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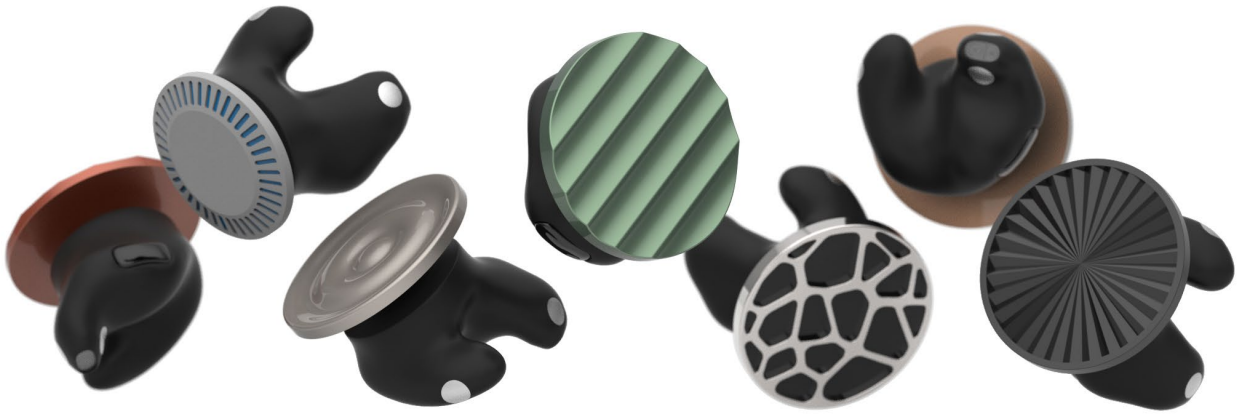

We All Need a HearO

Fighting Hearing Aid Stigma

Master of Science Thesis, Industrial Design Engineering

Lukas Riedel
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CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2018

Department of Industrial and Materials Science
Division of Design & Human Factors

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Preface

Master of Science Thesis IMSX30

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Master of Science Thesis in the Master Degree Program
Industrial Design Engineering

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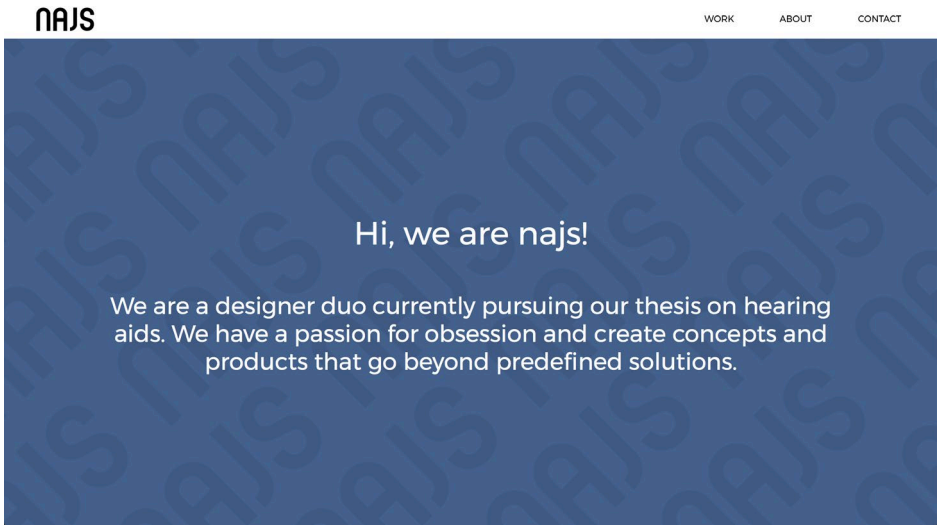
This master thesis project was made by us, Thure Waller and Lukas Riedel. We are both tall, skinny and from the countryside. When we started our collaboration before this project, we launched a company called najs design. This was a way for us to showcase who we are for interesting companies. Our homepage looked like this:



We got tired of people not hearing what is said. The endless repeating of "what" that followed us in the everyday. Not because we always have interesting things to say, but because we want people to be able to listen. A lecture on the theme *design for all* showed what journey eyeglasses had made, which inspired us to try the same with hearing aids.

With five years at Chalmers and in total almost 17 years at school, we felt an urge to spend some time in other premises. We got warmly welcomed at yovinn, a company with one of the finest offices in Gothenburg. Sorry for booking the meeting rooms almost every day. We also got in contact with Widex, a hearing aid company in Denmark.

Many interesting people spent time with us. Thanks a lot for that! Also thank you to Widex for always replying so quickly to our emails. Thank you to our supervisor Fredrick for your support and extraordinary moustache. Thank you to our examiner Oskar Rexfelt for teaching us the fine art of writing a thesis. Thank you family and friends for your support and belief in us. Thank you Johanna and Camilla for being the best a man can get.

Abstract

Hearing loss is a major health concern. In Sweden, 18.9% of the population above 16 experience it and only half of them take action to treat it. Hearing is vital for us to stay healthy and social, so why are we not fixing our hearing losses? We wanted to investigate what hinders people from wearing products that help them hear better. The aim was to create motivation for people to solve their hearing loss.

According to the public opinion, hearing aids make you look old, stupid and handicapped. These strong attributions play a significant role in why people are not wearing them. Nowadays, people want to hide their hearing aids as much as possible, why the design efforts on the monotone hearing aid market are pushed towards smaller and more invisible products. When people take the big step to acknowledge their need for the product, they often get disappointed in the performance. To acquire hearing aids today you are in the hands of your audiologist, with little power to choose which product you will get.

Eyewear was once a stigmatized product. A product that made you get attributions similar to those when wearing hearing aids today. Now however, they are a strong product to express your personal style with. How can the same revolution happen in the hearing aid business? A radical change is needed on the market. We created a vision for what hearing aids should be in the future. With this we added five focus areas that pinpoint how the stigmatization could be solved.

One of the most effective ways to diminish stigma was found to be by making a product used by all, even people without hearing loss. That would extinguish the special treatment hearing aid wearers get. A key to reach this was to find a function desired by everyone. After numerous surveys and a co-creation session, it was found that most people have situations when they can not hear conversations and would like to control their sound environment. Therefore this would become the main function in the final concept.

The final concept further builds on the speech enhancement and sound control function by extending it to include wellbeing in general. The ear is a perfect placement for biosensors. This gives the opportunity to capture data on stress levels and a new way of keeping track of your training efforts. This product called the HearO is for everyone. With an easy solution to change the style entirely, no one is left out. This will create proud users that want to show the product. The most important interaction is done in an innovative way that is intuitive to use, just like a volume knob.

Contents

1. Introduction

In this chapter, the project is introduced.

1.1 Background

Hearing loss is a major public health concern, with almost one fifth (18.9%) of the Swedish population over 16 having a hearing loss (Statistiska Centralbyrån, 2017). The most common type of hearing loss is age related (presbycusis). Among adults aged 65-74 one third has a hearing loss and among people over 85 this increases to more than half having a hearing loss (Statistiska Centralbyrån, 2017). Presbycusis affects both ears to the same degree and impacts high frequencies first. Another factor affecting hearing loss is noise exposure. Both these types of hearing loss makes it hard to follow conversational speech in noisy situations (David, D. and Werner, P., 2016).

A person with hearing loss needs to concentrate harder to follow conversations and can have difficulties to understand what is said. This can lead to people with hearing loss avoiding social situations (Socialstyrelsen, 2009). Research shows that untreated hearing loss has a negative impact on life quality and physical and mental health (David, D. and Werner, P., 2016). It is especially difficult for people working, for whom it is hard to live up to the demands at work (Socialstyrelsen, 2009).

Hearing aids can help a lot of people with hearing loss to hear better, thus giving them better life quality and health. Despite this, a small portion of all who could benefit from hearing aids are using them. In Sweden there are around 360 000 people using hearing aids but research shows that twice as many are in need of hearing aids (Hörselskadades Riksförbund, 2008). This means a large potential market for the hearing aid companies.

Widex, one of the world's leading hearing aid manufacturers are interested in reaching this market. With their global strength and knowledge as well as their reputation of being one of the most innovative in the industry, this makes for a good collaboration.

Designing for disability is an interesting area where it traditionally has been about enabling and attracting as little attention as possible. The approach has not been to project a positive image, rather trying to hide the products with glossy skin coloured plastics. However, when seen, these products may send out a signal that disability is something to be ashamed of. Fashion is rather the opposite, where it is much about creating a product seen by others. Eyewear is a fairly rare market where fashion and disability meet. Eyewear has a positive image without the effort of hiding the product (Pullin, 2011). It is interesting to see if hearing aids can make the same transformation.

1.2 Aim

Create more motivation for people to solve their hearing loss.

1.3 Demarcations

- Solution should not be an information campaign
- Complete technical documentation with correct drawings of a concept will not be included

1.4 Target Group

The main target group for this product development is set to people not using hearing aids with mild hearing loss of age 45-60. This is because we wanted to target those that are not using hearing aids today. By early research we found that people with severe hearing loss treat it, as they can not live a normal life without hearing aids. The ones not treating it are people that have a mild hearing loss where the motivation of solving it is weaker than the barriers of acquiring a hearing aid. The age span is defined by when people start suffering from hearing loss to a great degree.

1.5 Objective

The objective is to develop a concept that invites more users to treat their hearing loss. This will be performed by conceptualizing a new experience of acquiring a product that treats hearing loss. It must include aspects from the full experience. The result should be a product concept shown in its full context with a time to market of around five years.

Research Questions:

- Why are people refusing from solving their hearing loss?
- How can you make more users affected by hearing loss, be unobstructed by it?

2. Approach

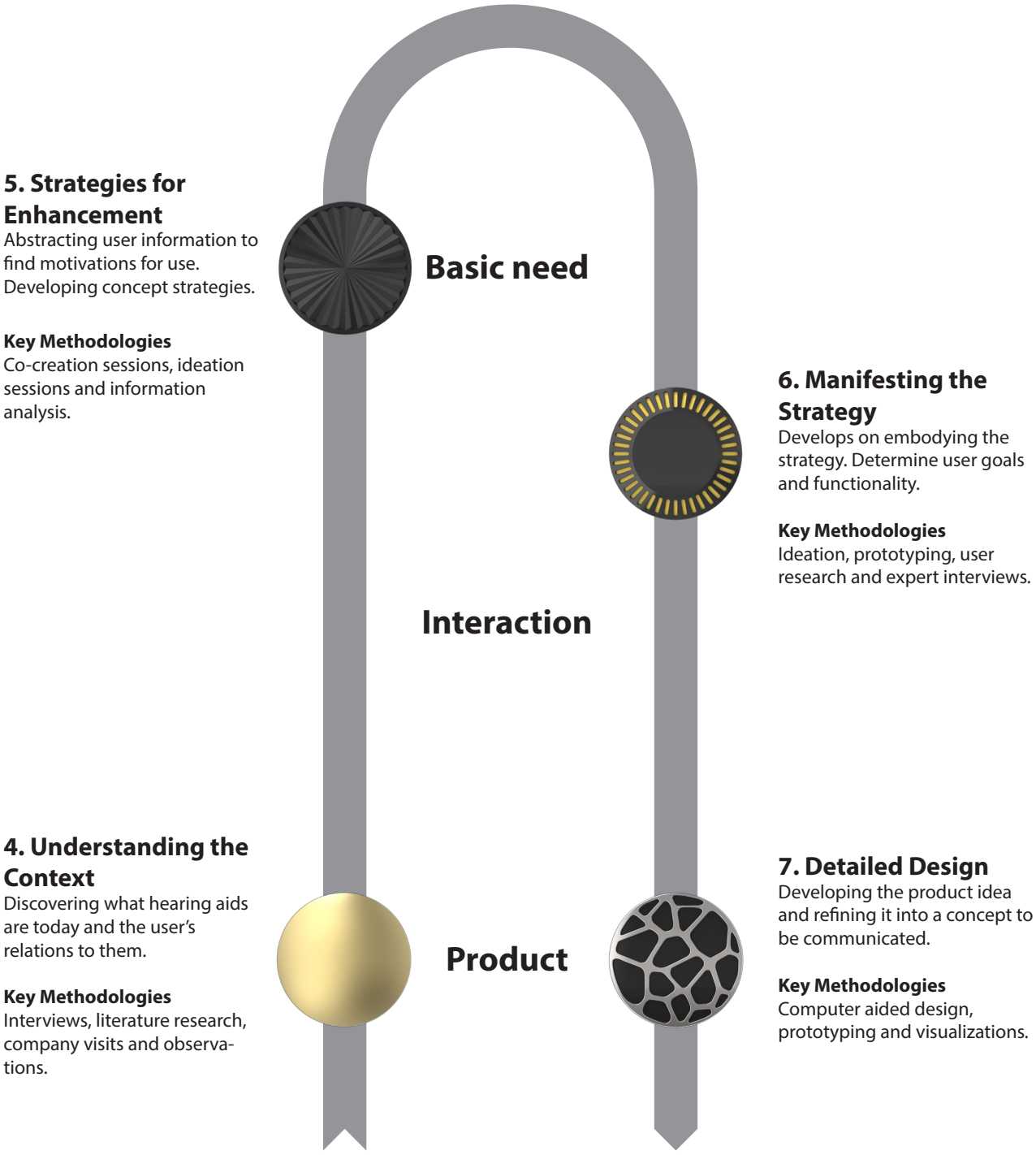
In this chapter the overall process is introduced. A figure over the report layout is also presented.

A hypothesis when this project started was that an incremental change to the products on the market today will not battle the underlying barriers of hearing aid usage. This hypothesis was soon confirmed in the first research phase of the project.

In this development process, where ground-breaking new innovations and radical solutions are searched for, information needs to be processed on a high abstraction level. The project started by researching the current products, abstracting it into basic needs of users before developing a new solution. This ensured that the current solutions did not influence the final design, rather solving the basic needs that people experience having a hearing loss.

An abstraction model used in the project in three steps was created, see figure 2.1, where all the chapters describing the design process are included. The basic level is product, where it is all about the key functions and physical construction of a product. The interaction level is where the user and the product meet. How the interface should be and what the product should do for the user. The top level are the basic needs that the user wants to accomplish by using the product.

Figure 2.1
The abstraction model.



3. Applied Methods

This chapter is a database to use as reference for the methodology used throughout the project.

3.1 Data Collection

3.1.1 Interview

Interviewing is a research method for direct contact with participants, used to collect first hand personal accounts of experiences, opinions, attitudes and perceptions. Interviews are best conducted face-to-face so that nuances of personal expressions and body language are recognizable. However, they can be conducted remotely over the phone or social media (Martin and Hanington, 2012).

An interview can be structured and follow a template with questions or unstructured with a more conversational format, allowing for flexible detours. Interviews can also be semi-structured following a template but allowing for improvisation and tweaking of the questions depending on the answers and the given situation (Martin and Hanington, 2012).

The form of the interview vary depending on the aim of the interview. When collecting quantitative data a structured interview is preferred. A structured interview gives data with less bias which is easier to compare between interview persons. For explorative research with qualitative data an unstructured interview might be preferable (Martin and Hanington, 2012).

3.1.2 Observation

The visual studies of people, artefacts, environments, events, behaviours and interactions are called observations. The purpose of observations in a design process is often to understand how the user acts in a certain situation. What the user says in an interview and what the user actually does in a real life situation can often differ (Martin and Hanington, 2012).

There are several types of observations. In a direct observation the event of interest is studied directly without alteration of the environment. In a participatory observation the observer is taking part in the event studied. There is also what is called self-observations, when the participants observe themselves, for example by writing a diary (Martin and Hanington, 2012).

Direct and participatory observations can be open or hidden. Open observations mean that the subject studied is aware of the observers, while the subject is not aware that they are being studied during a hidden observation. Open observations allow the observer to ask questions to

the participants and have them think aloud. This can give useful insights that are difficult to find in interviews (Boeijen et al., 2013).

3.1.3 Online Questionnaire

Online questionnaires are a type of survey used to collect information from people, typically from a large sample of respondents. The surveys are made using online survey platforms and distributed to participants using social media or emails. The method is an efficient way to collect a large number of quantitative data in a short period of time. With a large sample it is possible to analyse the data statistically. The validity of the survey is heavily dependent on the design of the survey. It is important that the participants can understand the questionnaire and answer in a correct way as they can not ask complementary questions if they do not understand (Martin and Hanington, 2012).

3.1.4 PrEmo

PrEmo is a specific type of online questionnaire which measures emotions towards a product. The tool is built on stimuli in the form of pictures of a product and an emotional rating of it by the participant. The participant rates 14 emotions, 7 pleasant and 7 unpleasant, by seeing an animated character with dynamic facial, bodily, and vocal expressions. This is to ensure a validity of the ratings and the sensed emotions and builds on how we communicate emotions to other people. The scale goes from 0 to 4. The pleasant emotions are: desire, pleasant surprise, inspiration, amusement, admiration, satisfaction and fascination. The unpleasant emotions are: indignation, contempt, disgust, unpleasant surprise, dissatisfaction, disappointment and boredom (Desmet, 2003).

3.1.5 Literature Review

A literature review is a method to collect and synthesize research on a given topic. The literature review is intended to distil information from published sources, capturing the essence of previous research that can be of use in the current project (Martin and Hanington, 2012).

Internet has made the search for information a lot faster, giving researchers access to libraries from around the world using online tools, digital journals and books. However, it is still important to consider the credibility of the sources. It is especially important for websites and blog post which have not been peer reviewed for credibility (Martin and Hanington, 2012).

3.2 Analysis

3.2.1 Affinity Diagram

As long as the knowledge is in people's minds or buried in interview transcripts it is difficult for designers to synthesize what has been learned. An affinity diagram is a method used to externalize the overall picture from a huge amount of data. When doing affinity diagramming all data is written on sticky notes, with each sticky note containing one unit of data. The sticky notes are then clustered based on affinity into a number of research-based themes. The result is an affinity diagram telling a story of the people interviewed, their tasks and the nature of their problems (Martin and Hanington, 2012).

3.2.2 Stakeholder Map

In the beginning of the design process it is important to define all the key constituents that might have a part in the outcome of the final design. One way to do this is through a stakeholder map. The stakeholder map aims to visualize all the key players affected by the design project. The stakeholder map also serves as a guide for the design team during the process, creating a good setting for a user-centered research (Martin and Hanington, 2012).

Stakeholder maps are often created speculative with the design team brainstorming all the people who may have an interest in the design. Stakeholders can be identified by general roles (students, nurses), specific roles (CEO, chief of surgery) or actual people (Robert, Linda). The different stakeholders are then sketched out on a paper or whiteboard. The sketch then evolves into a more structured net with connections and hierarchies between the stakeholders (Martin and Hanington, 2012).

3.2.3 Customer Journey Map

A customer journey map is used to understand all the steps a customer goes through while experiencing the use of a product or service. The customer journey map covers the emotions, goals, interactions and barriers the user experiences during the different steps. The customer journey map is often presented in a graphical way on a timeline with the different stages in the journey (Boeijen et al., 2013).

A problem faced by many designers is that they design touch points or features that work well in themselves but do not fit in to the whole

experience. The customer journey map is a tool to understand the whole process and experience, thus reducing the risk of designing isolated touch points. The customer journey can be created by the researchers in the project but the customers themselves can also be asked to draw their experience of a product or service (Boeijen et al., 2013).

3.2.4 Storyboard

Storyboards tell a narrative in a visual way meant to create empathy for the user and explain the context in which a product or service will take place. With the use of storyboards the context of how, where and why people engage with products can be communicated (Martin and Hanington, 2012).

Storyboards use a number of panels similar to those used in comics. How many panels that are used depend on the narrative. Usually there are three to six panels, but can be more if the narrative is complex. The panels contain illustrations which do not have to be photo realistic, often times simple stick figures will do just fine. The illustrations are then complemented with text-based narration or explanations (Martin and Hanington, 2012).

3.2.5 List of Requirements

A list of requirements states the important factors that a design needs to meet in order to be successful. The requirements are based on findings from the research study in the project and more requirements are added throughout the project. The list can also be useful in the evaluations of concepts during the design process (Boeijen et al., 2013).

The requirements in the list should be substantial. One way to make the requirements more substantial is to define them numerically. For example instead of saying that the product should be portable, say the product should weigh less than 5 kg (Boeijen et al., 2013).

3.3 Concept Development

3.3.1 Brainstorming

Brainstorming is an idea generation method based on the idea that quantity leads to quality. No premature criticism is allowed during the brainstorming process and the list of requirements can therefore be ignored during the process. Another way to do the brainstorm is to focus on a specific requirement at a time, and brainstorm ideas around that specific requirement (Boeijen et al., 2013).

The brainstorm is usually done in a group of people. It is important to create an environment where everyone feels safe and secure so that they dare to say even their most crazy ideas. Improvements and combinations of ideas are wanted so the participants should be encouraged to build on each others ideas (Boeijen et al., 2013).

3.3.2 Co-Creation Session

A co-creation session is a way to involve the users into the design process. The users often have a lot of knowledge and insights into the context and use of a product. Therefore the users can give good feedback on what works and what can be improved in a design (Designkit.org, 2017).

The first step when creating a co-creation session is to decide on which participants are wanted. It may be people that have been interviewed previously in the project or a specific demographic group like teens or people without jobs. The next step is to arrange a space, get necessary supplies and invite the participants to join. It is useful to have tasks or some kind of triggers to get the participants engaged in the problems to be solved. The feedback that the participants are giving during the session should be captured for use at a later stage. It is important to treat the participants as designers and not interview subjects during the co-creation session (Designkit.org, 2017).

3.3.3 Prototyping

Prototypes play a crucial role in the design process. It is the prototypes that make ideas and visions tangible, allowing them to be tested by designers, clients and potential users. Prototypes are defined by their level of fidelity. Low-fidelity prototypes are used in the early stages of ideation to quickly test ideas. This kind of prototypes can be created fast with the things at hand (Martin and Hanington, 2012).

High-fidelity prototypes are more refined and often represent the appearance of the final design in look and feel. These type of prototypes are used in the later stages of the product development to get feedback on aesthetics, interaction and usability from users and clients. In between low-fidelity and high-fidelity prototypes there often are a wide range of prototypes as prototyping is an iterative process (Martin and Hanington, 2012).

3.3.4 Image Board

Image boards or mood boards have been used for a long time in different design professions. Image boards can be used to visually communicate the targeted aesthetics, audience, context or other aspects of design intent. Image boards are made up of a number of images depicting the wanted expression (Martin and Hanington, 2012). Image boards can be used internally to make sure that everyone in a team are on the same track, functioning as a visual reminder of the targeted style. Image boards can also be used to communicate design intent to a client, clarifying on aesthetics or a specific target group (Martin and Hanington, 2012).

4. Background Study

In this chapter, the context of the project is explored. Technological research is performed and users are involved.

4.1 Hearing

This chapter summarizes the findings from a literature review on the basics of hearing and sound. This understanding is basic knowledge needed for the development of a product in this area. The aim was to clarify the physics behind sound and to investigate the hearing organ.

4.1.1 Sound

Sound is made up of pressure waves, which means that the molecules in the transmitting matter are densified and attenuated. The speed of sound differs depending on which material it is transmitted through. As sound is made up of pressure waves, it spreads out just as rings on water. Sound can be reflected or absorbed in different physical materials standing in the way of the waves.

Sound level, how loud we perceive the sound, is often measured in decibel (dB). The frequency of sound, or how high or low a tone is perceived, is measured in hertz (Hz). As we have different sensitivity for sound depending on the frequency, a normalized dB-scale has been developed known as dB HL (Hearing Level), where 0 dB HL in all frequencies describe normal hearing. Normal hearing frequencies lie between 20 Hz and 20 000 Hz, where the upper limit decreases with age (Andersson and Arlinger, 2007).

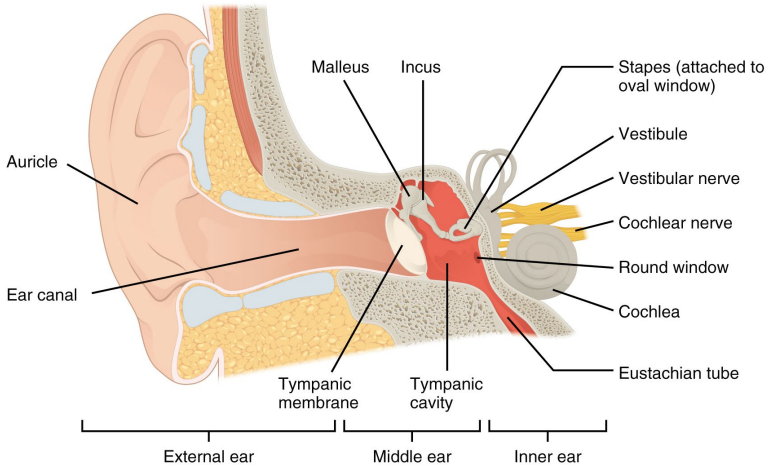


Figure 4.1
The parts of the ear (OpenStax, 2016).

