vecka hit eller dit är då inte så viktigt. Det är det långa perspektivet som måste premieras.

Varje enskild audionom här rätt att bestämma vilka rekommendationer som ska göras. Fungerar inte som för tex läkemedel.

Remiss: skickar med journalanteckningar, förtydligar om patienten vill ha ytterligare ett samtal med doktorn eller är redo för operation direkt.

Vid andra konsultationsbesöket – tar upp val av märke samt innebörden med valet, implantat osv. Noterar patientens svar, patienten ska veta vad som väljer, alla korten på bordet.

Patientsamtalet med kirurgen – upplägg varierar från kirurg till kirurg.

Appendix 7 - Assumption Bursting

Understanding

Assump: Today candidates do not fully understand the Baha solution.

Burst: The candidates do understand but the company wants to create a closer relationship.

Assump: A closer relationship will make customers choose the company.

Burst: The relationship still needs to feel trustworthy and professional.

Assump: A physical model can feel trustworthy information wise and emotionally meet patients by expressive design.

Use

Assump: The audiologists will not use the model.

1. It comes through as too selling when it comes from a company.
2. They think they already know their profession

Burst: The model is mainly for the patient as an educational tool and to have a conversation around with the audiologist.

Assump: For patients without any prior knowledge the model needs to be simple and clear

Burst: To show "everything" creates more questions and an increased understanding

Assump: The patient does not need to know everything, at least not all at once with a too complicated model.

Burst: The audiologist can deliver the information in different turns, even with a complete model. Maybe its better to know too much prior to proceeding with the Baha solution than that the info comes after.

Realistic

Assump: The model needs to be realistic to be able to fully understand.

Burst: It is possible to create a feeling and understanding with abstract shapes.

Assump: Abstract shapes do not connect to placement etc.

Burst: Abstract shapes can still imply on placement, body shapes etc. without being exact.

Design

Assump: Colors and textures can not be too realistic in order to give a pleasant impression.

Burst: If the shapes are abstract it can be good if colors and textures connect at least.

Assump: Material should give a clean impression to link to that the surgery outcome will heal nicely.

Burst: Candidates do not want to feel fooled, better to deal with the difficult parts now before surgery.

Assump: It might never be possible to show the exact outcome anyways. Then the model might as well give a nice and clean impression.