4.1.2 Anatomy of the Ear

The human hearing system consists of two main parts, the brain and the ear which together create perceived sound. The ear itself consists of three main parts, the outer, the middle and the inner ear, see figure 4.1.

The outer ear transfers the sound and the shape of it helps to perceive direction as frequency changes depending on where the sound source is. The ear canal then leads the sound further into the eardrum and slightly amplifies it. The area between the eardrum and the cochlea is called the middle ear and is an air-filled cavity. In this cavity three ossicles, or auditory bones, transmit the sound from the eardrum to the oval window of the cochlea. The inner ear consists of both the balance organ and the cochlea, which we use for hearing. The cochlea is liquid filled, and the vibrations caused by the ossicles on the oval window is perceived by hair cells, which transmit electrical signals to the auditory nerve which in turn leads the signals to the brain (Andersson and Arlinger, 2007).

4.2 Hearing Loss

In the following chapter hearing loss, its causes and how it appears is described. Data was gathered through literature reviews and interviews with audiologists. This is fundamental knowledge for developing a product aiming at solving issues related to hearing loss.

4.2.1 Diagnosing Hearing Loss

To diagnose the specific hearing loss someone experiences, numerous tests are performed at an audiologist. A general health check is done to see if any other disease could cause the hearing loss. It could be as simple as a plug of wax blocking the ear canal. When that is done, a hearing test is performed in an anechoic chamber. Both air conduction and bone conduction tests are performed, and signals are sent through the speakers to the patient who has to push a button when a sound is heard. Air conduction tests use headphones similar to consumer headphones, and bone conduction tests use a headphone vibrating on the bone in front of the ear. If there is a difference in hearing level between the two methods, it indicates a problem in the middle ear. If there is no difference, that means there is a problem in the inner ear. Speech recognition tests are also performed where the patient has to listen to words masked in noise and repeat the words (Grunditz, Gunnelid and Thelin, 2017).

4.2.2 Types of Hearing Loss

There are three main types of hearing loss, conductive hearing loss, sensorineural hearing loss and mixed hearing loss. Conductive hearing loss means that there is failure in transmitting the sound from the outer ear into the inner ear, typically middle ear issues such as hole in the eardrum

or stiffness in the ossicles. Sensorineural means that there are issues either in the cochlea or on the auditory nerve. Hearing impairment because of age, presbycusis, is sensorineural and is a degeneration of the cochlea. It is the most common hearing loss. Noise induced hearing loss is also sensorineural, and these two conditions can worsen each other. A mixed hearing loss means that you have both sensorineural and conductive issues (Grunditz, Gunnelid and Thelin, 2017).

4.2.3 Untreated Hearing Loss

There are numerous drawbacks with not treating a hearing loss. The brain deteriorates and socially a person with hearing loss will become more disconnected. A person with hearing loss is more likely to experience depression, social isolation and even dementia. Also physical risks have been found related to hearing loss, such as increased risks of falling (Bouton, n.d.).

Neuroplasticity is the ability our brain has to reorganize itself by making new neural connections. This is what happens to visually impaired persons who experience increased hearing and haptical precision. The same process happens when not treating your hearing loss, as the brain does not get the auditory stimuli it is used to (MedicineNet, n.d.). This means that speech recognition and voice perception in noisy environments will gradually worsen. Therefore an early treatment of the hearing loss to limit the neuroplasticity is important (Anderson and Kraus, 2013).

4.3 Hearing Aids

A market analysis of existing hearing aids together with literature review and expert interviews with people working with hearing aids gave an understanding of the components and the different types used today. This information was useful to understand the possibilities of development with the state of the art today.

4.3.1 What They Are and How They Work

Hearing aids are sound-amplifying devices made to help people with hearing impairments. There are quite a few different types of hearing aids on the market, but most of them share a similar set of components. Today most hearing aids are digital and have at least one microphone to pick up sound, a sound processor, a small speaker sending the sound

into the ear and a battery for power (Fda.gov, 2016). These components are the core of almost every hearing aid but can be made in different sizes and shapes. Hearing aids can be categorized into two main categories. The ones sitting behind the ear and the ones that are placed in the ear (Plotnick, 2017). Within these categories there are several sub categories.

4.3.2 Behind the Ear

Behind the Ear (BTE)

Behind the ear hearing aids have the components placed in a plastic case resting behind the ear, see figure 4.2. The case is connected to an ear mold by a clear plastic tube in which the sound travels into the ear. This type of hearing aid is easier to clean and handle because of its bigger size (Fda.gov, 2016).

Figure 4.2
BTE hearing aid.

Receiver in the Ear (RITE)

RITE hearing aids are similar to BTE in that they have most of the components in a plastic case resting behind the ear. The difference is that the speaker (receiver) lies in the ear canal instead of in the plastic case of the hearing aid, see figure 4.3. Therefore the receiver gets further into the ear canal and closer to the eardrum. The other components such as microphones and the processor are still placed in the plastic case. The wire between the plastic case and the receiver is much thinner than that used in regular BTE hearing aids (Aids and Plotnick, 2017).

4.3.3 In the Ear

In the Ear (ITE)

These hearing aids sit inside the outer ear instead of behind the ear. ITE are the largest hearing aids sitting in the ear. Because of the larger size they can accommodate more advanced technology, have longer-lasting batteries compared to other hearing aids sitting in the ear. They can also be easier to handle than other smaller hearing aids (Oticon.global, 2016).

Figure 4.3
RITE hearing aid.

In the Canal (ITC)

In the canal hearing aids fit partly inside the ear canal but are not completely inside the ear canal (figure 4.4). Because they are larger than hearing aids that fit completely inside the canal they have longer battery life and more advanced technology. They are also easier to handle than the smallest hearing aids and can handle a wider range of hearing disabilities (Oticon.global, 2017).

Figure 4.4
ITC hearing aid.

Completely in the Canal (CIC)

CIC aids are smaller than ITCs and sit completely inside the ear canal and are therefore hard to see, but not entirely hidden. They are often made in a skin coloured plastic to make them less visible. They usually have less functions but are good for people wanting discreet hearing aids. This kind of hearing aid requires you to have large enough ear canals and are suitable for people with mild to moderate hearing loss (Oticon.global, 2017).

Invisible in the Canal (IIC)

These hearing aids sit so far inside the ear canal so that other people are not able to see them. The only thing sticking out of the ear canal is a small plastic pin with which you can pull them out. Because they are so small, they lack many of the functions of the larger ones. As with CIC, you need a large enough ear canal and a mild to moderate hearing loss (Oticon.global, 2017).

4.3.4 Components

This chapter gives a more detailed description of the components of a hearing aid. A hearing aid is composed of the following main components: one or two microphones, an amplifier/signal processor, a receiver (loudspeaker) and a battery. The hearing aids also contain other electronics such as chips, coils, capacitors and resistors.

Microphones

The microphone in hearing aids is a diaphragm that converts acoustic energy into electrical signals. The diaphragm vibrates in response to the condensation and rarefaction of air molecules from incoming sounds. The vibrations of the diaphragm are then transferred to electrical signals corresponding to the amplitude, frequency and phase of the acoustic signal. The microphone is not only sensitive to acoustic vibrations, but also mechanical vibrations. Mechanical vibrations can therefore lead to feedback problems, when the signal output is registered by the microphone, and it is therefore important to reduce the risk of mechanical vibrations in the design of the hearing aids.

Microphones used in hearing aids can be either omnidirectional or directional. Omnidirectional are similarly sensitive to sounds from all directions while the directional microphones are more sensitive to sounds coming from a specific direction. The directional microphones are used to enhance speech intelligibility in noisy environments. The directional microphones are optimized to pick up sounds coming from a specific direction and sounds from other directions are attenuated.

The hearing aid industry are mostly using what is called electrostatic capacitor mics (ECM) in their products. There is another microphone technology called MEMS (micro electromechanical systems) with some advantages. The main advantages with MEMS compared to ECM are that they have the same performance with less volume, less variation of sensitivity with temperature and less variation between different microphones of the same type. They are more expensive though (Sound & hearing, 2007).

A/D Converter

Most hearing aids today are digital which means that the analogue signal from the microphones must be converted to digital signals. This is done with analogue to digital converters (A/D converters). The advantages of digital is that complex analogue circuits requiring many components can be transformed into a number of computations. Another big advantage is higher precision, as digital is not as sensitive to changes in temperature and voltage (Sound & hearing, 2007).

Digital Signal Processor

The digitised signal is processed in the signal processor and amplified according to the needs of the user. As the signal is digital there is no need for external components, all is done by the signal processor, see figure 4.5. One of the main challenges for the hearing aid manufacturers is to make the signal processor perform optimally while using little power. Another is the physical size of the signal processor, in order to make the hearing aids as small as possible.

There are three ways to go when developing a signal processor for a hearing aid. First is to use a generic digital signal processor (DSP) and implement the right functionality in a programmable software. The second way is to use a specialised off-the shelf DSP and the third is to develop a dedicated DSP.

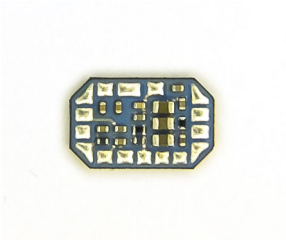


Figure 4.5
A DSP chip.

The open-platform generic DSP is software-controlled which gives added flexibility. The development of a generic DSP often requires a shorter time frame than a dedicated DSP. The disadvantages are larger size and higher power consumption.

The specialised off-the-shelf DSP is similar to the generic but developed for a more specific use, in hearing aids for example. Similar to the generic DSP it requires less time than a custom DSP, and what takes most time is to program the software. The size is fixed and the only way to reduce the power consumption is by lowering performance.

A dedicated custom DSP is adapted for a very specific purpose, and optimized for size and power consumption. Most of the functionalities are hard-wired, which permits quicker processing than in software based processors. There is little flexibility in dedicated DSP but the power consumption is lower. This is the type of DSP used in Widex hearing aids (Sound & hearing, 2007).

Electronic Filters

Hearing aids use filters to modify the characteristics of the sound spectrum. The filters are electronic circuits that amplify or attenuate specific frequencies. The number of filters used differ between hearing aids, some have 15 filters whereas other have two or three.

One of the most common types of hearing loss is presbycusis, which affects only the high frequencies. The low frequencies are not affected. Reduced capability to hear high frequency sounds makes it hard to understand speech in noisy environments. A low-cut filter is used to attenuate the low frequencies that are fully audible for a person with presbycusis. Only the high frequencies are amplified to make it easier to understand speech in noisy environments.

Apart from low-cut filters there are high-cut filters. The high-cut filters are used to reduce the gain for high frequencies, above 1000 Hz. This is to give an appropriate amount of high frequency gain for a given hearing loss. On more powerful hearing aids it can also be used to reduce the risk of feedback.

Before the digital signal enters the signal processor it is divided into a number of frequency bands. The more advanced hearing aids usually have more frequency bands. The division of the signal into multiple bands makes it possible to manipulate different parts of the signal in different ways. This means that the output sound can be manipulated to match the user's hearing loss. Unwanted sounds can be identified and a particular frequency band can be attenuated (Sound & hearing, 2007).

D/A Converter

After the digital signal has been processed by the signal processor it needs to be converted back to an analogue signal that can be reproduced as a sound by the receiver. This is done by a digital-to-analogue converter (Sound & hearing, 2007).

Figure 4.6
A balanced armature receiver.

Receiver

The receiver or loudspeaker converts the amplified electric signal into sound waves. A receiver works like a reversed microphone. The electrical

signal from the amplifier sets the diaphragm of the receiver into motion, generating vibrations that are picked up by the ear and heard as sounds. The type of receiver used by Widex is called balanced armature, see figure 4.6.

The output level that a receiver can generate is dependent on the physical size of the receiver. This means that a larger receiver can generate a higher output level. The smallest receivers are used in CIC hearing aids, where space is limited. This means that CIC hearing aids are only recommended to be used by people with mild to moderate hearing loss. The larger hearing aids like BTE and RITE can have larger receivers with output levels around 140 dB (Sound & hearing, 2007).

Batteries

The most common type of batteries used in hearing aids are disposable zinc air batteries. These come with different capacities and dimensions, see figure 4.7. Modern hearing aids operate at a voltage of 1.1 volts. Zinc air batteries have a nominal voltage of 1.4 volts but this is only the case when the batteries are not in use. When the hearing aid is in use the effective voltage is between 1.15 and 1.35 volts.

High and stable voltage ensures that the hearing aids are functioning optimally. Too low voltage increases the risk of hearing aid malfunction. If the operating voltage is below 1.1 volts the gain and output of the hearing aid might be reduced. The only drawback of a high operating voltage is high power consumption (Sound & hearing, 2007).

In an interview with Kim Hjortgaard Nielsen (2017), who has been part of developing electronics for hearing aids at Widex, he explained how much energy the components in the current hearing aids consume. The consumption is shown in figure 4.8.

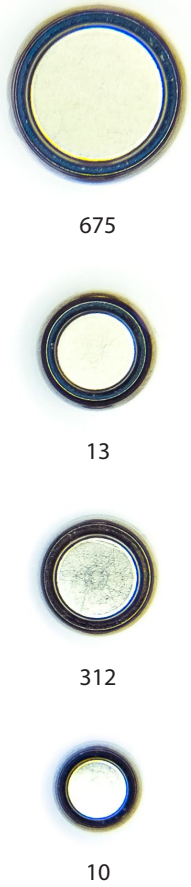


Figure 4.7
Zinc air batteries used in hearing aids.

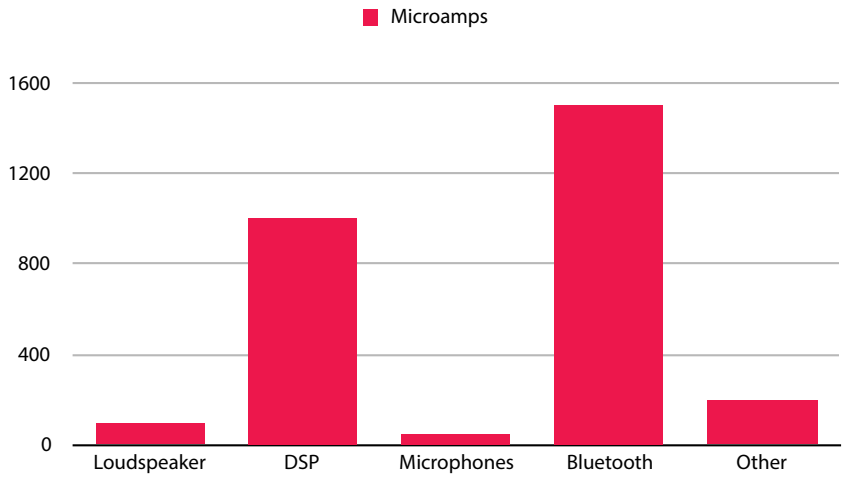


Figure 4.8
Power consumption for different components.

In the recent year, hearing aid manufacturers have introduced hearing aids with rechargeable batteries. There are two technologies of rechargeable batteries being used, lithium-ion or silver-zinc. Both technologies give a full day of battery life before they need to be charged. One rechargeable silver-zinc battery provider is a company called Z-power. They provide retrofit batteries that will fit into existing hearing aid models and use the same form factor as traditional zinc air batteries (ZPower Hearing, 2017). These are now implemented in Widex' hearing aids.

The most common battery size in RITE hearing aids is 312 which has a capacity of 210 mWh (Sound & hearing, 2007). To receive similar kinds of energy levels in a silver-zinc battery from Z-Power, you need a size 675 which has 211 mWh (ZPower Hearing, 2017).

Telecoil
A tele coil is a receiver in some types of hearing aids. It uses a loop system that can be installed in specific rooms. This loop system creates an electromagnetic field sensed by the tele coil in the hearing aids. The hearing aids convert the electromagnetic variations into sound. A switch on the hearing aid lets users decide if they want to hear what is sent out on the tele coil or use the built-in microphones. The loop systems are often installed in theatres, cinemas and churches (Sound & hearing, 2007).

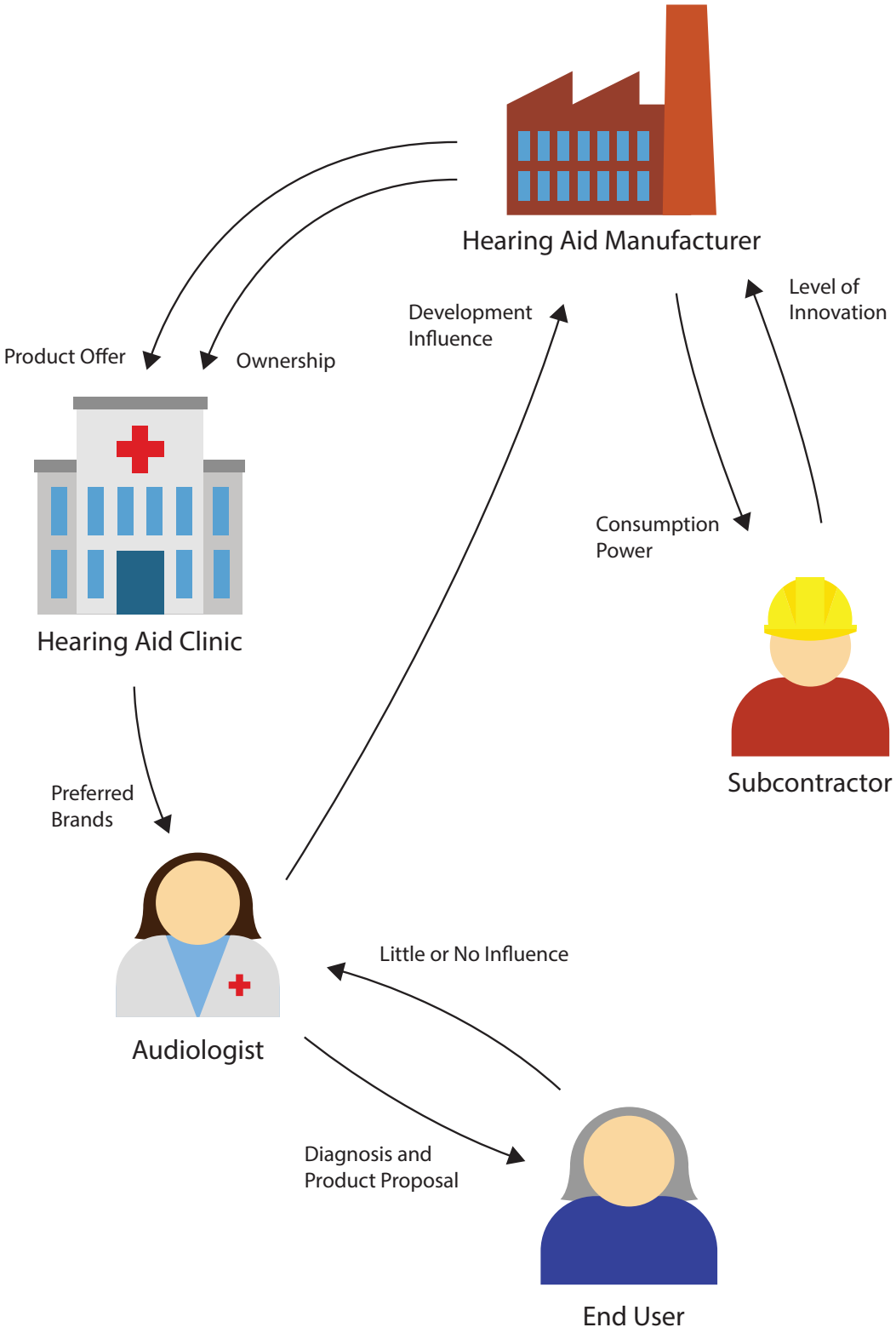
4.4 Stakeholders

The stakeholders are important to investigate in order to create a product that is feasible to put to market. It is also important to see what the different stakeholders can contribute with and what their different needs are. The stakeholder map was created by brainstorming and by interviews with Widex representatives, see figure 4.9.

The most important stakeholders are: the end users, audiologists, hearing aid clinics and hearing aid manufacturers. Other stakeholders to take into consideration are the suppliers of parts for the hearing aids and the legislation controlled by the government.

The way the hearing aid industry looks today, the hearing aid manufacturers are dependent on the audiologists. The hearing aid companies do not sell hearing aids directly to the end consumer. All sales are done through audiologists. Because of this, the hearing aid manufacturers are keen on keeping a good relationship with the audiologists.

Figure 4.9
Stakeholder map.



The audiologists diagnose hearing losses and adjust the hearing aids correspondingly. Apart from diagnosing, they present the different hearing aid products that the end user can choose from. In Sweden there are two options when getting hearing aids: either via the public healthcare or via private clinics. In both cases the end user is in the hands of the audiologist when it comes to which products are being presented. The audiologists often have a preferred hearing aid brand. Either because they have the best knowledge of how to adjust these hearing aids or because the clinic they work for are owned by this brand.

Many private hearing aid clinics in Sweden are owned by hearing aid manufacturers and the audiologists working there are not only medically responsible, they are also sellers. The clinics carry other brands than their own but might be biased on the preferred brand based on the shop's ownership.

Hearing aids are classified as medical devices and the manufacturers are therefore bound to follow certain regulations. The legislation varies between countries and concerns both the technical details of the hearing aids as well how they are to be sold.

Hearing aids use a type of loudspeakers called balanced armatures. According to Joe Jensen (2017), Electroacoustic Engineer at Widex, there are two large manufacturers of balanced armatures in the world, Knowles and Sonion. The hearing aid companies are dependent on what kind of balanced armatures the two manufacturers are developing.

4.5 Laws and Regulations

In order to design a product that is possible to sell, a research on market regulations is needed. This was performed by literature review and expert interviews with an employee at Widex working with regulations.

4.5.1 General Regulations

In an interview with the Senior Innovation Architect at Widex, Svend Vitting (2017), it was explained how they handle regulations at Widex. In general there are strict regulations. The regulations in the USA pronounced by the FDA (Food and Drug Administration) are the toughest and the ones they look the closest to when designing new products. In the EU, the European Commission makes the rules for hearing aids. Today, hearing aids can only be sold through audiologists. In the USA there

is a category called PSAP (personal sound amplification product) which is similar to hearing aids, but can not be marketed as solving hearing loss. These products can however be sold by anyone.

4.5.2 Over the Counter Hearing Aid Act

On August 18 2017 a new law was signed in the USA called the Over the Counter Hearing Aid Act (OTC). This law includes that hearing aids directed towards people suffering from mild to moderate hearing loss should not need to be sold only by specialists. This means that there is no need for prescriptions. There will still be sharp regulations on the devices though. The FDA is required to establish regulations for this new category of hearing aids within the coming three year period. (Hearing Review, 2017)

4.6 Benchmark

A benchmark was performed to investigate the state of the art on the hearing aid market. It starts by finding the major players on the market, and continues to investigate new alternative technologies and innovations. This gave input on how far the development in the industry has come and gave a good starting point on technology insights for the product development.

4.6.1 The Hearing Aid Market

The hearing aid market is controlled to a large extent by six manufacturers, see figure 4.10. The company with the largest market share (24%) is the Swiss Sonova. They have two large sub brands making hearing aids, Phonak and Unitron. The second largest manufacturer is Danish William Demant (23%) with the sub brand Oticion. There are two more Danish companies among the six, GN Resound (16%) and Widex (9%). Apart from the Danish companies there is the German manufacturer Sivantos (17%) and the American Starkey (9%) (Hearing Loss Journal, 2016).

Together these six manufacturers control 98% of the global market. All manufacturers provide a similar range of products, each with their own strengths and weaknesses (Hearing Loss Journal, 2016)

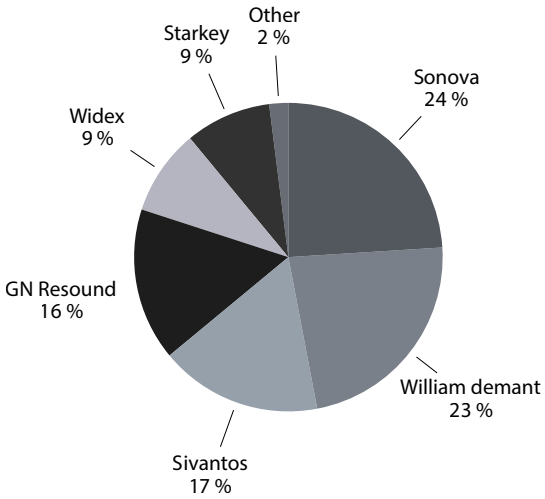


Figure 4.10
Market shares.

4.6.2 Wireless Earbuds

With the evolution of wireless technologies it is now possible to connect headphones wirelessly to other devices. This has led to manufacturers releasing wireless earbuds, some with similar functions to hearing aids, see one example in figure 4.11. Some of the wireless earbuds can amplify sounds and filter out unwanted noise.

Three companies which were early with releasing this kind of products are Bragi, Doppler Labs and Nuheara. As the hearing aid companies are trying to make their products as discreet as possible, these earbuds are larger and more visible. They sit in the ear as traditional in-ear headphones, but are larger and without wires.

Many wireless earbuds have rechargeable batteries with a battery life of two to four hours per charge. Most of them come with a portable charging case giving around three extra charges.

The wireless earbud is a product relatively close to hearing aids and some hearing aid companies have made collaborations with earbud companies. The American hearing aid company Starkey for example have a collaboration with Bragi. Together they make a version of the Bragi earbuds, custom made for your ear canals for a better fit.

Figure 4.11
Bragi the Dash
(Chris F, 2014).

4.6.3 Alternative Technologies

Phonak Lyric

Phonak Lyric is marketed as the contact lens for your ears. It is a really small hearing aid that sits even further into the ear canal than the invisible in canal (IIC) hearing aids. The Phonak Lyric is placed approximately four millimetres from the eardrum by an audiologist. Because of the

placement close to the eardrum less electronic gain is needed. This in combination with an analogue sound processing means that the battery can last up to 120 days (Hearing Review, 2009).

Another benefit of having the hearing aid far into the ear canal is a more natural sound. The microphone picks up the sound inside the ear thus letting the outer ear transform the sound as it does naturally (Hearing Review, 2009).

Except that it sits deeper inside the ear canal, Phonak Lyric differs from regular hearing aids in that it uses a subscription model. Patients pay a subscription fee and get a new Phonak Lyric inserted by an audiologist when the battery runs out (Hearing Review, 2009).

EarLens

EarLens is a new type of hearing aid that uses light to transmit sound. The Earlens system includes a custom lens placed on the eardrum by an Ear, Nose and Throat physician. It also has a behind the ear processor picking up sound and delivering it to an in-ear light emitter. The sound is then converted into light delivered to the lens attached to the eardrum. The lens then activates the natural hearing system (Hearing Review, 2015).

The advantage with this technology is that it prevents the feedback loop troubling traditional amplification, with the microphone and speaker close together. With no risk of feedback loops the EarLens can achieve high gain values across a broad bandwidth (125-10.000 Hz) (Hearing Review, 2015).

Bone Conduction Headphones

Sound is vibrations. Traditional hearing aids and headphones send vibrations through the air into our ears where they are transformed into electric impulses. With bone conduction headphones this is done by sending the vibrations directly through the bone into the inner ear. Most of the bone conduction headphones on the market today sends the vibrations through the top of the jaw (Everyday Hearing, 2017).

The sound quality with bone conduction headphones are is not as good as with air conduction headphones. This is in part due to the transmission not being direct to the bone because of the skin in between. What might be an advantage though with bone conduction headphones is that they do not cover the ears making it possible to hear ambient noise (Everyday Hearing, 2017).

Adhear

Adhear is a new type of hearing aid using bone conduction developed by Otorix, see figure 4.12. The main difference between Adhear and other bone conduction hearing aids is that Adhear does not require surgery. This eliminates costs and complications related to surgery. Their solution is based on an audio processor that snaps onto an adhesive adapter placed on the skin behind the ear. The disposable adapter sticks to the skin of the user like an adhesive plaster that can be worn 3-7 days before changing to a new plaster (Otorix.com, n.d.).

Figure 4.12
Adhear in use.

SoundBite

The first patent for a bone conduction listening device was registered in 1924 by Hugo Gernsback. This device used the teeth as the conduction medium (The Verge, 2016). In the late 2000's a company called SoundBite introduced a hearing aid using similar technology. This hearing aid has two units. One behind the ear with a microphone picking up the sound from the environment and one device placed inside the mouth (ITM). The part in the mouth sits around the inner teeth. The BTE wirelessly sends information about the surrounding sounds to the device in the mouth. The ITM then sends out sound vibrations to the teeth which through the bones lead the vibrations to the inner ear (Everyday Hearing, n.d.).

Personal Sound Amplification Products (PSAPs)

The hearing aids today are very expensive and in countries where they are not subsidized by the government the high cost is a large reason why people are not using hearing aids. In the USA there is a category of

devices supposed to combat the affordability problem of hearing aids. The product category is called personal sound amplification products (PSAPs). The PSAPs are retailed at much lower prices than traditional hearing aids and can be sold directly to consumers without going via an audiologist (Hearing Review, 2016).

For a regular consumer the traditional hearing aids and the PSAPs probably appear to be identical. They both amplify sound, but there are regulations saying that a PSAP is intended to amplify environmental sound for non-hearing impaired consumers. The PSAPs cannot be marketed as hearing aid replacements and should not be seen as hearing aids sold over the counter (Hearing Review, 2016).

4.7 Analysing the Widex Brand

A brand is more than a logo. A brand is how consumers perceive a company. To analyse the Widex brand we have therefore searched in numerous channels to see how they portray themselves and how they communicate with the customers. The aim with this was to see how a future product could fit into the current portfolio or how the brand could be developed.

The hearing aid business is different from other consumer electronics brands in that the brands are not as strong. This might be due to that the hearing aid companies are selling to audiologists and not directly to the end consumers. This means that the branding has been focused towards audiologists. The brand elements can be seen in figure 4.13.

4.7.1 Widex Branding Guidelines

The Logo

The logo originates from the start of Widex in 1956. It has been updated a couple of times during the years but stays true to the original. The most recognisable part of the logo is the shield with the negative space forming a "w". This shield is used on its own when space is limited and on the products. Most of the time though it is accompanied with a custom typeface writing out the rest of the letters in Widex.

The logotype is always presented in a monochrome way in either white, black, grey or silver. With the silver having a brushed metal effect. Sometimes the logo is accompanied by the corporate slogan "high definition hearing" (Branding.widex.com, 2017).

Logotype

WIDEX®
HIGH DEFINITION HEARING

Shield

Colours

Typeface

a b c d e f g h i j k l m
n o p q r s t u v w x y z

Imagery

Colours

The colour scheme of Widex is minimal using black and white as a base. This is to make the content stand out and make the products seem less complicated. To complement the black and white colours they use supporting blue colours (Branding.widex.com, 2017).

Typeface

Widex uses the geometric sans-serif Gotham typeface in their printed materials. It has simple undecorated letter forms making it good at delivering messages in a clear way. To make the message even clearer Widex uses two different weights, Gotham Light and Gotham Bold. The bold weight is used to highlight words or parts of sentences (Branding.widex.com, 2017).

Slogans

Apart from the main slogan "high definition hearing" sometimes seen with the logo, they use slogans for the different product series. The Beyond range has the slogan "Life without limits" and the Unique range uses "Live life large". Both clearly meant to express that you can have an active life even with a hearing loss using Widex products (Branding.widex.com, 2017).

Images

Most of the images used to communicate the Widex brand focus on people and activities. It is about telling a story of the user and the benefits of using hearing aids. The images are made to look authentic and as they are captured in the moment (Branding.widex.com, 2017).

4.7.2 Communications on the Website

The website follows a similar style as the graphical profile. Focus is on storytelling using videos and images. The videos and images show people in active situations. There is little information about the products on the website and it is hard to find images showing the hearing aids.

Apart from the storytelling focus is on technology and functions. This is done by using clear copy writing with the text set in a mix of light and bold weights. This highlights the key functions of the products. The technology and functions are communicated in a non-technical, easy to understand tone.

Compared to some of the competitors, Widex has a website focused much more on lifestyle and storytelling. They also have less information and statistics about hearing loss presented on the website. The lifestyle focus is probably a strategy to tackle the stigma surrounding hearing aids.

Figure 4.13
Elements from Widex's visual identity (Widex, 2016).

4.7.3 Communications on Social Media

YouTube

Widex has a YouTube channel with over 100 videos uploaded. The content of the videos vary between user testimonials, instruction videos, product videos and more lifestyle focused content. In general the videos have a couple of thousand views. The first video was uploaded 2007. In 2015, with the promotion of Widex Unique, the videos started to get more professional with higher quality filming and editing. This was continued with the Beyond series.

For the Beyond series five fictive personas were introduced in short YouTube videos. The videos tell the stories of these personas and how the hearing aids help them in their active everyday lives. The personas are in their late sixties and are portrayed as active and healthy. Of the personas two are female and three are men. They all have fancy jobs and hobbies. The five personas can be seen in figure 4.14.

James, 67
Design CEO and Surfer

Dana, 67
Fashion Consultant and Yogini

Lawrence, 70
Trumpet Player and Grandfather

Haru, 67
Novelist and Jogger

Selene, 67
Restauranteur and Photographer

Figure 4.14
The five personas used to promote Widex Beyond (Widex, 2016).

Facebook, Instagram and Twitter

Widex has almost 200 000 followers worldwide on Facebook. There are new posts one or two times a week and the content ranges from product information and information about hearing loss to other news related to hearing aids. The interaction from the followers is low with few likes and comments on each post.

Widex does not have an official global Instagram account but there are national accounts. The content of these national accounts differ but most of it is promotional materials with images of the Beyond personas and the hearing aids. The accounts have few followers with little interaction.

Widex is active on Twitter and has 4500 followers. The content is similar to that on facebook but with more focus on their products. During the hurricanes Harvey and Irma, Widex searched for goodwill when they announced that all customers would get free replacements of hearing aids lost or damaged during the catastrophes.

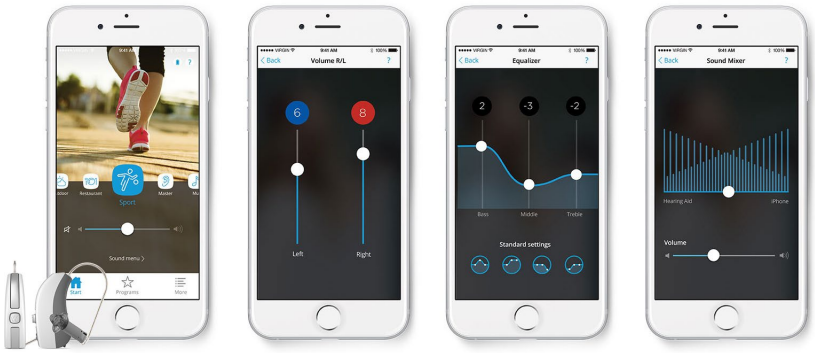


Figure 4.15
Widex Beyond with bluetooth connectivity.

4.7.4 Product Portfolio

Widex has two main product series, Beyond and Unique. Beyond is the newest of the two and has bluetooth connection making it possible to stream sound from a smartphone directly to the hearing aids (figure 4.15). Both series comes in a large number of models and form factors.

The look of the products do not differ much between Beyond and Unique. If you are not into hearing aids you probably would not notice the difference. The shells have a simple design with slightly sharper edges compared to some of the competitors. The larger models have the Widex logo on a button. Other than that there is not much distinguishing a Widex hearing aid from the competitors. Worn behind the ear they all look more or less the same.

The products do not match the other communication from Widex. Widex is portraying themselves as a lifestyle brand with cool people in active situations but their products do not express this lifestyle. Hearing aids have had the same form factor since at least the 60's (Hearing aid museum, 2017) which can be a reason why they feel outdated. They also carry a stigma built up during a long time.

4.8 Interviewing Users and Audiologists

All information in this chapter is derived from interviews. Six interviews were held with users and potential users. The interview sample was selected by their usage of hearing aids and their age. Key were interviews with people with presbycusis that do not use hearing aids, as they are the main target group for this project. Two interviewees fit this description, both around 55. Important were also interviews of other ages and users of the current products, as the stigma is hypothesized to be general in society and users can highlight how usage of the product is. Two other interviewees were younger, 18 and 29, one with hearing aids and one without. One of the last two interviewees was a hearing aid user of 80 years of age and one non-user of 54 years age. Three of the interviewees were women and three were men. To supplement these interviewees, a discussion session was held at "Hörselskadades Riksförbund" in Gothenburg Sweden. 20 participants elaborated on the barriers of acquiring hearing aids.

To get the professional point of view, audiologists were interviewed. One audiologist working in a private clinic in Gothenburg was interviewed. Three more working at the hospital Sahlgrenska in Gothenburg were interviewed.

All interviews had the focus of finding barriers when acquiring hearing aids and how the usage of them is. The interviews were planned beforehand, and the semi-structured interview guidance documents used can be found in appendix 1.

4.8.1 The Public Opinion

All interviews were transcribed and categorized by doing an affinity diagram, see figure 4.17. This analysis formed different subjects that were named. Below all subjects are presented with what the interviewed subjects told.

Batteries

Regarding battery lifetime, the wearers of hearing aids said they last between 3 to 14 days. A preference from all subjects showed an expected battery life of one day if they were rechargeable or one week for single use batteries. Charging was said to be easier than changing batteries. Rechargeable batteries were preferred due to environmental and price reasons. The hearing aids today do not signal in an acceptable manner when they run out of power.

Battery handling was believed to be hard for elderly by the non-users that were interviewed. However, the users that were interviewed told handling was not an issue. Distinguishing between new and old batteries and that batteries fall out of the hearing aid when stored were experienced problems for users. The batteries were sometimes lost when they were dropped because of their size. As the only way to turn off the hearing aid is by opening the battery lid, the batteries were prone to fall out during storage. Hearing aid users said they kept batteries everywhere in case they needed them.

Figure 4.16
Person handling a pair of hearing aids.

Handling

When speaking about putting on and taking off hearing aids, non-users imagined it as hard, especially for elderly (figure 4.16). This was confirmed by some of the elderly interviewed but not one said it was a problem. However, the audiologist told that many elderly do come back for help and had problems with their hearing aids.

SJÄLVBILD
BILD AV ANVÄNDARE
SITUATIONER
PROBLEM
HANTERING AV HÖRSELNEDSÄTTN.

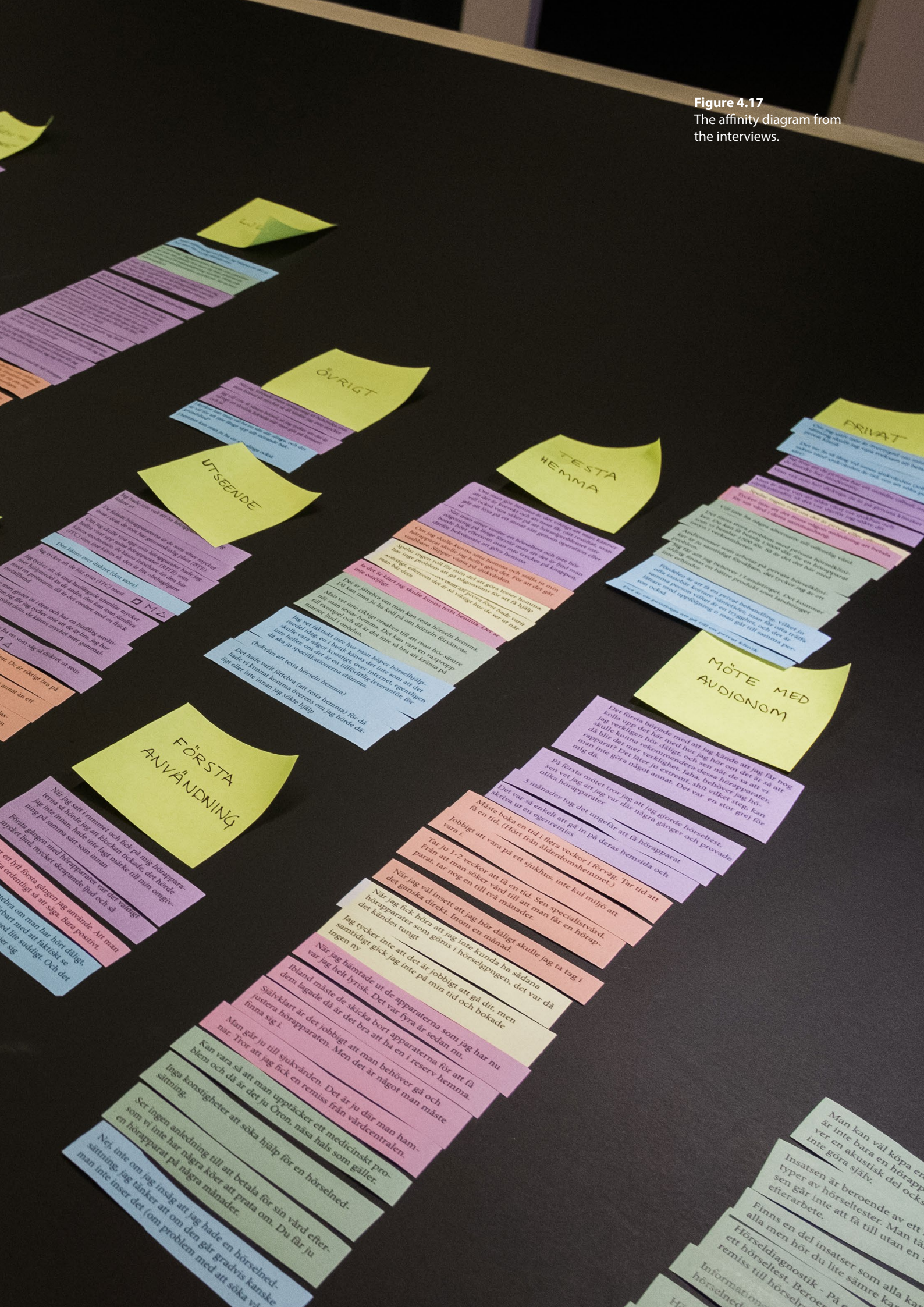


Figure 4.17
The affinity diagram from the interviews.

Cleaning the hearing aid is the most important maintenance the user needs to do. Insufficient cleaning is the biggest reason for broken hearing aids according to the audiologists. Sometimes users are unable to do it themselves which leads to visits at the audiologist for that single reason. All users that were interviewed were ashamed about the cleaning and said they do it to seldom. Cleaning was said to be unsatisfying, as there was never a true feeling of complete cleanliness, even after thorough cleaning.

Changing volume is a much used feature of the hearing aid, and is experienced as very important by hearing aid users. It is a desired function by all the interviewees, but not all hearing aids have it.

Some hearing aids have different programs for different soundscapes, to help the user get the best sound. An audiologist told that the programs were hard to change and that only experienced hearing aid wearers used them. The interviewees at "Hörselskadades Riksförbund" told that the telecoil mode was an important function.

Comparing to Other Disabilities

Many interviewees envy the success story of the eyeglasses and want the hearing aid industry to follow a similar transformation. They think that glasses can be worn only to be cool without any impairment, but hearing aids are still connected to stigma. One reason for this was told to be that glasses are always visible, you can not hide them. However, age related stigma still exists with glasses, as one interviewee refuses to wear reading glasses despite the experienced vision impairment. The impairment of vision is seen as much less of a handicap than impairment of hearing.

Pricing

The interviewees were all ready to pay themselves for hearing aids, except the audiologists interviewed. The amount varied between 4 000 and 20 000 SEK. There are also differences in what should be paid for. One argues that the care should be for free, but that the product can cost money.

Conditions that the interviewees had on paying for a hearing aid were set higher than the existing hearing aid on the market. They wanted to have them smaller and more invisible, and better technological features.

The interviewees compared paying for glasses and paying for hearing aids. Many agreed on that paying for a pair of glasses was nothing strange, but somehow it felt a bit more strange paying for hearing aids. However, if given the same care and the same feeling in the shops, the interviewees said they were ready to pay for hearing aids as well. One

thinks that the branding is important in glasses but not hearing aids, which might be a reason for the willingness to pay yourself.

The prices at a private audiologist clinic are between 10 000 and 27 000. The price range has less to do with the physical type of hearing aid and more to do with how advanced the sound processing is. This means that the more expensive hearing aids handle hard listening situations better than the cheaper ones. The pricing does not depend much on the degree of hearing loss either.

Usage of Hearing Aids

A majority of the interviewees including the audiologists agree on that you need to wear hearing aids constantly in order to get accustomed to them. However, one interviewee who had hearing aids had never worn them for a long time and thought their sound was too bad. One hearing aid wearer said that the hearing aids were worn during occasions when better hearing was needed, such as lectures at school. Another wearer said that the aids were taken on in the morning and then worn for the full day. The users agree on that it is more comfortable not wearing them, but one has to use them at home since the partner is not speaking clearly enough to not wear the hearing aids. One user says that they can be tickling, and sometimes she gets a strong need of taking them off.

The users tell stories both about when they were close to forget or forgot to take them off for swimming, as they are not waterproof. A wish from a user is that they should be possible to use for activity sports, hence they should be possible to wear in more extreme conditions.

Listening Situations

All interviewees confirm that the hearing aids handle situations with background noises, such as restaurants, badly. However, one user says that they help in those situations too, even if they are not perfect. One user refuses to wear hearing aids because of the belief that they are not helping in such situations.

Other Problems That Users Experience

Some of the issues that users experience that did not fit in the other categories are explained in this paragraph. Streaming music to the hearing aids provides bad sound quality, so two of the users interviewed told that they rather use their headphones for that purpose. The hearing aid does not show that it is functioning properly, and one wearer was stressed putting them on in order to hear the startup sound to know that they were on. Feedback is seen as a big problem for

one user, as when it happens it clearly tells everyone around that one is wearing a hearing aid. It happens when hugging other people, and restricts from wearing a cap.

Acquiring Your Hearing Aids

How people realize their hearing loss differs from user to user. One user realized it when someone surprisingly came up behind her and she did not hear the person coming. Another user tells about a Christmas tie that all friends thought was funny, but for the user only appeared as blinking even though it played a funny melody. One interviewee tells about a gradual loss and that the loss was realized only by comparing the current state to when the interviewee was younger. Some users tell about other people in their vicinity telling about the problem before they realized it themselves. One user only went to the audiologist to take out a plug of wax, but was told that the problem was a hearing loss.

When trying to solve the problem, some users speak about a surprise when the doctor said the solution would be to use hearing aids. An underlying hope for another way to fix the problem such as by surgery was present. The interviewees without hearing loss told that they would get hearing aids if they needed them. One user did a hearing test seven years ago which showed hearing loss and got hearing aids, they have not been used since then. The audiologists at Sahlgrenska spoke about a fairly long and tiresome process of getting hearing aids.

The audiologists at Sahlgrenska say that it takes at least six months before you are a user. The audiologist from the private clinic says that the patients can do a hearing test and get hearing aids the same day. The interviewees without hearing loss thinks it takes around one year.

The motivation for solving a hearing loss differs between patients according to the audiologists. Many patients have motivation to come to Sahlgrenska as they like the social connection they get. Others are only motivated as their families say they have to address the hearing loss. If someone else is the driving force for the patient to visit, they are usually more negative. The audiologists say that it is most often men that are motivated to go there by their wives.

View on Hearing Impaired

The view on oneself wearing hearing aids tends to be negative for both users and non-users. The general view shows attributes such as old, handicapped and stupid. When telling this view, interviewees say they are embarrassed having it. One user tells that as the hearing aids are not

giving back hearing to 100%, it is the function rather than the size and shape of the product that gives away that someone has a hearing loss.

When speaking to people with hearing loss, even if it is treated with hearing aids, interviewees tell that you have to speak in a different way, slower and more accentuated. One audiologist also says that younger people tend to not speak to hearing aid wearers, as they do not know how to handle it.

Self-Image When Wearing Hearing Aids

Four interviewees agree on that the self-image is distinguishably worse when wearing hearing aids than without. One user says it is a difference of telling someone about your hearing loss and telling someone about the need for hearing aids, where the latter is worse. Another interviewee agrees on the difference of hearing loss and hearing aids, but goes further and says that everyone thinks you are older and more stupid when wearing them. The same interviewee has no problem telling about the self-experienced hearing loss. The audiologists interviewed said that the self-image still is bad, but has become much better lately. They think it is thanks to new technology. The result of the bad self-image makes people wait 7-8 years before they solve their hearing loss, according to the audiologists.

The interviewees think that their self-image has a connection to the public opinion, but they think that their view is worse. They think that the stigmas of being handicapped and old are not only self-experienced, but do exist in public.

For the interviewees to feel less stigma, they think that the hearing aids need to become smaller, so they are not seen. Also, a change in how the products make you feel would make a change, making you feel cool instead of handicapped.

When it comes to romance, hearing aids tend to make moments disappear. One user says that when the partner whispered something to be sexy, the partner needs to be told to speak up. Another story is when a partner first said that "I love you", and needed to repeat the phrase because it was whispered. Telling someone that you need hearing aids is not something one interviewee would do on the first date.

Handling a Hearing Loss Without Hearing Aids

There are ways to improve understanding of voices except amplifying the sound as a hearing aid does. One interviewee says that you can use lip reading to understand others. Another interviewee says that one way to understand others is to look at their expressions. This is needed for

that user, as it is one way to assure that something is not happening that is unnoticed. By moving the sound source closer to you, you can avoid having loud sounds. One user does that by connecting a portable speaker to the TV to not disturb the neighbours with a loud TV.

The Sound Quality in Hearing Aids

Most of the interviewees, both users and non-users think hearing aids have bad sound quality. Users tell that the soundscape is different wearing the hearing aids than when not wearing them. Background noises are amplified too much according to the users which makes hearing harder in situations with much background noise. To tell the direction of sounds is also harder with hearing aids, especially to distinguish between front and back. The audiologists tell that hearing aids amplify soft sounds more than loud, and that the sound is strange with a sharp tone with noises from the letters f and s.

Sound quality is a restricting property of usage in hearing aids today. Some users say that they take them off when they are at home to limit hearing scratching noises from paper and such. That they do not help that much in noisy situations is also a limiting factor.

According to the audiologists, sound quality differs between different types of hearing aids. ITCs are so far into the ear, so they can use the frequency response of the outer ear which gives them a more natural sound. However, one user says that ITCs have worse sound quality compared to RITEs.

Aesthetics of Hearing Aids

In general, the interviewees had many opinions on the appearance of hearing aids. A big majority wanted small and discreet hearing aids. One comment was that if hearing aids were more connected to fashion, they would probably be worn more. To handle stigma, three interviewees think that the hearing aids should express coolness and a wow-factor. To be able to express your personal style through hearing aids is also wanted. The users want to be able to change the appearance themselves. A big majority also concludes that it is OK if the hearing aids express that they are hearing aids. One said they should not be compared to something else, for example headphones, to avoid uncertainty of the function of the product.

Audiologists have a clear picture of what hearing aid wearers want in terms of aesthetics. Most of the users want a neutral coloured hearing aid that is matched to the colour of their hair. Men tend to be more sensitive in their colour and type choice, according to the audiologists. They want to hide their hearing loss more and often prefer a hearing aid type that

sits in the canal, ITCs. The audiologists also agree on that there is little difference in aesthetics between brands.

Different hearing aid types have different aesthetics. Many interviewees agree on that ITCs are most visible, even though they are the smallest. An attribute the ITCs get is that they with their skin colouring resemble an aid for a handicapped person more. The RITEs are preferred by many, as they are the least visible ones. BTEs are similarly experienced as RITEs, but have plastic tubing and a transparent mold that can look scary.

When looking at development in hearing aids, most interviewees are happy that they are getting smaller. They like that the hearing aids now have a small wire instead of a tube. One interviewee says that they are still uncool.

Some interviewees speak about camouflaging the hearing aids to resemble something else. One user has tried to use a smartphone with headphones because it looks better than hearing aids. There are counter-arguments, as the interviewees tell that if they look like something else, people might think that you are not listening.

Alternative Ways of Testing Hearing Loss

Many of the interviewees want the ability to test their hearing loss at home. Arguments are that it is much easier and less embarrassing. One hearing aid user said that the tests can be embarrassing, as when you do not react for a long time in the tests, you know you have missed silent noises. However, trust is an important factor, and the user must be assured that there is no better treatment than that proposed by the test at home.

During the interviews with the audiologists about self-testing, they did not seem to be as optimistic. The hearing tests they do are performed in an anechoic chamber and the headphones must be calibrated, this precision would be hard to achieve in home tests. Medically there is another problem, and that is that the audiologists always perform a check of the ear canal to look for other reasons for deteriorated hearing. The audiologists also mean that if a user has full control over the adjustments for their hearing aid, they might adjust it to be as comfortable as possible, which is not always optimal for hearing.

Private Clinics Versus Public Clinics

There are both benefits and drawbacks of a private health care. The most profound drawbacks are that you need to pay for your care and your hearing aids. One audiologist compared a specific hearing aid for 15 000 SEK at a private clinic to a public clinic, who buys the same for 1 500 SEK. You also do not have the same assurance that the audiologists have

the right education. Another problem is that the audiologists at private clinics benefit from someone's hearing loss, which could lead to more care than needed. A benefit is that private clinics often have much shorter waiting times.

Audiologists from both private and public clinics were interviewed, and there were of course differences in their opinions about the two systems. From the private clinics perspective, they say that they have more modern technology and faster handling times. So people who have the money can get a better service than at the public clinics. The audiologists from the public health care however say that they all have the same hearing aids. The audiologists also tell that there is a difference in the healthcare system throughout Sweden, and in some countys there are only private clinics.

The Experience From Wearing a Hearing Aid For the First Time

It is a rather special moment when you first put on your hearing aids. One user says that the clock on the wall was ticking, which was never experienced before. Another user said it was tiresome to wear them in the beginning, and they could only be worn for around one hour at a time. Another user said it was only a pleasurable experience, as the hearing came back. A non-user believed that the first experience might be tough.

Meeting With an Audiologist

How users got their first contact with the audiologist differs. One user got a letter of referral from the public clinics homepage, and got diagnosed during the first meeting. After that some more meetings were necessary to try out and calibrate the hearing aids. The same user thinks it is tiresome to visit the audiologists for simple calibrations. One interviewee who has hearing aids but does not use them said that there was no problem in going to the audiologists, but also remembers that the last visit was cancelled and a new one was not booked. One user says it is not nice to need to go to a hospital for treating your hearing loss, as the environment is special at hospitals and not nice.

Interviewees have different estimations on how long time it takes to get hearing aids. Users say it takes around three months. Non-users believe it takes weeks before your first appointment and then one or two months to get them.

Users tell that the diagnosis and prescribed hearing aid came as a surprise for them. One user absolutely wanted ITCs, but was prescribed RITEs, which was tough. Another user is lyrical about the ones that were received the latest. One user was unaware of the need for a hearing aid

throughout the diagnosis process, and the need for hearing aids came as a big shock as it was believed that the problem could be surgically solved.

4.8.2 Procedures at the Audiologist

According to the audiologists at Sahlgrenska hospital, the process of acquiring your hearing aids is not quick. First you need to get a letter of referral from a physician at your health centre, and to book a scheduled meeting there you often need at least one month. When this letter is received, another due time of around two months is normal. At the audiologist, they do hearing tests, both through bone conduction and air conduction with tones and speech understanding (figure 4.18). If a serious medical issue with the hearing organs is found, the patient will be sent to another doctor. When the first tests are performed, the patient will revisit the audiologist to try out hearing aids. This is also the time they receive their hearing aids, unless they have a need for custom fit hearing aids.

Figure 4.18
Images taken during a hearing test.

Diagnostics

The diagnostics are performed in two major steps: first a medical screening to see if the ear is healthy, then a hearing test. The first screening is performed mostly by general health questions and through inspection of the ear canal and ear. After that the patient sits in an anechoic chamber and wears carefully positioned headphones. The audiologist plays tones and checks the hearing level for every tone between 250 and 8000 Hz. After that, the same test is performed with bone conducting headphones and if the results differ more than 10 dB HL, there is an issue with the middle ear. Hearing the tones between 0 and 20 dB HL means that you have normal hearing. Some audiologists also perform speech tests, where speech is heard in noise, and the patient has to repeat the same words.

Regarding how the audiologists decide which hearing aids to prescribe, there are many parameters. However, for the audiologists at Sahlgrenska, price is not one of them. First of all, the greater the hearing loss, the bigger the hearing aid. This is because smaller hearing aids are more sensitive to feedback with strong amplifications. It is also important to make an evaluation if the patient can handle small things, as some hearing aids are very small. They also check if the patients are sensitive to if the hearing aid is visible. Most prescribed hearing aids are of the RITE type. It is often not good to use hearing aids that plug the ear canal completely, as you can get infections in the ear canal from them. It is also very important not to mix two patients, as that can be dangerous for the patient with less hearing loss.

Different Types of Hearing Losses

When speaking to the audiologists, they mainly tell about presbycusis. This together with noise induced hearing loss stand for around 95% of all hearing loss diagnoses they experience at the clinic. These both diagnoses affect the hearing organs in the same way, the hair cells in the cochlea are degenerated. That people come for hearing loss treatments but only have a plug of wax is very unusual, it is often combined with another hearing loss as well. The audiologists at Sahlgrenska say that the average age of their patients is around 75.

Own Experiences of Hearing Aids

The audiologists agree that you can not wear hearing aids if you do not experience a hearing loss yourself. Despite that, many of them have tried using hearing aids to get a personal experience. Those that have tried say that the sound quality is not that good and that the soundscape is hard to get accustomed to, as soft sounds are amplified more than loud sounds. The audiologists also agree that you need a certain degree of hearing loss before it gets useful with hearing aids, as the artificial sound they create not is as good as the natural sound.

Performance of Hearing Aids

Many patients believe that they will be fully treated when they get hearing aids. When comparing to eyeglasses, which gives back the visual sense to almost 100%, the hearing aids are not as good. Therefore it is important for the audiologists to inform the patients that they will be helped by the product, but the experience might not be great at the beginning.

Figure 4.19
PrEmo tool in use.

4.9 Studying Attributes and Emotions

This chapter shows and explains the results of two surveys, one on product emotions and one on product attributes. They were made to lay a benchmark for further development, to know how the current products are experienced. An online survey was used for the product attributes, and a tool called PrEmo, see figure 4.19, was used to measure product emotions.

4.9.1 Implementation of Methods

The selection for this study was open, as it was shared on social media. The 90 participants were between 19 and 74, with an average of 35. 73% were women. In total 45% told they experienced some kind of hearing loss or were unsure. 11% used a hearing aid.

The participants were then asked to rate their experience on likert scales on three pictures of different products to wear in the ear, see figure 4.20. One was a RITE hearing aid, one was an ITC hearing aid and one was the HereOne wireless earphone from Doppler Labs. The last was included to see which attributes that differed between hearing aids and earphones.

The attribution adjectives were chosen based on how hearing aids and earphones are marketed today. The selection is also based on attributes that were thought to be important in a new product category. The pairs of adjectives shown on the following page were used, the first three are about experience of wearing the product, the latter are how the product is experienced.

There are many tools to measure product emotions. A tool called PrEmo was seen as robust and to give good results for this measurement. The stimuli used were the same used in the product attribute survey. Due to technical instability with the tool, only eleven participants were able to finish the questionnaire. Therefore the reliability of the results are not as high as could be wished for.

Figure 4.20
Stimuli used in the product attribute survey and PrEmo shown in the order RITE, HereOne and ITC.

4.9.2 Results on Product Attributes

The RITE hearing aids and the ITC hearing aids receive similar ratings in the different product attributes. This could be explained by the products being rated more on their product categories than on their physical appearance, meaning they are both hearing aids.

The RITE hearing aids are the ones that express the most hearing aid of all products tested. They are rated the least robust and the least on shame. We think that the RITEs have the closest relationship to the semantics of traditional hearing aids, they both sit behind the ear with a cable or tube into the ear canal. This explains that they are rated highest on hearing aid. The low rating on robustness is analysed to that these hearables have a thin wire and sit loosely behind the ear. The least shame might have a connection to that the interviewees expressed a clear longing for discreet hearing aids and that the RITEs were seen as the most invisible.

The HereOne is rated the least comfortable and by far the least discreet. They are rated the ugliest and the lowest on status, hearing aid and smartness. They receive the highest rating on robust and shame. We think that as they are rated the least discreet, the ratings on ugly, low status, shame and smart are closely connected, as said in the user interviews. The least comfortable could be explained by their size and placement in the ear. Their appearance is also not seen in hearing aids today, why their rating on hearing aid could be explained by that.

Adjective Pairs Used in the Product Attribute Survey

Shame - Pride

Low status - High status

Dumb - Smart

Something else - Hearing aid

Not personal - Personal

Uncomfortable - Comfortable

Outdated - Modern

Ugly - Beautiful

Weak - Powerful

Cheap - Expensive

Conventional - Advanced

Discrete - Visible

Fragile - Robust

4.9.3 Results on Product Emotions

All hearables that were tested score low on shame and desire, and high on fascination and boredom. We think that desire and boredom are closely connected, why the connection between them in this result is not surprising. The high boredom might have to do with that there is only one product that actually has a newer appearance, the other two have an appearance well known for a long time. The high fascination is a bit surprising, but could be connected to that hearing aids and hearables are not familiar groups of products to many.

The RITE hearing aids score the highest on hope, satisfaction and boredom. They score the lowest on disgust and dissatisfaction. In total they score higher on pleasant feelings than on unpleasant feelings. We analyse this result to that there is a lot of familiarization with traditional hearing aids. The boredom could be explained by the fact that hearing aids have had a similar appearance for a long time. The lowest disgust rating could be explained by that the product sits less in the ear canal than the other two.

The ITC hearing aids score the least on joy and pride and the highest on disgust. We think that these are connected, as a high disgust makes it hard to be proud. The ITC hearing aids were spoken about in the interviews as disgusting and as they were more looking like a prosthesis than a high-tech product. This is reflected in this result as well.

The HereOne score the least on satisfaction and the highest on fear. We think that the high score on fear has a close relationship to that the interviewees said that it might be hard to wear a product that does not yet belong to a product category. The low score on satisfaction might be connected to that the interviewees told that they would rather wear a discrete hearing aid than a visible one. The HereOne is clearly the most visible of the three products in this survey.

Figure 4.21
Lukas wearing hearing aids.

4.10 Wearing Hearing Aids Ourselves

Hearing aids were tested by us in a participatory observation in order to create empathy for the users, see figure 4.21. We received RITE hearing aids from the hearing aid clinic at Sahlgrenska university hospital, one pair of Phonak hearing aids and one pair of Signia. The hearing aids were borrowed for three months and were worn for longer periods of time. A diary of experiences was made.

4.10.1 Results from the Experience Diary

When first receiving the hearing aids, we realized that they need to go very far into the ear canal. This feels uncomfortable the first time, and wax got stuck on the hearing aid as well. It comes with different inserts that either block the ear canal from outside sounds well or almost not at all. This meant that you could sometimes hear what was said with the aid turned off.

The hearing aid is very small, and inserting batteries was a bit hard the first time. Adjusting the volume was hard when wearing them, and it was easy to touch the microphone and create unpleasant sounds and feedback when doing it. Otherwise the size made them sit behind the ear without you noticing it.

One of us felt a strong sensation of tickling in the ear canal when wearing the hearing aids. This sensation was so strong that they were taken of. Another drawback of wearing hearing aids is that you cannot listen to music via your headphones while wearing them.

The sound in the hearing aids was experienced as fairly bad. Sounds that came from a longer distance than two meters were harder to hear. Wind noises were attenuated well. The validity of our sound experience is however low, as hearing aids do not function well for people without hearing loss. There was a tendency of feedback throughout our tests though, when wearing hats or when changing the volume.

4.11 Observations at the Audiologists

In order to get a good understanding for what a person acquiring a hearing aid goes through during a visit at an audiologist, we paid multiple visits to clinics and did a participatory observation. Both private and public clinics were visited. Information was gathered and impressions of our own ears were taken to be used later in the product development process.

4.11.1 General Impressions

The audiologist clinics visited were hidden away and nothing you would ever visit if you were not in need of hearing aids. The public clinic was placed in a hospital area, one private clinic was placed on the second floor with an anonymous entry and the second private clinic had a sign but no display windows. The clinics felt old and disorganized with things everywhere and they all had a feeling of hospital environment. The staff were always welcoming and raised the experience of the clinics.

4.11.2 Making Ear Impressions

The ear impressions were primarily made in order to get a 3D-file of our own ears. This was to be used when 3D-printing the product in development to ensure a good fit. It was however also a good moment for a participatory observation on how impressions are taken and what it feels like, see figure 4.22.

The process starts by the audiologist checking the ear canal. The first visit we paid to an audiologist was not successful, as we both had too much wax in the ear canal to make impressions, and both felt embarrassed. This was not at all foreseen. The second visit was successful, and all impressions were taken. The audiologist puts a foam stopper in the ear canal in order to protect the eardrum. This hurts a lot. After that a fluid silicone is pressed into the ear canal, which feels a bit odd but not uncomfortable. The silicone sets in about two minutes and the audiologist wiggles the impression out, see figure 4.23. The audiologist then checks the ear canal for wounds and if there is silicone left. It often starts bleeding from the foam stopper, and it hurts some time after the visit.

Figure 4.22
Steps when making impressions at the audiologist.

Step 1
The audiologist checks the ear canal to see that everything looks good and there is not too much wax.

Step 2
The audiologist puts in the foam stopper to protect the eardrum from the silicone.

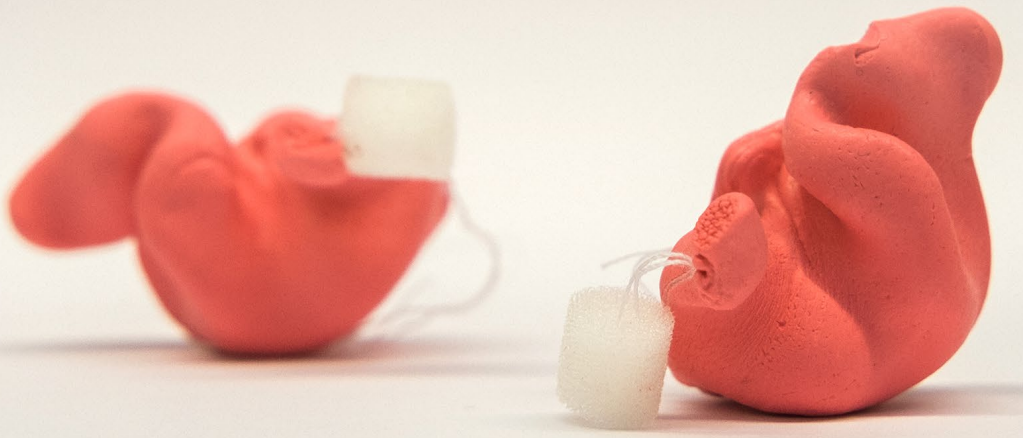
Step 3
The audiologist checks placement of the foam stopper.

Step 4
The audiologist mixes the silicone.

Step 5
The audiologist puts the silicone in a syringe.

Step 6
The audiologist pushes the silicone into the ear.

Figure 4.23
The final impressions.



4.12 Creating a Storyboard

A storyboard was created in order to communicate the results from the interviews. Showing insights in a storyboard makes the information easily accessible and easy to communicate externally. This was important later on in the process, when users were involved. The storyboard is based on a customer journey mapping performed during the interviews.

4.12.1 Collecting the Insights

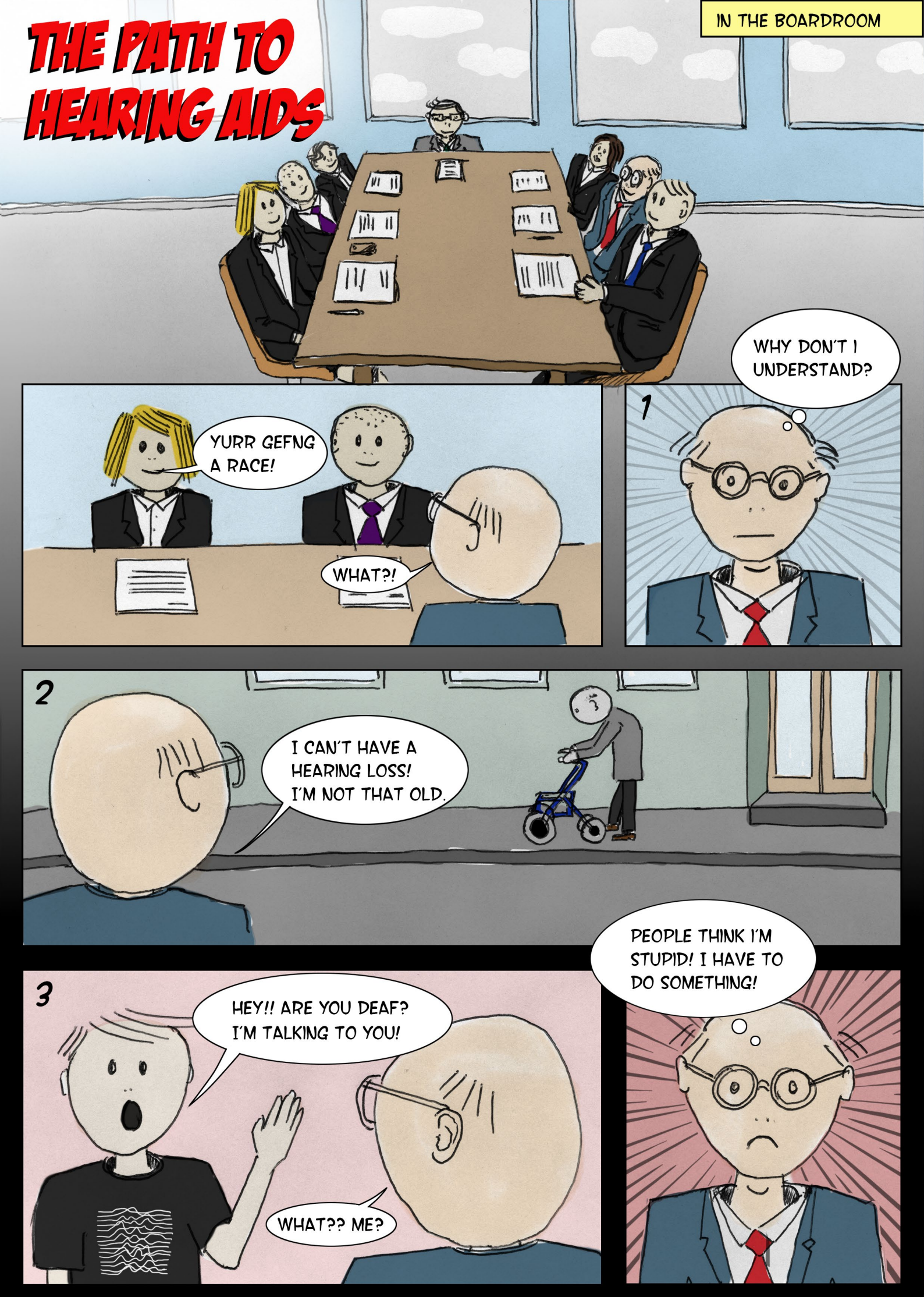
Six different customer journeys were collected, and they all differed. The task given was to map out how pleasant the experience was in the different steps towards using a hearing aid. The timeline was set to start when the users thought about having a hearing loss to the actual usage of a hearing aid. Some users described it as an easy journey, most as long and tiresome. Analysing the customer journeys, seven steps were found:

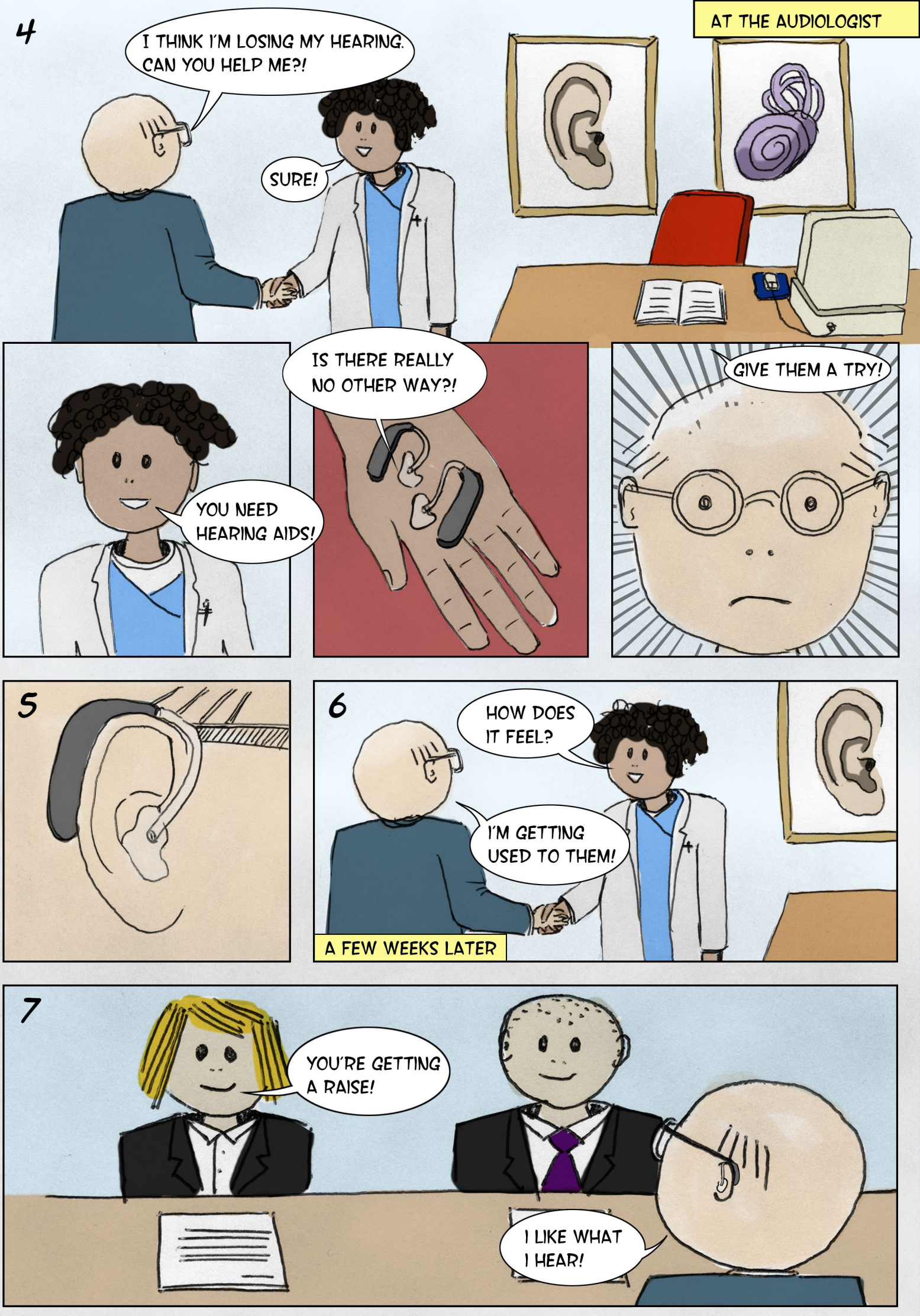
1. Realise hearing loss
2. Reflect on hearing loss
3. Get reminded by others
4. Seek help
5. Try out hearing aids
6. Revisit and adjustments
7. Usage

4.12.2 Drawing the Comic

The storyboard was made in the form of a comic, as it was seen as fairly easy to make and something most will understand. The steps derived from the user's customer journeys were used as a basis for the creation of the comic. The emotions people have during the steps and what is actually done is drawn from information found during the interviews. The illustrations are made to show the process and the user emotions. Turn the page to see the comic.

THE PATH TO HEARING AIDS




4
I THINK I'M LOSING MY HEARING. CAN YOU HELP ME?!
SURE!
AT THE AUDIOLOGIST
YOU NEED HEARING AIDS!
IS THERE REALLY NO OTHER WAY?!
GIVE THEM A TRY!
5
6
HOW DOES IT FEEL?
I'M GETTING USED TO THEM!
A FEW WEEKS LATER
7
YOU'RE GETTING A RAISE!
I LIKE WHAT I HEAR!

4.13 Listing Requirements

To make the data from user studies and observations useful, a list of requirements and wishes was created. All data was searched through for problem areas, which would pinpoint a specific problem with the solution of today. The data also contained wants for future solutions from the users, why a list of wants was created as well. These two lists were merged into requirements and wishes to be used as evaluation and inspiration for the product development. The list was further categorized into functional and emotional requirements and wishes, with the most important requirements highlighted.

4.13.1 Requirements and Wishes

In total there were 25 requirements and 22 wishes elicited. The most important requirements are listed below, the full list is in appendix 2.

Emotional

- Wearers of the product should not be seen as stupid
- Wearers of the product should not be seen as handicapped
- Wearers of the product should not be seen as old
- Self worthiness and self esteem should not be lowered by the product
- The product should express that the wearer is listening to external sounds
- The product should be comfortable to wear

Functional

- Wearers of the product should not need to be handled in a different way than regular hearing people
- The user should be assured of the precision of a hearing test performed by the product
- Handling the product must be easy for new users
- Handling the product must be easy for people with age deterioration
- The product should enhance hearing for those with mild hearing loss
- The product should be adjustable to the hearing impairment of the user without the need of a third party
- The product should provide the ability to interact with others not dependent on the soundscape
- Battery anxiety with the product should be limited

4.14 Visiting Companies

In order to gather information from the industry, company visits were made. The visits were to companies that have some connection to the area or that have an interesting technique they are using. All visits were prepared by writing interview forms with open questions. A semi-structured approach was used in order to be flexible but still get the wanted information.

4.14.1 Bellman & Symfon

Bellman & Symfon is a company from Gothenburg making hearing protection products and products for people with hearing loss. Their products made for people with hearing loss include alarm clocks, doorbells and listening devices. To understand how they work in the development of products for people with hearing loss we made a visit to their office and interviewed their Chief Marketing Officer Fredrik Ahlström (2017).

Bellman & Symfon has a few different hearing protection products and many of them are custom made. These are sold at audiologists, where the customer goes to make ear impressions. The impressions are the same that are used for hearing aids. According to Fredrik, the audiologist clinics are often associated with health care and are not the most trendy stores. Almost ten years ago Bellman & Symfon built a fictive concept store in their office to showcase how their products could be sold, see figure 4.24. During our visit we got to see the store and discuss it with Fredrik.

Figure 4.24
Bellman Concept Store.

Fredrik also shared his view of the hearing aid industry. He meant that the hearing aid companies have tried to reach a norm of giving normal hearing back to the users. He wondered what would happen if they were to break the norm and give other empowerments to the users.

A trend spotted by Fredrik is in the product category of hearables which he predicts is the next big thing when it comes to wearables. Fredrik showed a compilation of hearables on the market 2017. There are few hearables that express fashion and lifestyle at the moment, and Fredrik thought this might be an opportunity for the product in development. Much of it comes down to making a product that the user wants to show and can feel proud of. To create a want instead of a need. Fredrik also believes that paying for the product can lead to that the user feels prouder of the product than if it is received from the healthcare system.

4.14.2 Widex A/S

During a two day visit to Widex headquarters in Lynge outside Copenhagen (figure 4.25), interviews were done with many different people with different roles. The interviews concerned details from the components of a hearing aid to the development of their sound processing. A group interview with audiologists with experiences from different part

Figure 4.25
Widex headquarters.

of the world was done to see if the attitudes differ between countries. We were also interested in the strategies for development used at Widex and where they want to be in the future.

Strategy for Development

To get a basic understanding for where Widex are right now and where they want to be in the future we spoke to Maja Bülow (2017), Senior Innovation Audiologist at Widex. Maja told us that Widex, as all the other hearing aid manufacturers, has been developing products for the end user but selling to audiologists. This has meant that the marketing has been somewhere in between the end user and the audiologists. A couple of years back they shifted their marketing towards the end user.

According to Maja, Widex is very careful not to oversell the capabilities of their products. They mean that overselling could strike back. They are therefore for example very careful not to mention studies that suggest that untreated hearing loss might lead to dementia. They need more evidence before doing that.

Talking to the Audiologists

During the visit to Widex a group interview was done with three audiologists. The three audiologists were employed by Widex and had experience from working in countries such as Canada, USA, Great Britain, China and Brazil. They all shared a similar view on that the barriers for getting hearing aids are similar worldwide. Stigma is a large problem in all countries they have worked in and people are trying to hide their hearing aids everywhere.

The audiologists thought that the OTC act might lead to people getting into the cycle of getting hearing aids earlier. But they also said that there is a fear among fellow audiologists who think that they will lose business because of the new law. The three audiologist interviewed thought that the new OTC products would appeal to a different kind of customers and would not impact the traditional hearing aid business much.

As the hearing aid industry is today, the manufacturers are not selling to the end consumer but to the audiologists. This means that they have to adjust their product service system to the audiologists' needs. The brand chosen by the audiologist can be based only on what brand the audiologist have used during the education. The customer service offered by the different brands is also important according to the audiologists. Another important factor that sells hearing aids is unique features that no other manufacturers are offering. That was the success behind the made for iPhone hearing aid from GN Resound.

Figure 4.26
Testing HereOne earphones.

Filtering Unwanted Sounds

In an interview with Magnus Nørgaard (2017) and Joe Jensen (2017) they explained how noises are filtered out in the hearing aids today. This is performed mainly by directionality, which means only sounds from a specific direction is picked up. The technology to use directionality is called beamforming, which uses two or more microphones. When the sound waves hit the first microphone, a DSP calculates the time difference to the same sound waves hitting the second microphone. By doing that it can calculate where the sound comes from. Another way of filtering unwanted sounds is to bring microphones closer to the soundsource.

For people with hearing loss it is enough if the hearing aids only skips amplifying, but not blocks, the unwanted noises. However, for people without hearing loss, an active or passive attenuation is needed. Active noise cancellation is a technique that sends out sound waves that are the opposite of the sound waves from a noise source. This way the noise is dampened. Another way of blocking noises is by blocking the ear canal, also called passive noise cancellation. A problem with blocking the ear canal is that what is called the occlusion effect can create discomfort.

The occlusion effect appears when blocking the ear canal. When you speak and have the ear canal blocked, the soundwaves that go through your skull bone resonate in your ear canal. The soundwaves travelling in the air are blocked. This creates an unnatural sound and is experienced as odd.

Test of Hearables

At Widex we got to try some of the new hearables on the market. Most interesting was the test of the HereOne from Doppler Labs (figure 4.26) and the IQBuds from Nuheara. Both are wireless earphones with the possibility to control the sound of the environment through a smartphone app.

A problem with in-ear headphones is usually that they block the ear canal which leads to occlusion effect. Our experience with these hearables was that the occlusion effect was not a big problem, as the earphones passed through the sound of our own speech with their microphones.

To be able to control the sound of the environment was a great feature when using the products. It was possible to both amplify and attenuate sounds with the smartphone app. We did not have the possibility to test them in a noisy environment but the noise cancellation seemed to work inside the Widex headquarters. Outside they struggled a bit with the wind but there is definitely potential in this kind of products.

4.15.3 Otorix

It is easy to be seen as indifferent when wearing headphones in a social situation. The headphones create an uncertainty whether the user is listening or not. Therefore we wanted to explore if there were any other ways to transfer sound into the ear without blocking the ear canal. One way to do this is by bone conduction.

To explore this further we visited a company called Otorix in Gothenburg. Otorix makes a bone conduction hearing aid, called Adhear, that is attached with a sticker behind the ear of the user. The founder of the company, Patrik Westerkull, told us the basics about the technology used in their products and we also got to try the hearing aids ourselves (figure 4.27 and 4.28). Unfortunately the technology will not work for the product in development as it is unable to deliver enough bass for music streaming. The product would also need to be fairly large to be able to amplify the sounds enough for a person with a hearing loss in the inner ear.

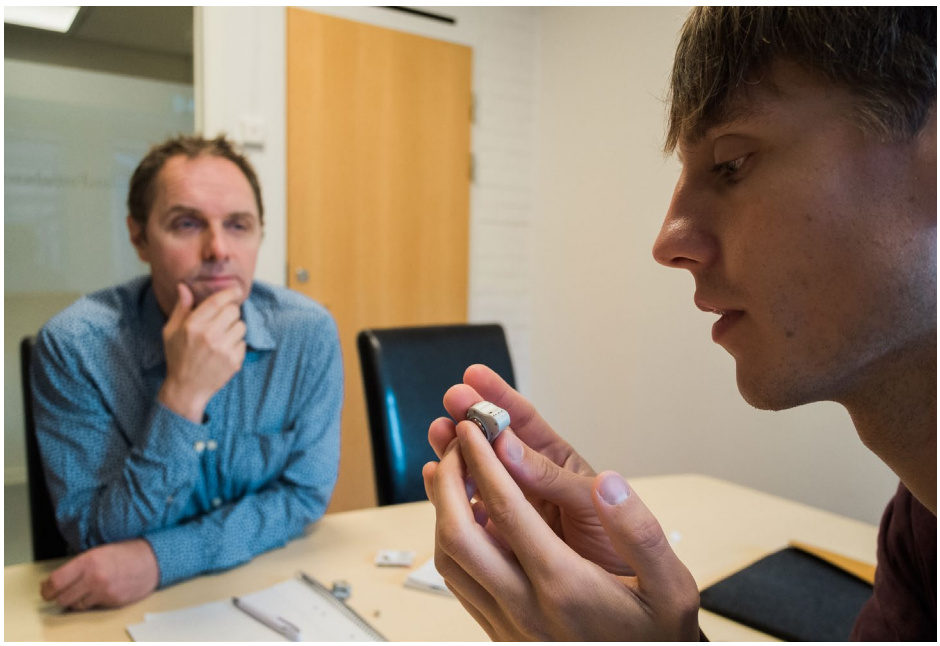
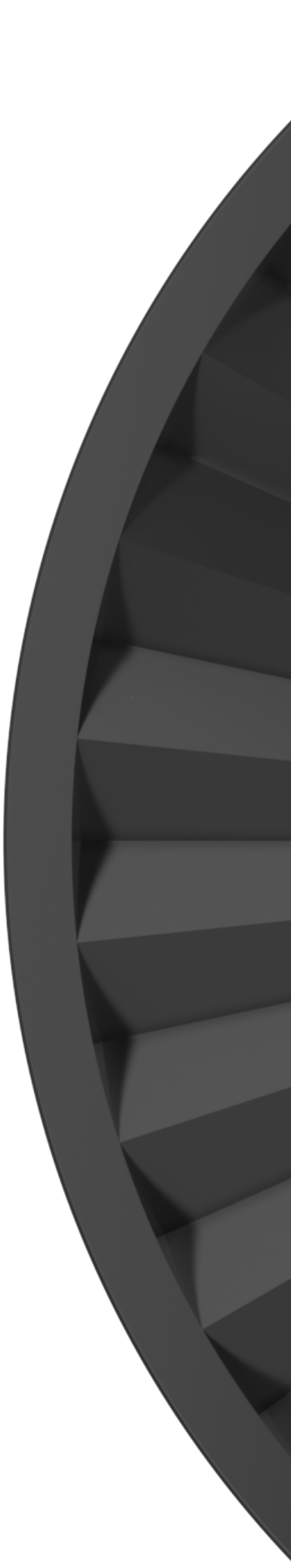


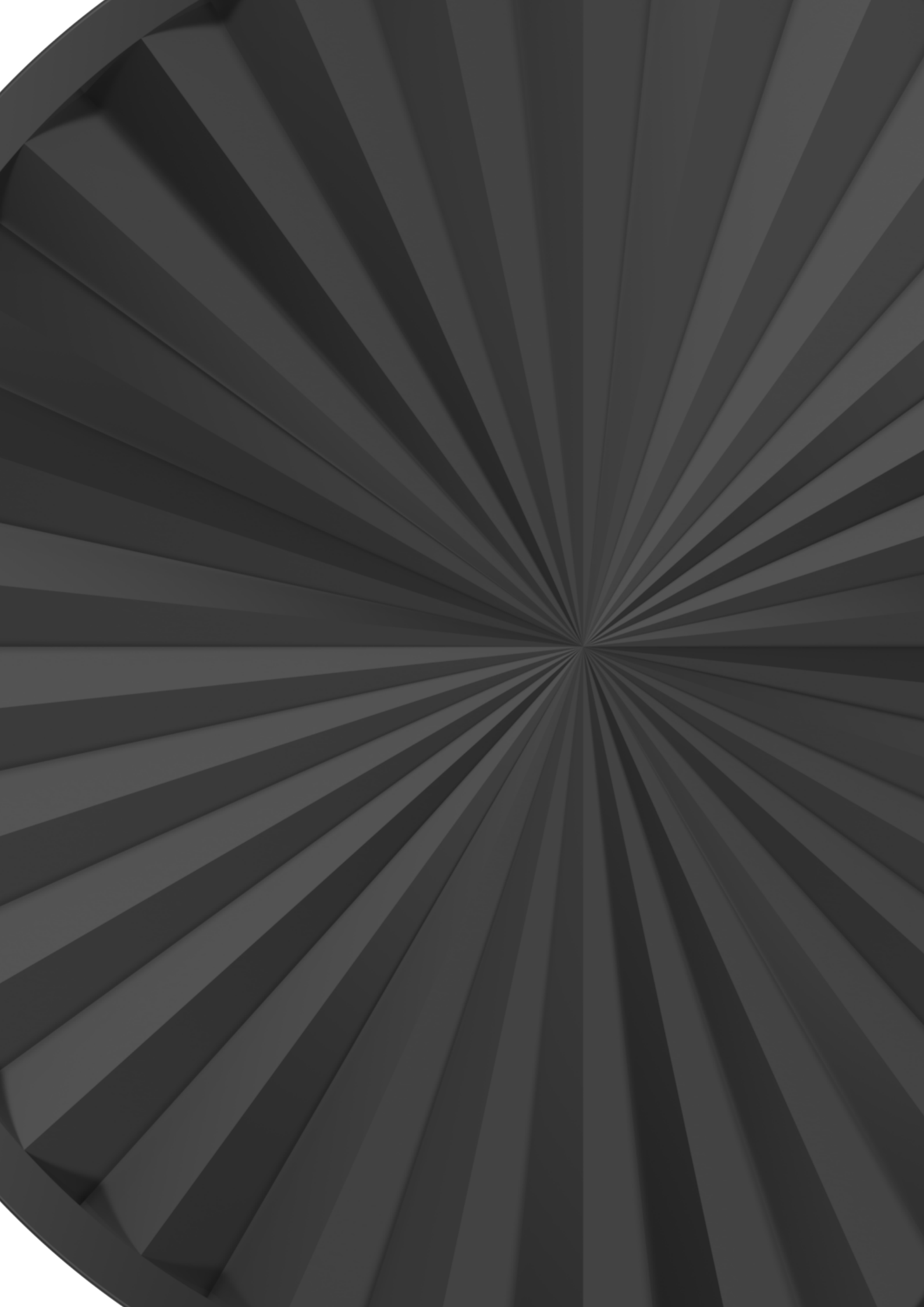
Figure 4.27
Looking at the Adhear hearing aid by Otorix.

Figure 4.28
Trying out the Adhear.



5. Strategies for Enhancements

The barriers that hinder people from solving their hearing loss are battled in this chapter forming strategies for development.



5.1 Creating Focus Areas

In order to use the information gathered in chapter 4 in the design process, there was a need to refine the data into less solution based requirements. The need was to make the data more abstract to not be bound by current solutions, but still precise to the extent that it was still useful. The requirements together with all other findings from chapter 4 were analysed and distilled to the five focus areas described below. This was done using affinity diagrams.

5.1.1 Have Power Over the Choice

The patient has little or no control over acquiring hearing aids today. When going to a clinic, the patient is offered a full service package, where service, hearing aids and hearing tests are included. This makes comparisons hard for the customer. The audiologist then decides which options suit the patient, and often the patient is left with very few products to choose amongst. Also, the patient does not have the proper knowledge to make a sound decision. Another factor making the choice harder is that there are six major hearing aid manufacturers on the market which sell very similar products, making the choices similar

A power shift is needed to please customers. The customers need to be the ones in charge over the aesthetics, the technology and the pricing of the product they are buying. Only by doing that, the customers can express themselves through a product and avoid feeling stigmatized. There is also a need for more open regulations around hearing aids, as people with mild hearing loss can be treated with simple electronic products. One example is an app to the iPhone which uses the built-in microphones and earphones. This app is sound wise comparable to expensive hearing aids on the market (Hearing Review, 2016).

5.1.2 Self Esteem

Today hearing aid wearers are stigmatized and feel different from other people in a bad way. They feel a need to hide the hearing aids to not be troubled by the existing stigma. Due to this, people wait too long before they solve their hearing problems.

Working with self esteem is central in this project. The concept developed will not be used by customers if stigma and self esteem are not properly addressed. There are numerous positive attributes to balance up the existing stigma. The most important in this project is to explore

the possibility that people without hearing loss use the same product. If they do, stigma will not exist. Pride is another important attribute. If the concept solution provides pride, the self esteem of the user would rise and the need for hiding the product would not exist.

5.1.3 Equal Value

In order to speak to hearing aid wearers today, people think that you need to speak clear and slow. This leads to that people wearing hearing aids feel that they are different and valued lower than others. The reason for this can be that hearing aids today do not restore hearing to 100% and many wearers are in fact people with severe hearing losses who are only partially helped by their aids. An example from the user study was that one interviewee had to ask the partner for what was said during a romantic moment, thus needing a different treatment than normal hearing people.

If hearing aids are to be de-stigmatized, equal value is important. Everyone has a want for equal treatment, not depending on hearing loss. With the product developed in this project it is important that the wearer can interact socially in the same way as everyone else.

5.1.4 Adaptation

Today hearing aids are physically fitted for every person's ears, but often the aesthetics of the products have small variations. There are some models which offer colour selections, but it is hard for a wearer to express their own style with the help of a hearing aid. Hearing aids are also made to be used for full days, as the experience of sound differs too much between wearing them and not.

If a product that is worn for full days is to be successful, there should be a way for the user to express themselves. There can be parallels drawn to other products that are worn for full days, such as glasses or watches. In those two product categories there is a wide variety in aesthetic appearances and style expressions. For this project it is important to address the need for different style expressions. It is also important to address that users will be using the product differently, some only on specific occasions and some for full days.

5.1.5 Trust

Users of hearing aids say that the hearing aids do not perform well in noisy environments. However, non-users think that hearing aids are to no use in these environments. This means that there is little trust in the

Power Over the Choice

Self Esteem

Equal Value

Adaptation

Trust

The five focus areas

function from non-users. There is also no confirmation of that the hearing aid is turned on nor that the battery is low on voltage.

If there is no trust in the product developed during listening situations when they are most needed, the product will not reach out to its customers. The opinions of the non-users are important to address, as they might one day be in need of hearing aids and should not have the idea that hearing aids only help people with strong hearing losses.

5.2 Creating a Vision

To be able to push the development into a new way of solving hearing loss issues, we saw a use for a strong vision. This vision sets higher goals than the current vision used by Widex and pinpoints what hearing gives to humans. The vision shall spur futuristic and relevant ideas and be something to strive for when solving hearing related issues in the future as well. The vision was created by analysing what a person with hearing loss actually loses together with analysing how the five focus areas presented in the previous chapter can be used for future ideas.

5.2.1 Current Vision at Widex

The hearing aid industry today is striving towards giving hearing back to people. They are not trying to give other benefits to the user, why wearing a hearing aid for someone without hearing loss is not useful in any way. Where this strategy is lacking is if the only benefit is perfect hearing with the product, then the motivation for someone with mild hearing loss is fairly weak. As there will always be drawbacks of wearing a product in any way, and the only added value that the product gives is giving back hearing, there will be a threshold when the hearing is sufficiently bad to motivate hearing aid wearing. Today the industry is far from reaching this norm of perfect hearing, why there is an even bigger problem with motivation. To minimise the drawbacks of wearing the product, the industry is also striving towards making the hearing aids smaller and smaller and more invisible.

The vision of Widex used today showcases just that, reaching the norm of perfect hearing and not pinpointing anything beyond. The vision is as follows:

Our vision is to give people unlimited access to a world of sound by providing perfect hearing.

5.2.2 Developed Vision

To give more benefits to the user than only restoring lost abilities was central in the creation of a new vision. If there is a desire for a product except restoring the hearing, more people would be prone to use it. Therefore the created vision does not pinpoint hearing at all, but pinpoints what hearing is about. By hearing we humans receive information from the outside world. With the use of sound, we have strong capabilities of interacting with others and our surroundings in a broad sense. This is why interaction is central in our vision. We also know that there are situations where interaction is not optimal for anyone. This could be when there are loud background sounds masking what you want to hear. The developed vision is: *People should be able to interact optimally with other people and their surroundings.*

5.3 Finding Strategies

With the five focus areas at hand, an open idea generation within the project group was initiated. This idea generation was to result in ways to improve on each of the five focus areas. The focus areas were handled one by one and the results were then grouped using an affinity diagram. An analysis of these ideas was made and resulted in three main focuses for further development.

5.3.1 Idea Generation

The first area for further development that was found was easier acquisition. More people would be likely to buy one if acquiring the product gets easier than today. Pricing is important, as the products are expensive today, and with a lower price more customers would be attracted. An easy comparison for the end customer is lacking today and would also make it easier for the customer. To be able to buy the product at your own convenience from wherever you want would also make it easier. This means that the audiologist should not be the only one selling the products.

Accessibility of help was another important development factor. If help is easily accessible, then the need to go to a specific location and book an appointment would not be necessary. There were ideas that an audiologist should always be contactable from anywhere, and the guidance should be more personal. The guidance should also not only be around the hearing loss, but about style and technology as well.

People should be able to interact optimally with other people and their surroundings.

The developed vision

One of the more promising areas found was giving something extra. This means that the product should not only reach out through its function of giving hearing back, but with something extra. It could be an extra technological feature or a special expression. This would create hype and pride if successful, making stigma non existent. Most powerful would be if this extra function addresses all users, not only those with hearing deficiencies. One could use already stylish and successful celebrities to market the product. The extra function would not necessarily need to be something very special, it can be something small that enhances the everyday life.

Making usage more common is another important factor for a successful treatment of the stigma. If people wearing the product do not feel alone in their usage, usage will be normalized and stigma would diminish. Visibility also enhances the advertising the products makes itself. It also creates trust for non-users if users wear a product more open.

Today testing of hearing is something users feel embarrassed about. A thought was developed that the hearing loss might not be necessary for the user to know about. If the product just works for you, then there is no need to know which degree of hearing loss you have. Also the product itself could be the diagnosing unit, and confirm its measurements through audio playback to the user. This works the best if introduced before hearing loss gets severe, as the soundscape will differ much for those with severe hearing loss.

The customization of style is important if the product is worn for long times and is visible to others. The product would most likely need to be customizable, as we all want to express different styles. To be able to customize the appearance on the go was one idea. If the product clearly associates with another product without stigma, people's opinions towards the product might be more positive. These product associations could be for example jewellery or headphones.

The customization of fit is crucial as we all have different ears. To make use of 3D-printing is one solution already used in the hearing aid industry today. Another take on the problem could be to make the contact points with the ears very soft, spreading pressure points out over a bigger area. Widex receives impressions from hearing aid wearers today to make custom fit hearing aids. These impressions could be used in an analysis to make an earpiece that fits more users.

5.3.2 Reaching More Users

When analysing the findings from the idea generation, three main strategies for development were found. These three are: make usage spread to normal hearing people, make usage of the product less stigmatized and make the product more accessible.

Make usage spread to people without hearing loss

If more users would use the product, and if the same products would be used by people without hearing loss, then the whole base for the stigma would not exist. The stigma today is based on the idea that you are different having a hearing loss. To make usage spread, an extra function that works for everyone could be applied. Fashion and style could also be used in order to enhance the spread of the product to new users.

Make usage of the product less stigmatized

The product today suffers from being stigmatized, and that restricts new users from acquiring their hearing aids. One way to tackle this could be to make a product that has a different appearance than the products in use today. If the product appears to be a hearing aid, it will bear on the stigma from hearing aids. To change the stigma of an existing product is seen as much tougher than creating a new product category with no existing stigma. The new product could also resemble existing products that do not possess a negative stigma. Another way to work with stigma could be to make the product express more style than today. A strong style connection with fashion would make the product more desirable and thus reduce stigma.

Make the product more accessible

If the products would be more accessible in all ways, more people would be able to use them in their own way. Today it is a rather long and tiresome journey to acquire your hearing aids. Making the acquisition easier and more pleasant for the end customer would improve the experience of the product. The usage of hearing aids is also different, and the need of help with hearing also differs between different users. Therefore being able to take the product on and off as you like without showing a stigmatized product would be beneficial.

5.4 Innovating Together With Users

At this stage it was important to involve users. The product development had led to be less about the existing hearing aids and more about something closer to earphones. With the focus areas set, it was time to evalu-

ate the steps with the users and ask them what they believe for the future. First off, an analysis of what the users could contribute with was done. Then a co-creation session was designed to get new inputs. The results from the participants is presented, and then results from when we made the co-creation session ourselves is presented.

5.4.1 Areas to Investigate

The aim of the co-creation session was to receive new ideas and input to use in the development process. Main areas to ideate on were found using the analysis in the previous chapter.

The first area to ideate on was the whole customer journey. Which emotions are desirable, and how do customers want to interact in stores and with salespersons or audiologists? It was important to gain insights on this as the background research did not fully investigate this.

The second area to ideate on was aesthetics. Do people prefer that the new product resembles existing products, or is a whole new expression desirable? Aesthetics is important to connect the product to style and fight stigma, and users could have valuable input on this matter

The third area to ideate on was how the product should be used. This means exploring when and how the product is useful, with focus on making it useful for everyone regardless of any hearing deficiency. In which occasions do users think they would like to use a product, and what should it do?

5.4.2 Finding Extra Functions

In order to ideate with users on new functions that do not exist on the market, idea spurs were developed. The most important area to do research on beforehand was technology, as new technology usable for this product category is not common knowledge. The research was focused on two aspects: technology and use cases. The areas are described below, and are still fairly open to act more as spurs than final solutions. These idea spurs were printed on cards and used during the co-creation session, see figure 5.1 and figure 5.2. The cards can be found in appendix 3.

Technology

Artificial intelligence is a technology in high development. Machines will soon have intelligence that is more human like. Can that be used in this type of product?

There are many sensors on the market for usage in the ear. Bragi the Dash Pro is a product utilizing much of the newly developed technology in sensing within the ear. They utilize heart rate sensors, accelerometers and bone conduction microphones (Bragi, n.d.). Are there other sensors that can be used, and what should we do with the data?

The Internet of Things is growing, where soon every electronic product has some kind of connection to the internet. Which new functionality can that lead to in a product providing sound to its user?

Figure 5.1
An example of spurs for technology.

One selling point in new headphones today is the function to cancel noise. How can noise cancellation be used in a product, and what new usages could that lead to?

As the product collects more and more user data, it will be able to learn the habits of the wearer. How can the product be beneficial by knowing your habits?

Every ear canal is unique to the user. In fact, just as unique as a fingerprint (NEC, 2016). This can be used in a product that sits in the ear canal. What benefits can we draw from a product that constantly knows the wearers ID?

Biomimicry is the imitation of systems found in nature. Can we look at nature and see how something regarding sound is solved that can be beneficial in this product development?

Use Cases

Today the wearable technology market is focusing much on physical training. Is there any possibility to make use of a product that sends sound into your ear in the area of training? Can the concept of training be widened to incorporate wellbeing in general?

Figure 5.2
An example of spurs for use cases.

Today stress is experienced much in society. It is getting harder and harder to find a place for relaxation in the city. Can this product help the user to relax in any way?

The electronic products worn in or around the ear today focus much on music. Is there any other aspects of entertainment this product can be useful for?

The brain is sometimes compared to a muscle, and the analogy works for hearing as well. The brain redirects its assets to other areas if the hearing sense is not properly trained. Therefore, are there any ways this product can help train the users hearing?

The hearing can be severely damaged by loud sounds. How can this product help protect the ears from harmful sounds?

When focusing on a specific task, surrounding sound and noise can be very disturbing. Is there any way this product could help the user to focus?

5.4.3 Creating a Co-Creation Session

By analysing what the users could contribute with in this stage of the product development, three research questions were found:

- What can technology do to make the product useful for everyone?
- How can the aesthetics of the product help form a new product category?
- How can a product for hearing loss be acquired in the future?

As the final product should not bear on the public stigma of the hearing aids of today, it was important to have a wide user group as participants. This also gave the possibility to create innovative ideas. The participants were four women and six men of whom four had design education. The ages were spread between 26 and 75, and half of the participants stated that they experience some kind of hearing loss. Only one of the participants used a hearing aid.

The group of ten was divided into three, and the three research questions were handled one by one in different rooms (figure 5.3). The participants had 15 minutes in each room and they got descriptions of the task and inspirational pictures in each room. The created vision was on the wall for guidance.

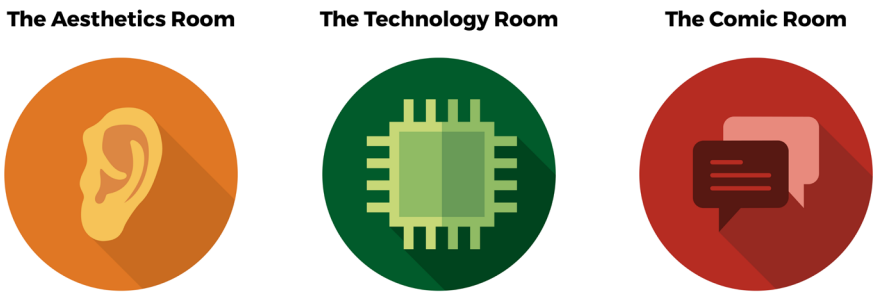


Figure 5.3
The three different rooms.

The technology room had a focus on ideating on how to make a product that solves hearing issues and at the same time is useful and desirable for everyone. In this room the participants got idea spurs on cards generated in the previous chapter 5.4.2. These cards were to be combined to form new ideas. The outcome was to be documented on post-it notes.

In the aesthetics room, the participants ideated on how to create a new expression. Wanted was an expression that could be more visible than

hearing aids and that creates a new product category. Adaptation to different styles and anatomies was also discussed in this room. For idea generating, the participants had access to 3d-printed ears and modelling clay. There were also stencils of a head and pencils to sketch ideas. The outcome was photographed or handed in on the stencils.

In the storyboard room, a new way of acquiring the product was explored. This was to avoid the stigmatization of the hearing aids of today and look at what kind of motivation users can get in the process. Another factor that was explored was how pride could be integrated into the acquiring process. The outcome was sketched as a comic on a stencil.

After the session the participants were invited to discuss their findings. All groups got to share their ideas and this session was filmed to review afterwards. The groups built on each other ideas and also got a chance to say what they believed would work or not.

5.4.4 What the Users Said

Ideas from the technology room

In this room the focus was on finding ideas on what an earphone-like product could give to its user that does not exist on the market today (figure 5.4). One way to improve sound was through the tele loop system that exists for those wearing hearing aids today. This system could be used to give the listener a better experience of sound from a theatre or cinema through the own earphones.

To be able to get rid of noises was a main function discussed. Someone suggested that you could choose which frequencies you want to hear or which directions you want to hear from in order to filter out noise. There was also an idea that there could be situations where you would want to amplify the sound, for example when you are out in nature. All in all it was concluded that there might be a bigger use of controlling your soundscape than you might first think. There are a lot of sounds you wish you did not hear every day. The ear has a function to filter some noise, but a device that helps the ear would fulfil a need.

To control the product in development, the participants mostly thought your smartphone would be useful. The volume adjustment on the hearing aids today is small, and if a new product is developed, it needs to have bigger volume controls.

Other interesting ideas presented were about socialisation and guidance. The product could be used to hear another person in dating apps, as a

Figure 5.4
Ideation in the technology room.

compliment to the pictures that are used in the apps today. The product could also be used as a tour guide where you could ask about different things in your surroundings.

Ideas from the aesthetics room

One of the major discussion points from the aesthetics room was about showing that you hear other people. As the new product should be more visible, it is also likely that it blocks the ear more than the hearing aids of today. Blocking the ears, just as headphones do, is seen as very arrogant when speaking to another person. Therefore it is desirable to have a product that shows when the wearer is listening. This could be done through light or by mechanical differences, such as opening a lid. This might also be an overgoing problem, as people might change their conceptions of such a product and thus rely on that the wearer is listening.

To make the new product take much visible space was mainly seen as positive by the participants. However, the question around if the product gets more in the way was raised. When the product takes more visible space, style gets even more important. An idea was to let the users take part in styling their own product. Another thought was that there needs

to be many different models to allow for choice. An idea about modularity also arose, where the styling could be one part and the electronics could be a separate part. In this way changing style would be cheaper. More examples of different styles from the aesthetic room can be found in figure 5.5.

What expression the new product should have was also discussed. Someone suggested a form that is like an extension of your ear. Another participant told that the organic forms in hearing aids today are not desirable, but sporty looks are not either. Monitors that musicians use during live performances are close to hearing aids in aesthetics, but are seen as cool. Is there something from them to take example from?

It was also important for the users that the product was wireless. However, a necklace with batteries was seen as okay and could also add to the personalized style. There were also ideas that a separate product used with something put into your ears could be tucked under your hair, or maybe glued to your head in some way.

Ideas from the storyboard room

The first story created in the storyboard room (figure 5.6) started with a person walking down a shopping street. Passing by lots of shop windows, the person suddenly walks by an audician, a store for the newly developed product. The store has to be present with many stores in the cities with big display windows and a fancy interior design. This creates hype and the person walking by wants to go into the store. In the store you get to try the products out, and the persons working there are leisurely clothed to make a nice environment. The person trying out the products finds a style that corresponds, and then gets a hearing test. This hearing test is quick and without waiting time. The product is then installed with your personal settings and you bring it home in a nice package. At home the person films the opening of the package and uploads it to YouTube. The person now hears better and looks good and is very satisfied. This story was partly based on how glasses are sold today.

The second story starts at a concert, where a person experiences bad sound and has a bad experience. The person then does not need to go to a health care centre, they take too long time. Instead the person goes to an audician, which is like an optician but for hearing products. In the store there are many models with different styles to try out. The hearing test might not be needed in this scenario, there will be a selection of different products which are tweaked to help different hearing losses. These would then be tested by the users themselves to find the correct product.

Figure 5.5
Ideas from the aesthetics room.

Figure 5.6
Ideation in the storyboard room.

As the trust for hearing specialists was low in this participant group, it was seen as better if the users diagnosed themselves. The person then remembers that the drummer in the band wore a specific style, and wants to have the same. Next time at another concert with the product on, the person has a great experience.

The third story is a shorter one. It starts with that a person is sad during a restaurant visit, as it is hard to follow the discussions. Then a friend shows that she has a hearing aid to spare, and shares it with the person. This builds on that hearing aids are so accessible and cheap that many people have them as spares. This makes the person follow in the discussions again.

When discussing over hearing loss in general, the participants conclude that it is something that affects your daily life. They go as far as describing it as an identity change when not hearing properly. A parallel was drawn to not speaking a certain language: if you are not understanding, you will feel and be excluded.

The way to buy the product was a major discussion theme. The participants agree on that the solution of today is not desirable at all. It is good

if the person working at the store is audio and tech interested, as this will help in the choice. Audiologists do not always have this interest today. One way to come out of the full service package would be if the hearing test and the acquisition of a hearing product would be separated. Then you would get a prescription which you could use to buy the product from wherever you want. The store where the products are sold could be a store for sound, including the product for hearing better, but also headphones and speakers and such.

5.4.5 Doing the Co-Creation Session Ourselves

The co-creation session was done by the authors as well. This was to further build on the ideas created during the co-creation session with outside participants.

Ideas from the technology room

Training is a big area for wearables today. Smartwatches often come with heart rate monitors and can show you how effective your training is. What if this could be done within your ear? Some people already wear headphones or similar when running, so integrating this functionality into the product in development would make people bring one device less to their training. It would also be desirable if tracking your training would be smarter than today, knowing what you like in training and suggesting training sessions based on your fitness level.

As there are unwanted sounds in your everyday life and you do not have power to change some of them, regaining the power to shut off some sounds would be beneficial. What if the product could help with focus and know when you want to shut off the outside sounds? The product could attenuate low voices when working in an office, and let louder voices through for when your colleagues ask you something. It could also analyse what kind of sounds makes the user calm, and use these sounds for when relaxation is needed. The device could track your energy levels and tell you when you need to relax.

Ideas from the aesthetics room

How people you talk to understand that you are listening to them is an interesting area. We had ideas around letting the user steer the directions from where sounds are heard physically. That the device itself is somehow pointed to the direction of interest. You could also make use of the natural shape of the ear and extend it. The main topological forms were explored on sketches and with clay. These were basic shapes with different locations around the ear that can be seen in figure 5.7.

Figure 5.7
Simple clay shapes.

It is important that the user can select the preferred style. While changing the whole product to change style, just as you do with glasses, might not be optimal, as it would be too pricey. Therefore a modular system as proposed by the participants is better, as the styling module can be cheaper for the user.

Ideas from the storyboard room

It is seen as important to make the whole acquisition of the product easier than hearing aids acquisitions are today. There are some major drawbacks with the system that could be solved. One is the hearing test, that today is experienced as embarrassing. This could be done through the device itself, when the user is at home. It is also an unpleasant experience to do custom fitted hearing aids, as they need a silicone impression. This could be solved through an earpiece so soft that it adapts to every ear. It could also be solved by making a 3D-scanner for your ears.

5.5 User Thoughts on Functionality

As this project turned out to be closer to developing earphones than hearing aids, we needed to involve the users once again to see which functions are preferred by them. A survey with functions that were possible to integrate in the product in development was made. The functions were formulated on the base of earlier ideations, and the respondents

were asked which functions they would find desirable in their future earphones. The survey got 77 respondents with ages between 19 and 59. 53% of the respondents were female, the rest male.

5.5.1 Presented Functions

When the users got to rate which functions they wanted of the ones presented, they got to rate between 1 and 7. 1 represented "I do not want this at all", and 7 represented "I would much like to have this". The functions chosen to be desirable by the users were the functions that received half or more of the users rating a 4 or higher on that specific function. The functions and their desirability are shown below.

Not desirable	Desirable
Direct translation between different languages	Attenuate background noise to make speech clearer
Provide personal health information	Cancel out background noise completely for focus
Provide updates on news, weather and calendar activity	Connectivity to your TV
Measure your stress level	Play music from your smartphone
	Be able to receive and make phone calls

One question was asked in the end about how appreciated a function that makes conversations easier would be. 78% of the respondents rated it as a desirable function, and 45% in total wanted this function very much.

5.5.2 Other Interesting Functions

There was an open question in the questionnaire if there are any other functions people find interesting in such a product. There were a lot of answers to this question and the most interesting are presented here. Active noise cancellation, which already exists in the headphone market today was mentioned by many. The ability to add ambient noises that suit you was another function mentioned. Mentioned was also the ability to amplify important information, or to be able to repeat it. Someone brought up heart rate monitoring, and being able to use their earphones as a smart assistant. To make them waterproof was also mentioned by the respondents.

5.5.3 Difficult Listening Situations

When asked about if there are any situations when it is hard to hear what someone says, 82% of the respondents said yes. Places that are hard to conversate in are according to the survey:

- Public transport
- Phone calls
- Bar/restaurant/nightclub
- Noisy workplace
- In a car
- Windy environments
- Silent speech

5.5.4 Conclusions

It is interesting to see that so many (82%) feel that it is hard to hear what someone says in some situations. This is a strong indicator that a function that enhances speech understanding would be helpful for people. There are also other ways that people want to control around sound. To be able to filter out unwanted sounds when you focus on something else is also a function rated high.

The other major area where the respondents want new functionality is connectivity. To be able to use connectivity as earphones are used today with a smartphone is seen as basic functionality. A smart assistant could also be incorporated according to the users.

5.6 Morphological Matrix

A morphological matrix was constructed in order to put all relevant ideas in a table to get an overview. It was also made to help in the concept creation. The morphological matrix had five main areas: form topology, technical functions, aesthetics, acquisition and usage. The matrix was used to generate the three conceptual strategies shown in the coming chapter.

5.7 Creating Conceptual Strategies

With the co-creation session, own ideation sessions and the morphological matrix, the formed ideas were to be collected to become concepts. But as the ideas were rather about strategies to solve the issues of hearing aids, and not so product specific, concept strategies were formed. Brought into this concept creation was a high importance of making conversations easier, realized from data from the surveys, and the importance of many users. Many users means that they are less special and not different anymore.

5.7.1 Concept Strategy Basic

The first concept strategy, see figure 5.8, is about making a much more accessible product. It should be cheap and easy to buy, available at many stores and on the internet. There should be no need for an audiologist to buy it, and the hearing test should be performed by the user at home. The hope with this is to gain more users that show their product, and this will in turn diminish the associated stigma.

The strategy also means making a product that is to be used like reading glasses, taken on when there is need but not worn all the time. This puts lower demands on wearing comfort and battery life, two aspects making the concept cheaper.

Figure 5.8
Figure of concept strategy basic.

Technology

The product for this strategy will make use of the built in microphones in a smartphone or in a carrying case. This has the potential of putting a microphone closer to the sound source that you want to listen to, hence make it help you more. Having only external microphones means that the technology in the earphones themselves will remain simple, making the earphones smaller. Sound processing will be done in a smartphone or in the case, giving potentially more processing power for a smaller cost. Connectivity to your smartphone for music streaming and phone calls is included in this product.

Aesthetics

The product in this strategy will resemble the wireless earphones on the market today but with a slightly different use. One issue important to solve is that these earphones need to signal that they bypass sound from conversations to the wearer. Otherwise wearers will be associated with indifference.

5.7.2 Concept Strategy Conversation

The general idea behind the concept strategy conversation, see figure 5.9, builds on what was found in the survey about functions. Therefore this strategy is about making it easier to hear conversations in crowdy or noisy environments. It deals with stigma by making the products useful for those without hearing loss as well. It also makes the listening situation better for everyone, why there is no need for personal settings.

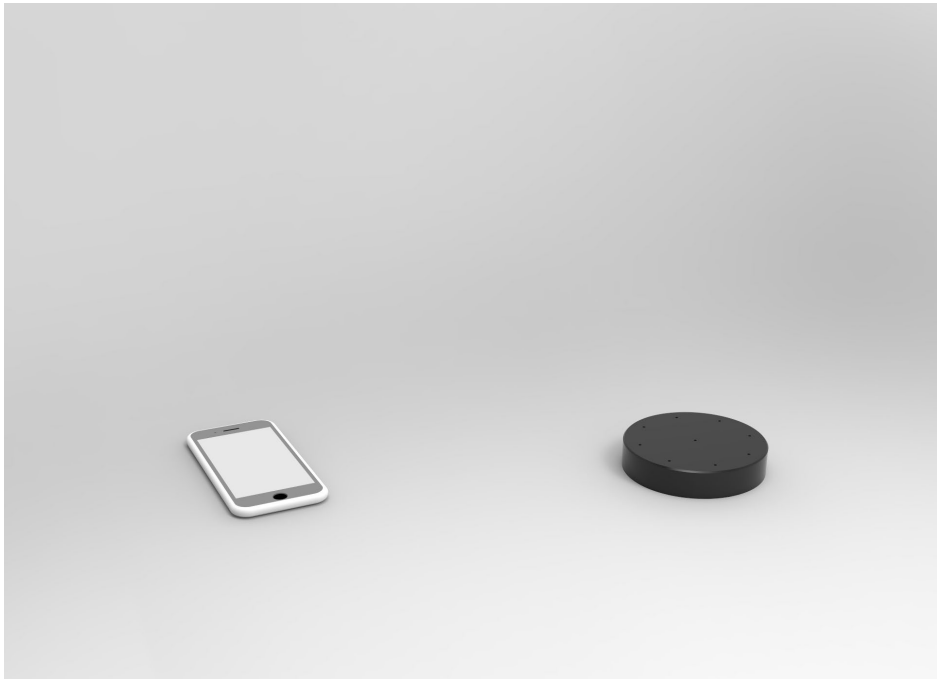


Figure 5.9
Figure of concept strategy conversation.

The sorting of conversational sounds can be done by two ways today: either putting the microphones closer to the sound source, or using directional sensitivity via beamforming technology. Therefore this strategy houses two different product concepts which addresses these two sorting techniques, one is about making an app for a smartphone and making use of existing earphones with microphones. The other concept is a device with beamforming microphones put on a table which records the sound you want to hear and connects to your own earphones. This device needs to be placed out on a table, which can be stigmatizing in a new way when a person with hearing loss shows the product. Therefore this product is to be sold directly to restaurants.

Technology

Making an app to use with your own earphones and microphones in your smartphone needs testing. In one way this could be compared to everyone taking part in a conversation doing a conference call. To not be compared with this, sound quality and latency are very important parameters to make a good experience. Therefore different wireless technologies must be investigated as well as the quality of microphones in smartphones and headsets. This concept is strong when distributed for free as an example of how good the other product range from the same company sounds.

Using beamforming instead is a robust way to filter out noises from conversation sounds. Through directionality, only the noise in the very specific direction as the speaker will be heard. Difficulties here are when many conversations around the same table are active, then some kind of sorting must be done. This concept does also need more motivation for restaurants to buy than only by making conversations easier, so ideas around taking orders and making personal quizzes through the product were developed.

Aesthetics

As the app is distributed for free, it needs to catch the user's attention for the company's other products. Therefore the user experience is important. It needs to communicate social and youth, to get far away from hearing aids and the associated stigma.

The aesthetics for the product with beamforming needs to fit the restaurant environment. Either it is a very minimalistic and simple design to blend into many different spaces or there is a wide variety of styles for different types of restaurants.

5.7.3 Concept Strategy Extra

The third strategy, see figure 5.10, builds on making a similar journey with the hearing aid business as the glasses business has made. This means taking a product that is stigmatized to something that people want to use to express their style with. This strategy will include fashion, and as Widex has no earlier connection to fashion, a collaboration with a fashion house is needed. The connection to fashion also means that the product should not be shy in its expression.

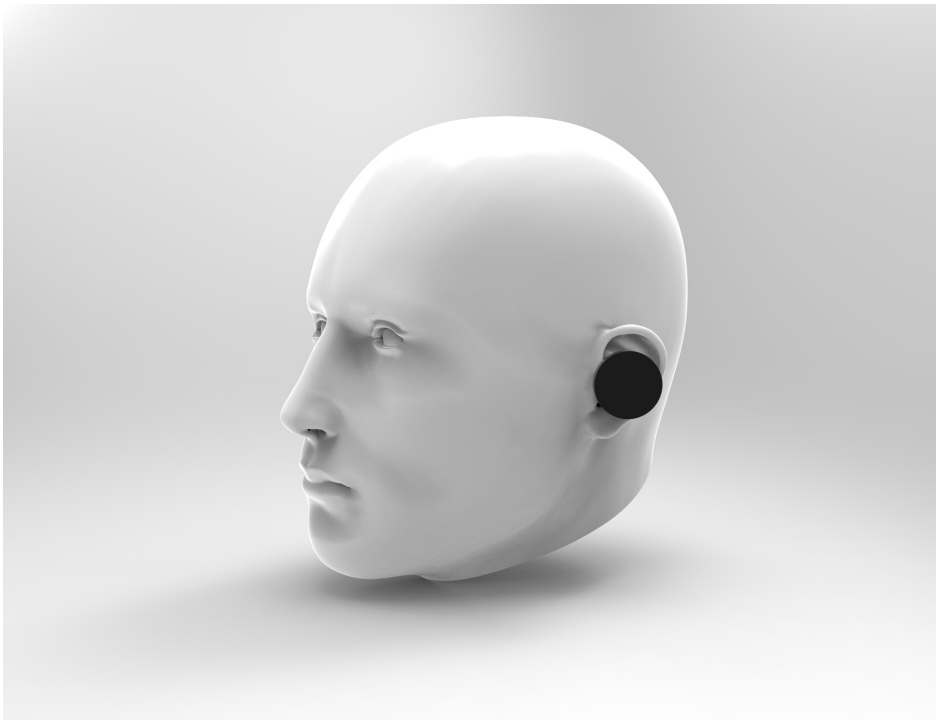


Figure 5.10
Figure of concept strategy extra.

Also the way of acquiring your product is something that changed radically with the glasses industry. From getting your glasses in a hospital-like environment to stylish and modern shops. This means that the way of selling the products in this strategy should be changed. Stores should be a place where people can walk in whenever they want and look at the products. There should be no need for scheduling, and with a stylish and modern interior the stigma will diminish.

As this product strategy will include much of the latest technology and will be one of its kind when released, it will retail at a high price. This should not be a too big concern though, as it will mostly be the first version of the product that will suffer from high prices. Coming versions will be possible to manufacture cheaper. A high retail price is also not hindering early adopters.

Technology

In order to make this concept interesting for a bigger crowd, it needs extra functions interesting for everyone. The basic connectivity is important to include, where music and phone calls can be handled through your smartphone. The same extra feature that the previous concept builds on is interesting to investigate in this concept as well, meaning a focus on making conversations easier. This function is by far the most desirable when asking users so it should be investigated in this strategy as well. One could also make use of a personal assistant that works with sounds in your ear. It could also make use of personal ID in the ear for identification processes when for example paying.

Aesthetics

As this strategy builds much on style and fashion, the aesthetics are of high importance. To get a good connection to fashion, it is believed that it is important that the product feels tailor made for you. That can be done aesthetically and technically, with specific features depending on the user. As the strategy means a product not shy for its appearance, it can take more visible space that hearing aids do today.

5.8 Evaluation

In this chapter, each concept strategy is evaluated itself. As the strategies (figure 5.11) are hard to communicate to users and differ fairly much, they are evaluated against the criteria set in chapter 5.3.2. These are: make usage spread to people without hearing loss, make usage of the product less stigmatized, and make the product more accessible.

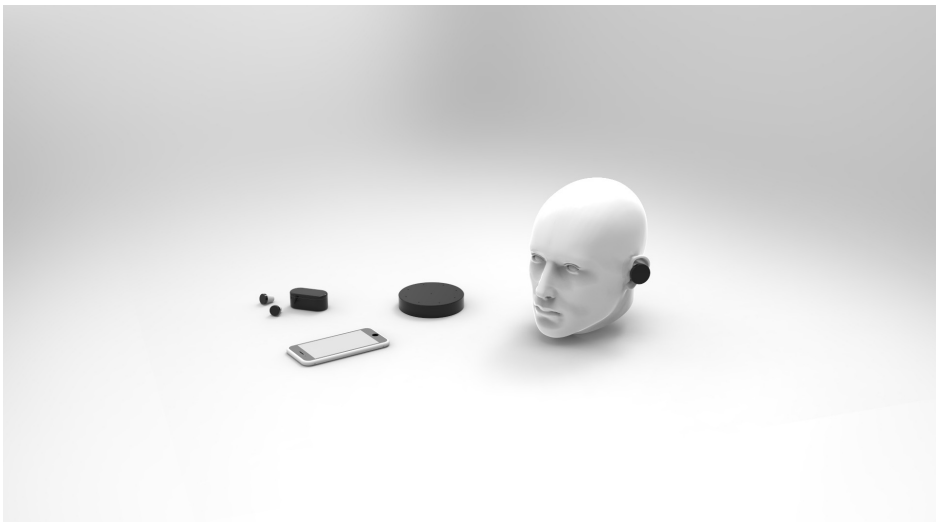


Figure 5.11
Figure of all concept strategies

5.8.1 Concept Strategy Basic

This concept builds on accepted products that exist on the market today. It differs by having new features with microphones, but is still similar to the earphones sold today. And by only adding a function that aims towards those with hearing loss to an already existing product category, users without hearing loss have no motivation using it. This makes the product exclusive to those with hearing loss.

The product takes advantage from an unstigmatised product category, which will take the stigma of the product itself away effectively. However, by not reaching to other users, usage will be exclusive to those with hearing loss. To fight stigma, this might be possible to use as a strategy over time, but to do a quick shift it is believed that involving outside users is key to success.

Benefits from this strategy is that it is easy to acquire, and maybe easier than the other concept strategies with a cheaper price. Making the product available online and without prescription is interesting, but not possible today if marketed towards people with hearing loss. This might change in the future with the OTC hearing aid act in the USA, with a potential with other markets following.

5.8.2 Concept Strategy Conversation

There are two product ideas in this strategy, where the one being an app used with existing earphones and smartphones was evaluated in feasibility. Current hearing aid apps were downloaded and different earphones and smartphones were used in a test in a busy café to see to which degree it could enhance conversations. The recording of sound did not reach a satisfying level, and by researching the wireless technologies available for use, there were no possibilities to build a local network of users with the desired latency. Therefore this product idea was abolished.

The strategy is directed at the function that the users seem to lack the most in the earphone industry today: making conversations easier to follow. This means that the concept will include users without hearing loss in a good way. The concept is restricted by that everyone needs to sit at the same table and will only be used when visiting restaurants with this feature installed.

This product handles stigma well by making everyone use the same product and by involving other functions that motivates usage. There is a risk with this strategy, that it might be seen as a gimmick. If the usage

by people without hearing loss drops, the motivation to use it is only by people with hearing loss. This creates a new stigma.

To enhance accessibility, this strategy needs to reach out to many restaurants and bars. Therefore there needs to be a strong motivation for them to acquire it, in order for the users to draw benefits from the system. The motivation for the restaurants with this strategy as presented are maybe not enough.

5.8.3 Concept Strategy Extra

This product strategy goes the furthest by diverting from hearing aids and spreading usage to people without hearing loss. It has its connection to style and the extra functions as motivators. The extra functions are what makes this concept, and as they are not determined, it is necessary to develop more on this.

A product category little stigmatized today that has gone from being very stigmatized is glasses. This concept tries to reach the same journey, by connecting more to style. It also tries to reach further by new technology, therefore it is promising. If the goal of reaching people without hearing loss is not met, this product might risk being stigmatized as well. However, as the product still has a strong connection to style, it will be much better off fighting stigma than the hearing aids on the market today.

This product is to be sold in stores on many locations. This makes the product accessible by location. By involving style and technology to this degree could however make the product rather expensive making it less accessible to those with less money to spend on such a product. But again, early adopters are more likely to spend much money on new products, why this should not be a problem for the first versions of the product. Later versions will be cheaper.

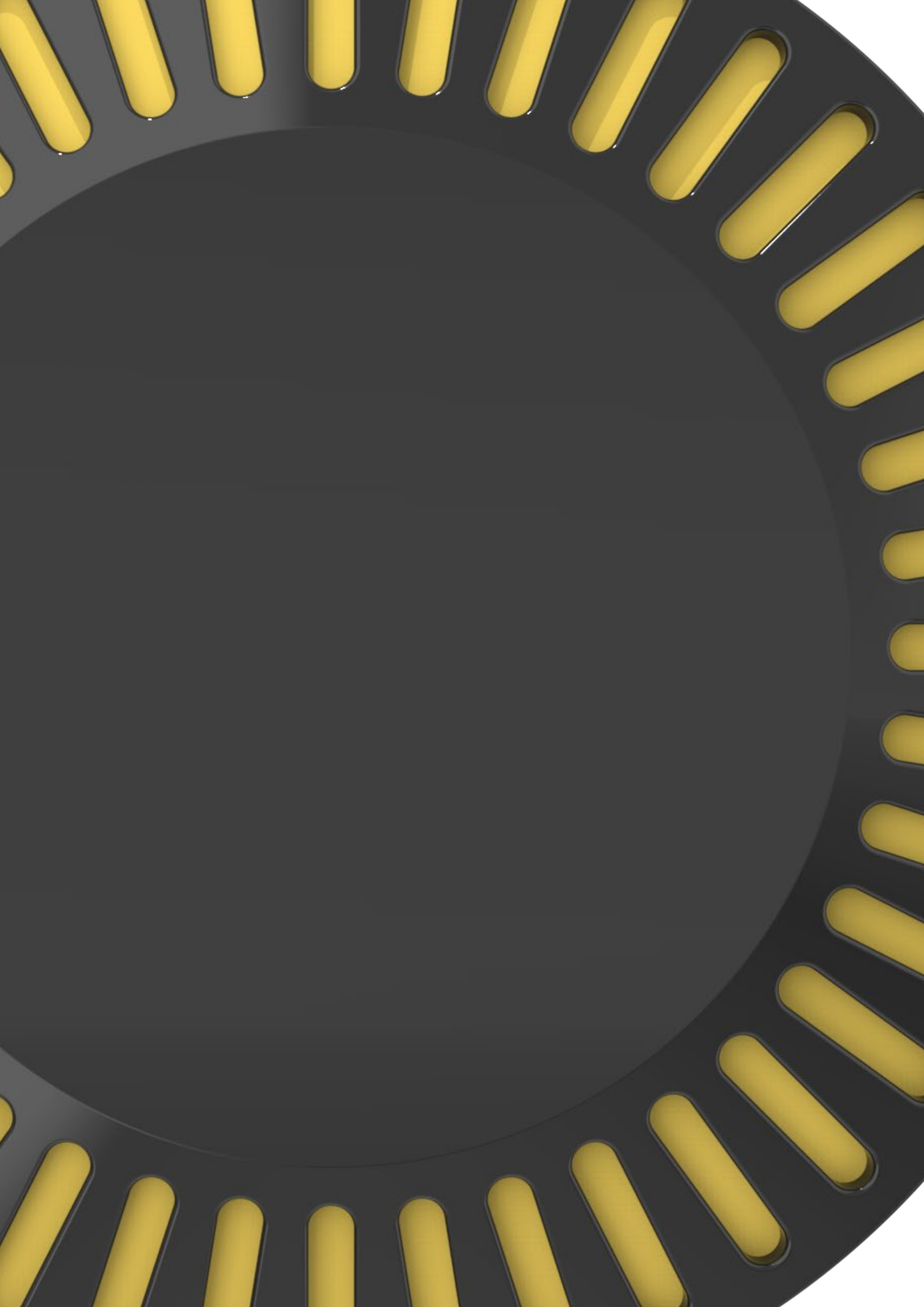
5.8.4 Conclusions

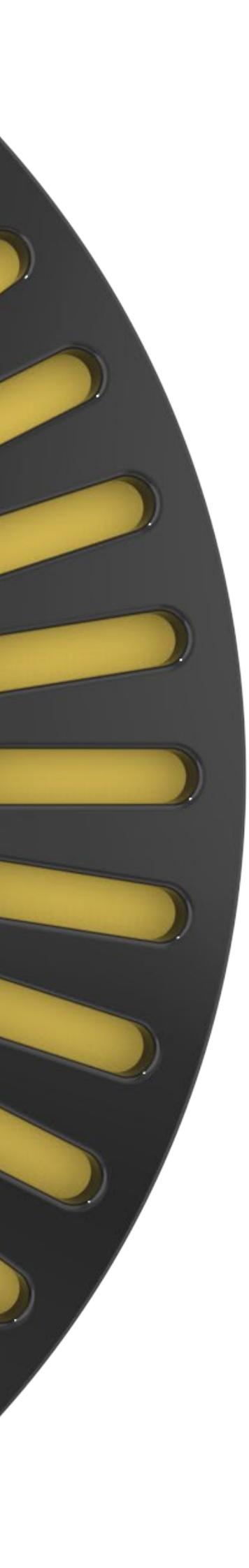
Concept strategy basic fails on one of the major evaluation criteria, which is make usage spread to people without hearing loss. It has interesting parts of making it more accessible and reducing stigma. The degree of innovation is low and as it does not reach as far as the other concept strategies on the evaluation criteria, it will therefore not be further developed.

The concept strategy conversation is interesting as it aims at a function desired by all users, not dependent on hearing loss. By making the prod-

uct being owned by restaurants instead of the users themselves, it is hard to reach out wide. Therefore this concept will be developed further on the basis of its technology but not by how it is conceptualized in a product.

The last concept strategy reaches fairly far on the three main evaluation criteria, and has no big drawback. This will make this concept as a base for further development. Important to investigate for this concept strategy is how it is to be sold and which extra functions can be integrated.





6. Manifesting a Strategy

Strategies are evaluated in the previous chapter, giving inputs for a more specific product development. This chapter concludes with a product concept for development.

6.1 Elaborating on Extra Functions

From the previous chapter the concept strategy Extra was the most interesting to elaborate on further. One area where little information was found before but was interesting was which kind of sensors that could be used in the ear. Therefore an interview with an expert researching on the use of brain sensors for hearing aids was made. A literature review of different types of biosensors was also performed.

6.1.1 Interview About EarEEG

Tomas Lunner (2017) is a Senior Scientist and Professor working on the Cocoha-project. The Cocoha-project aims to find a way to control a hearing aid device using brain signals. Today there are advanced methods to analyse the sound in a specific environment using a number of microphones and beamforming algorithms. The problem is that there is no good way to tell the hearing aid what sound source of many the user wants to focus on (cocoha.org n.d.).

We talked to Tomas about a concept called EarEEG, which picks up electrical activity of the brain from inside the ear canal using an ear-mould similar to those used in hearing aids. Electroencephalography or EEG is a method used to monitor brain activity. It is used in many different medical fields. Tomas hopes that this kind of technology in the future could be used in hearing aids, to determine what the user wants to focus on. If you can do that, you can amplify only that sound and attenuate other sounds making it easier to hear in difficult listening situations.

EarEEG uses the same electrode material, amplifiers, and principles as on-scalp EEG. There are some advantages with measuring EEG in the ear though. A custom made earpiece is comfortable to wear and more discreet than on-scalp solutions. A custom fit also makes for accurate measurements over and over again, since the electrodes will be at the same place every time. The tight fit of the custom earpiece also reduces motion artefacts from the electrodes (Looney et al., 2012).

The ear canal is a good place to measure EEG since it blocks the interference from external electrical and magnetic fields. There are also no muscle fibres which reduces muscle artefacts (Looney et al., 2012).

6.1.2 Biosensors

Apart from EEG it is also possible to measure data related to cardiac activity in the ear canal. By measuring heart rate variability it is possible

to track the user's stress level. Heart rate variability (HRV) is a measurement of variations in the rhythm of the heart. Studies has shown that HRV has a strong connection to stress and people suffering from stress tend to have a low HRV (Lennartsson, Jonsdottir and Sjörs, 2016). Heart rate and heart rate variability data can be given by measuring mechanical movements of the tissues under the skin of the ear canal. Tests have been done using multi modal sensors that can measure both EEG and heart rate (Goverdovsky et al., 2017).

Another way to measure cardiac activity inside the ear canal is by using what is called photoplethysmography or PPG. PPG shines light on the skin and measures how it scatters off blood vessels to measure change in blood flow. This technology is used by many smartwatches on the market today. To measure this inside the ear canal has proven to be more accurate than on the wrist. The reason for this is that the ear offers an area where blood flows neatly in and out, giving stronger signals and less noise. The fact that we move our ears much less than our arms also makes it easier to reduce motion artefacts from a sensor inside the ear (Metz, 2014). A study done at Duke University School of Medicine shows that PPG-sensors inside the ear can be used to accurately estimate the total energy expenditure (TEE) and maximum oxygen consumption (VO2max)(Leboeuf et al., 2014). Both these values can be used to accurately track the fitness level of the user. This means that the user can track the training progress but also get suggestions on exercises based on their level of training. The PPG sensors can also measure HRV.

A study done at Brunel University London shows that it is possible to place a electrocardiography (ECG) sensor behind the ear and get good results. ECG is one of the best ways to measure health status connected to the cardiac cycle, such as heart rate and heart rate variability. Another important measure to track health status is core body temperature. It can be measured inside the ear with good results using a non-contact thermopile sensor (Celik, Manivannan and Balachandran, 2016). With these kind of sensors the product in development would potentially be able to predict diseases before noticeable symptoms occur for the user.

6.2 Probing Extra Functions

As the development had lead to new functions that were not fully reviewed with users, it was time to involve them once again. First a probing was made when an interview with a potential user was performed. It was made to search for new extra functions that had not been found before. Another

online questionnaire about functionality was performed. It had focus on specific functionality and how the information should be presented.

6.2.1 A Normal Day in a Potential User's Life

A phone interview was done with a potential user without hearing loss to get an idea of what a normal day can look like. This was done to see if there were any extra functions that could make everyday life easier.

The person interviewed is a female in her 50s. Her day starts when the alarm clock of her smartphone rings. Before getting out of bed she checks the weather, emails and sometimes, if she has the time, social media such as Facebook and Instagram. At breakfast she reads the news in her local newspaper. She then checks the bus in her smartphone app to see if it is time to go. The bus trip to work is approximately 40 minutes with one change. During the bus ride she plays crossword-puzzles on her smartphone, listens to podcasts or e-books, or checks social media. There is a short walk from the bus stop to the office and during the walk she listens to a podcast and catches pokémons in the Pokémon Go app.

At work she has her own room in the office space. This means she can close the door to get a better working environment. At work she writes emails and builds web modules. When her working day is over she checks the app to see when the bus is leaving and walks to the bus stop.

The bus ride home is similar to the one in the morning but now she also plans what to cook for dinner. If there is some ingredients missing she might get of one bus stop earlier to buy them at the grocery store.

At home she cooks the dinner and cleans the apartment a bit. Then she often ends the day in the sofa watching a film or a tv-series.

6.2.2 Questionnaire About Extra Functions

To get even more input from potential users regarding extra functions we sent out a questionnaire. The questionnaire was distributed through Facebook. In total we had 70 people answering and of those 13 were between 43 and 80. The questionnaire concerned what functions the users would like to have and how they would like to have the information presented.

The questionnaire asked about five extra functions which were based on the possibilities found using different biosensors and sound processing.

All ratings are based on a scale from 1 to 5, where 1 is not valuable and 5 is very valuable. The five extra functions were:

1. to give information about the menstruation cycle
2. to measure stress level and help you if the stress level is high
3. to give exercise tips based on fitness level
4. to inform when you are about to get a fever
5. to provide a comfortable soundscape

The most appreciated function that almost all of the participants wanted was to get a comfortable soundscape, figure 6.1. The graph shows the number of persons rating each value on the scale. Most of the participants wanted this function to be presented automatically either in a graphical interface or in the headphones.

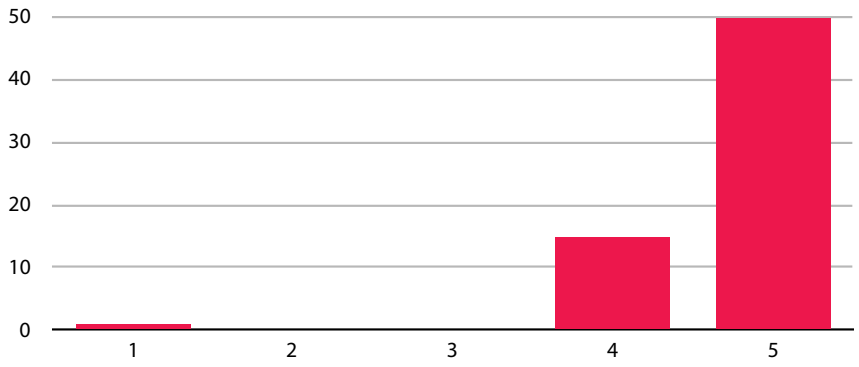


Figure 6.1
Graph over the ratings on providing a comfortable soundscape.

All other functions had answers ranging from not useful to very useful. The function seen as least useful was the information about the menstruation cycle, figure 6.2. This question was only given to women and in total 7 out of 32 found this function very useful and 11 out of 32 found it not useful. It was mostly the younger participants who found it useful. Of the participants over 43 years, non rated the function as very useful. Most of the participants wanted to have this information presented in a graphical interface.

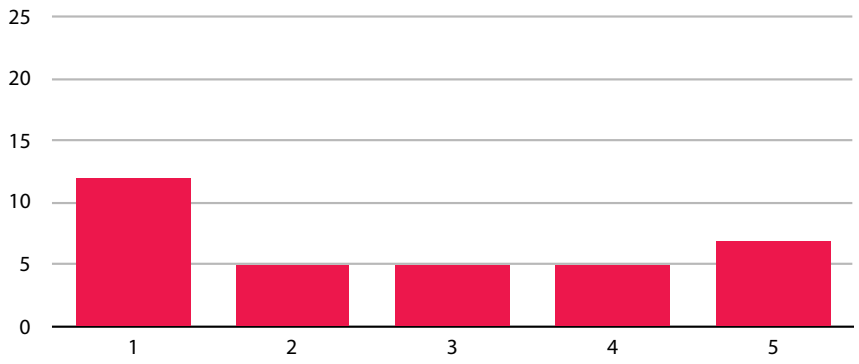


Figure 6.2
Graph over the ratings on giving information about the menstruation cycle.

The measuring of stress level had a varied response with answers distributed across the scale, figure 6.3. Most people would like to have this information presented in a graphical interface.

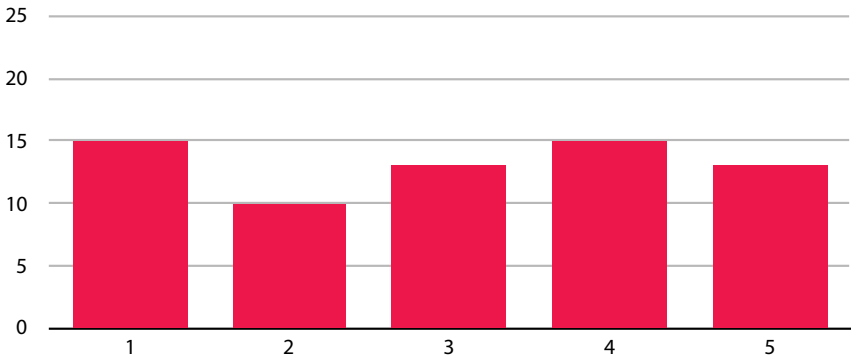


Figure 6.3
Graph over the ratings on measuring stress level and help you if the stress level is high.

To get exercise tips based on individual fitness level was a function seen as useful or neutral by many, figure 6.4. Most participants wanted this information presented in a graphical interface.

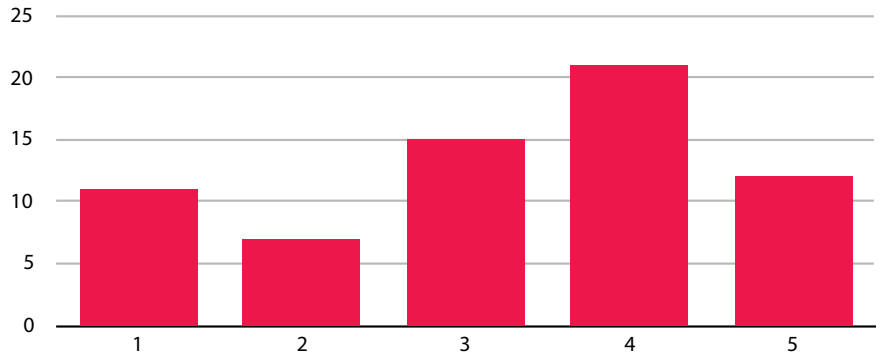


Figure 6.4
Graph over the ratings on giving exercise tips based on fitness level.

To be informed when you are about to get a fever was a function seen as useful by quite a few, figure 6.5. But there were also participants who did not find this function very useful. Most wanted this information presented automatically to them through a graphical interface.

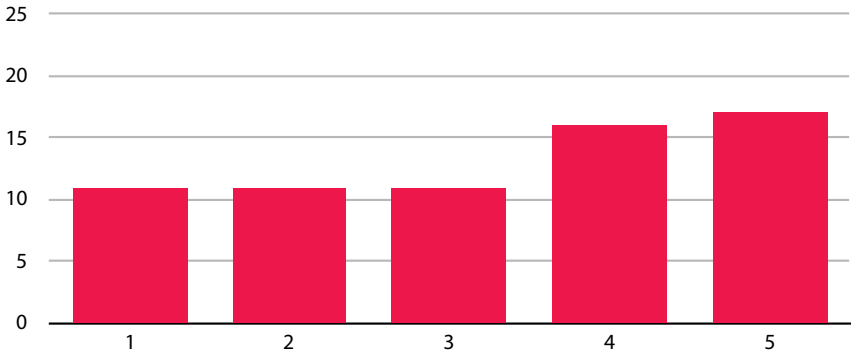


Figure 6.5
Graph over the ratings on informing when you are about to get a fever.

The questionnaire also contained a question about how the users would like to control sound streaming from another device, for example music from a smartphone. The most popular way to control streamed audio was on the earphones with 58 answers, the second most popular was on the device streaming the audio with 38 answers. Ten participants wanted to be able to control this using voice commands.

6.3 Packaging the Extra Functions

This chapter ties the information gathered together in three areas for functionality. The sensor information that can be received and the possibilities with technology in the ear lead to these three areas.

6.3.1 Speech Enhancement

From the interviews and questionnaires it can be seen that speech enhancement is a function wanted by most people. This is true for people with and without hearing loss. Everyone has situations when they have difficulties hearing and understanding other people.

As mentioned previously, the sound processing technology has come a long way. There are possibilities to isolate sounds coming from specific sources using an array of microphones and beamforming algorithms. The problem is how to know what the user wants to focus on.

We believe that the technology in EarEEG has great potential when it comes to controlling what kind of sound information the user wants. This in combination with beamforming could create a product useful for people with hearing loss but also for everyone else in difficult sound environments.

To further enhance the speech recognition the charging case for the wireless earbuds can come with built in microphones. The case can be placed on the table in difficult listening situations such as restaurant and bars. The extra microphones in the case then extends the capabilities of the beamforming technology similar to the product in concept strategy conversation seen in the previous chapter.

6.3.2 Wellbeing

In recent years, fitness trackers and smartwatches have become quite popular. Many of them can track your activity and heart rate but studies

show that the wrist is not optimal for measuring this. In many ways the ear would be a better place to measure health data.

A large health problem in today's society is stress. With a heart rate variability sensor it is possible to track the user's stress level. This can be used to present useful information about the stress levels to the user. The product could also suggest different tools to help the user deal with stress.

The possibilities and the accuracy of health measurements in the ear are better than on other parts of the body. This gives us the opportunity to take a larger grip on health. Instead of focusing on training and fitness like many of the smartwatches today do, this theme focuses on wellbeing. Training and fitness is part of the wellbeing concept and with more accurate data the fitness level and progress can be tracked more effectively. The more accurate data will be used to track the progress of the user but also to suggest training programs based on the current fitness level.

With more data about the cardiac activity and body core temperature it is also possible to realize and predict diseases. This can range from a fever to heart failures. The temperature sensor can also be used to track the menstruation cycle for women.

6.3.3 Assistant

Apple got Siri, Amazon got Alexa and Google got the Google Assistant. Voice control is on the rise with smartphones, smart home speakers and home assistants. With the development of artificial intelligence the assistants are getting smarter and smarter. The voice assistants can now be used to control your smart home, DJ your music, read you the news and much more. That this function area has a use was confirmed by the probing interview, as the interviewee searched for the kind of information shared by an assistant every morning.

This can be convenient, but with a shared smart speaker in a household with more than one person it can be troublesome. At the moment the speakers can not handle multiple accounts and you might not want to hear the speaker read your partner's calendar events. From this perspective it is better to have the assistant in your personal earbuds.

The product in development can either have its own assistant or make use of the existing assistants from the existing brands.

6.3.4 Conclusion

Speech enhancement is a function that almost all participants in the questionnaire want. This makes it one of the most important functions for the product in development. With the use of EEG and beamforming there is a possibility to create a product that can make life easier for many people independent of hearing capabilities.

With the ear being a favourable placement for different biosensors, well-being is seen as having a big potential in this kind of product. To take a larger perspective than training feels interesting as mental health is a large societal concern.

Every tech giant now has its own assistant and as mentioned there are pros with having this technology in the ear. If the product in development can use the tech giants assistants it could be useful. There is no use in developing an assistant exclusive for the product in development. The assistant is not very dependent on the product in development and therefore it will not be the main focus in this project.

6.4 Creating a New Customer Journey

In order to develop the product fully in its context, it was necessary to build on the entire customer journey. As said before, the product in development is more likely to turn out closer to an earphone than a hearing aid. Therefore an expert interview with a person familiar with the headphone industry was conducted. The findings on what was necessary for the users were collected and turned into a new storyboard also shaped as a comic.

6.4.1 Interview About the Headphone Industry

The product in development will have similarities to headphones, in terms of placement and functionality. We therefore found it important to get a better understanding of the headphone industry. To get this we spoke to Göran Karlsson (2017), currently CEO at yovinn but with a large knowledge of the headphone industry. Göran has previously worked as a distributor of headphones in Scandinavia.

A trend that has been seen in the headphone industry the last year is wireless headphones with active noise cancellation. Previously the active noise cancelling has required too much battery power for it to be possible to have in wireless headphones. Another trend is voice control with

headphones using smart assistants like Amazon's Alexa. Some headphones are also including functions like fitness tracking.

There is a wide range of products on the headphone market and products can be had in every price range. There are some main segments such as lifestyle, sport, Hi-Fi and gaming. According to Göran it is not uncommon for people to pay 3000 kronor for a pair of headphones today. Göran also said that people often have more than one pair of headphones. The reason for this is both functionality, but also a way to express style. People might have a pair of in-ear headphones for everyday use since they are small and easy to carry. The small in-ear headphones are complemented with a pair of larger over-the-ear headphones with active noise cancellation used on long flights.

6.4.2 Making it Easier for the User

From the interviews in the background study it was found that the process of getting a pair of hearing aids can be quite tedious. Many people wait for years before seeking help for their hearing loss. When finally seeking help it takes at least six months to become a hearing aid user. How can we reduce this time and make it more pleasant to become a user of the product in development?

The reason why people wait a long time before seeking help is related to the stigma surrounding hearing aids. They are afraid of getting hearing aids because they will be seen as old and handicapped. But the stigma of the actual hearing aids are not the only problem. By going through the healthcare system to get the hearing aids you are classified as sick. Compare this to the way you get eyeglasses today and you find one of the reasons why eyewear is seen as cool and hearing aids are not. The optician stores are located in the city centre with large display windows showing stylish and fashionable people wearing the products. The hearing aid clinics on the other hand are located in hospitals or hidden in small premises without display windows.

The product in development will therefore need a new sales channel. It is important that it steps away from the health care system for it to be seen as a product for everyone and not exclusively for people with a hearing loss. Stores with better and more visible locations make the product more accessible which hopefully reduces the barriers towards getting it. To have the stores sell other products related to sound can also be a way to reduce the stigma and get a more diverse group of people visiting the stores.

For many it is hard to get the result of the hearing test on paper. This shows black on white that they have a hearing loss. What if this was not necessary? Maybe the user can make the hearing test using the product in development at home and maybe they do not need to know the exact result. It might be enough to know that the product is adjusted perfectly for their hearing.

Another problem seen in the background study is that the user is dependent on the audiologist in the choice of hearing aids. The only way to get hearing aids today is through audiologists. Different audiologists have different brands that they prefer and will present to the customer. It is hard for the consumer to compare different models in terms of price and specifications. To give the users the power to choose their hearing aids, the store should have more options on display. Personalization of the product is also a way to make the user more engaged in the choice.

A stage that is quite unpleasant in the process of getting hearing aids is the impression making of the ear to get a custom fitting hearing aid. This can be done in a more comfortable way using a 3D scanner or maybe even a custom fit earbud that does not require an impression of the ear.

When the user gets the hearing aids and uses them for the first time the sound is experienced as sharp and uncomfortable. This means that the user gets a bad first experience of the hearing aids. By using the hearing aids a couple of weeks you get used to the new sound but many people do not have the patience to do this. The product in development could adjust the enhancement of sounds in steps as the user gets more and more used to wearing the product. This could lead to a more pleasant first time experience.

Even if the product in development is distributed using other sales channels than hospitals it is important to build trust. To do so it is important to have good support from healthcare professionals available for the customers. This applies to both the in store experience and during daily use.

6.5 Creating Boards

As a tool to use in the coming detailed development, image boards were used. The first board was the concept board, which was made to communicate the most important aspects of the product in development, as well as the overall feel of the product. The second board, which was the function board, was developed to highlight the most important functions to take into consideration during the form exploration phase of the project. The function board also worked as inspiration to how different functions could be solved.

6.5.1 Concept Board

Every picture on the board (figure 6.6) has its own header and its own meaning. "*Extended capabilities*" is about making a product that everyone finds useful, not only people with a hearing loss. "*Social*" means to make it easier for people to communicate with each other in all environments. "*Active choices*" represents the choice to treat your hearing loss and to choose a product that fits your personality. The ability to "*Control the Soundscape*" puts the user in control of the effects from surrounding sounds. As this is a product focused on sounds and audible information

Figure 6.6
The concept board.

"*Sound Quality*" is of great importance. "*Unrestrained Wearing*" means physical as well as psychological restraints. The product should not be in the way for the user, when in the ear it should be so comfortable that you forget you are wearing it. "*Pride*" is another important word for this product. The user of the product should feel proud and comfortable of that the product expresses what the user wants to express.

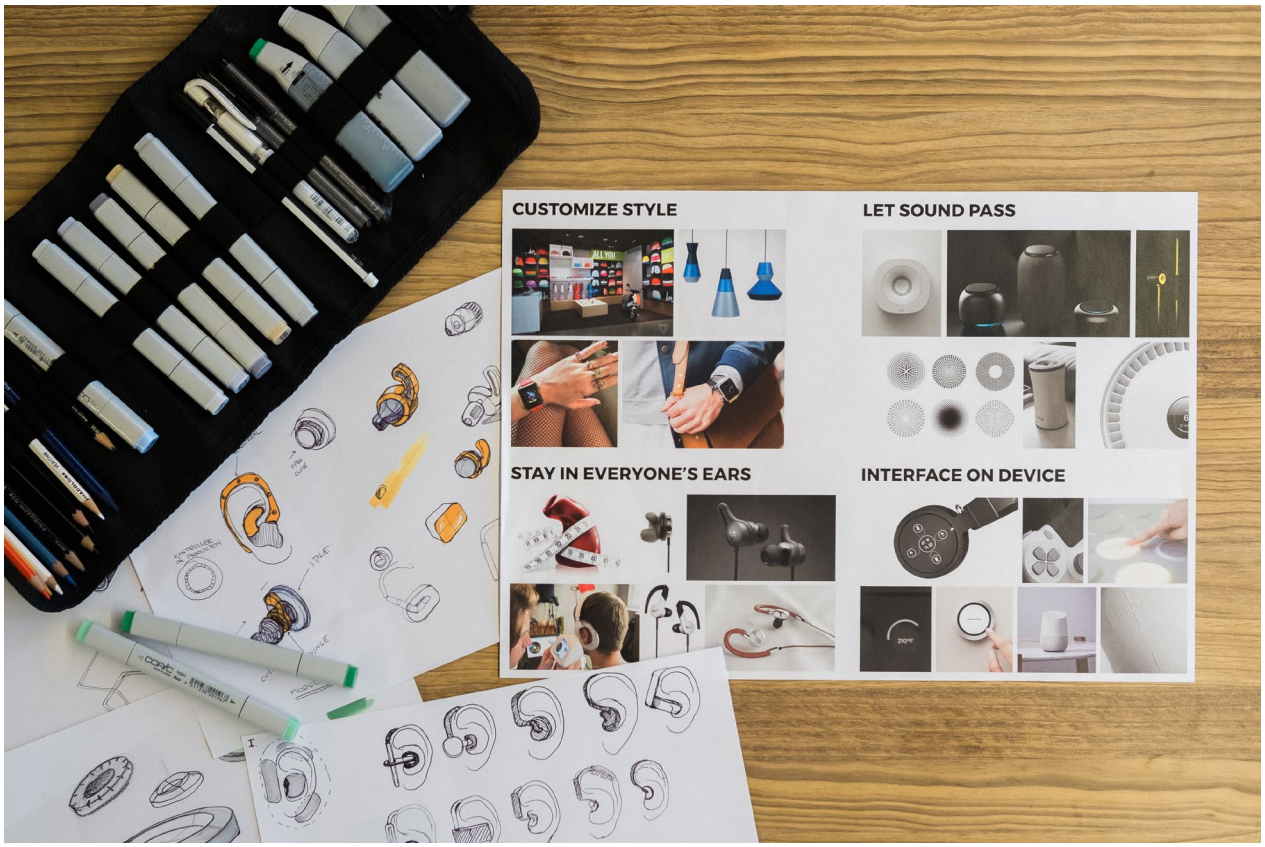


Figure 6.7
The function board.

6.5.2 Function Board

The first function of the board is the personalization of the product, see figure 6.7. This is seen as an important function as the product is aimed at a diverse group of people and will be used in many different situations. The board takes inspiration from products like the Gogoro scooter with its replaceable faceplates and the Apple Watch with the customizable watch faces and straps. Both these products offer the possibility to change the appearance of the product by having a modularity. This is important for the product in development as well as for it to be able to suit different people in different situations.

Another important function to consider is how the product communicates that it takes in sound from the environment. This is a problem

with headphones today. People do not think the wearer of headphones is hearing the world around them. The function board explores different ways to communicate sound inlet using different shapes and holes.

Furthermore the product needs to have a secure and comfortable fit in the user's ears. This is important for the user not to worry about losing the earbuds and to be able to wear them for a long period of time. The pictures on the board illustrate some ways this can be done.

The fourth and final function on the board concerns the interaction with the product. There needs to be some kind of interface to control the product. The images are there to inspire different solutions from buttons and knobs to voice controlled interfaces.

6.6 Finding the Key Functions

To find out which extra functions the product in development should have, use cases were developed. A use case is a description of how a user does a certain task. In this project the use cases were kept on an abstract level, focusing on who is using the product and in what context. The developed use cases were based around answers in interviews and questionnaires, and complemented with own experiences and technological possibilities.

6.6.1 The Five Key Functions

The product in development has a few functions that are worth highlighting. These are named the five key functions. All the key functions are based around use cases and how they provide usefulness to the users.

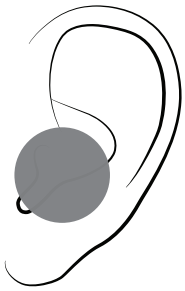
Make It Easier to Communicate

Our background study shows that almost everyone experiences situations where they have difficulties to understand what another person is saying. This can for example be in a crowded restaurant or bar. With the use of EEG and beamforming technology the product in development can help the user to communicate in difficult environments.

Help the User Relax or Focus

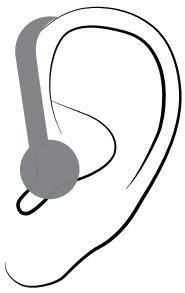
Another function that a lot of people found useful was to be able to control the soundscape. This can be used to turn down the volume of background noise in a situation where the user needs to focus for example in an open office space. It can also be used to attenuate sounds when

the user needs to relax. This in combination with sound therapy could further enhance the user's ability to focus and relax.



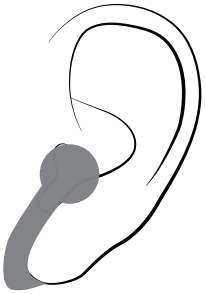
Express Style
With a modular solution that makes it possible to change the appearance of the product the users have the ability to find an expression that suits them. This means that the product can enhance your personal style and be matched with different outfits.

Give the User a Personal Trainer in the Ear
With the use of different biosensors it is possible to get accurate data of the user's progress and fitness level. This can be used to create personalised exercise schedules based on the user's fitness level. The product can also help coach the user through the workout.



Save Lives by Detecting Diseases Early
Another useful thing that can be done with the biosensors is to detect diseases. This can range from warning the user about an upcoming fever to something more severe like a heart failure.

6.7 Exploring the Form



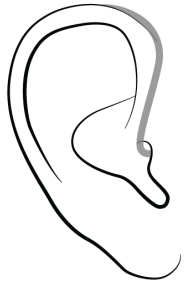
Sketches and quick prototypes in clay were used to explore different shapes of the product in development. The concept board together with the function board laid the foundation for the form development. Much of the form development aimed to solve and communicate the functions illustrated in the function board.

6.7.1 Sketches and Clay Models

Make the Product Stay in Everyone's Ears
To have a product that sits comfortably and securely in the ear was important. Therefore different placement options and ways to hold it in place were explored in a number of sketches and clay models. Four main placements were explored: in the ear canal, a hook above the ear, a hook beneath the ear and an over the ear placement, see figure 6.8.

Customize Style
Another important aspect was the possibility to personalize the product. This was important as the product is aimed at a large user group with different styles. Modularity was seen as a good way to make the product customizable and sketches were used to explore what could be made

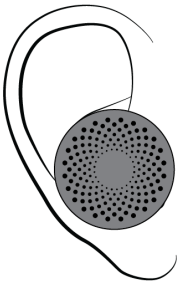
Figure 6.8
Placement options.



modular in the product. Things that could be made modular included the hook around the ear, the wing of the earbud, the wire and decorative elements on the earbud.

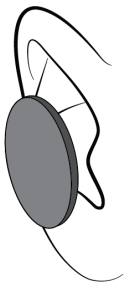
Show Intake of Sound

A product in the ear can often create an uncertainty whether the user is hearing the surroundings or not. To reduce this uncertainty it is important that the product communicates that it passes on sound to the user.



Different solutions to this were explored, see figure 6.9. One way to do it is by using a similar approach as the RITE hearing aids, an earpiece that is almost invisible. Another way to do it is by using holes or patterns on the earbud. Furthermore it was explored to have a gap between the ear tip and the earbud to make it seem as the earbud was floating in the air. Different mechanical solutions for opening and closing the earbud were also explored as well as the use of light to communicate that the user is listening.

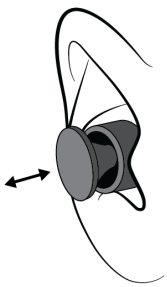
Control the Product



There are a number of things that the user wants to control on the product. This means that there has to be some kind of user interface available. The interface can be on another product like a smartphone, on the earbuds themselves, or a combination. From the questionnaire it could be seen that most participants would like to control the music player directly on the earbuds. Knobs, buttons and touch controls on the earbuds were explored. Voice control was seen as another way to control the earbuds.

6.7.2 Sketches in Ears

A number of form concepts were developed based on the different solutions to the four functional aspects. These concepts were sketched on a side view photo of a person's head to see what they would look like when worn, see figure 6.10. The sketches were done in a similar level of detail for all concepts with the colours kept monochrome.



The shapes of the different concepts were varied from organic shapes to geometric shapes. This was done to explore how that affected the expression of the product inside an ear and to get a feel for which direction to take with the final product. The larger more visible designs were seen as more interesting and better for expressing style. The geometric shapes created a contrast to the anatomy of the ear. The organic shapes blended into the ear too much and looked a bit revolting.

Figure 6.9
Sound intake options.

Figure 6.10
Side view sketches for evaluation.

6.7.3 Evaluation

The form evaluation was done using the function board as a guide. The different form solutions were judged based on how well they manifest the different functions presented in the function board.

Make the Product Stay in Place

No ears are the same which means that it is very hard to make a product that fits all people. Advantages can therefore be seen with a custom fitted product adjusted to the specific user's ear canal. This kind of product will be comfortable and sit tightly inside the user's ear. This is also useful to get accurate measurements from biosensors placed in the ear. A custom fit solution is more expensive than universal solutions. As this concept is showing what could be done with the most advanced technology and therefore targeting early adopters the higher price point is not seen as a big problem.

With a custom fit there is no need for solutions like hooks around the ear or wings to hold the product in place. It is also hard to get these features to fit everyone's ears in a comfortable way. A wire between the two earbuds could be useful when the products are not in use. The earbuds could then hang around the user's neck making them accessible when needed.

Personalization of the Product

With a custom fit solution the hook and the wing becomes redundant from a functional aspect. This means that their only function would be to change the style of the product. Both the hook and the wing can be seen in sport earphones on the market today. In the sport products

they are used to keep the earbud from falling out during sport activities. Modular hooks or wings could add a sportier expression to the product but are hard to motivate without any other functional advantage.

If the earbuds are connected with a wire, the material and colour of the wire could be used to change the expression of the product. Another way to change the expression of the product is to use a modular decorative element on top of the earbud. This makes it possible to change the expression of the product quite a lot to fit the style of different users. One important thing to consider is how much the appearance of the product can be changed for it to still be recognized as the same product.

Show Intake of Sound

Many different ways to show that the user is listening to sounds from the environment were explored. From simple solutions like holes and patterns in the earbud to complicated mechanical opening and closing mechanisms. The problem with this kind of mechanical solutions in a product this small is that it gets fragile and expensive. It is also hard to operate for the users as it is so small.

Holes and patterns could be a good and cost effective way to communicate that the product lets sound pass through. A problem can be that it might resemble a speaker and thus looking like sound is going out instead of in.

Lights to communicate the status of the product can be obtrusive. This is because they will shine bright and be eye catching, especially in the dark. Lights also require more components and power.

To have a disc with a gap to the earpiece sitting in the ear canal creates a visual illusion. This illusion makes it seem as the ear is not plugged, but there is only something appearing to hover outside of the ear. This is a simple and cost effective solution.

Control the Product

Voice control is useful in situations where the user cannot use the hands to control the product. This can for example be when cooking or driving. There are situations when voice control is not possible or the user does not feel comfortable speaking to the product. Thus voice control can not be the only option to control the product but acts as a good complement.

A smartphone app is a good way to visualize more complex information. It is important not to overwhelm the user with auditory information. Auditory information is an obtrusive way to interact with the user, as it takes a lot of focus away from other things and the user is not able to

shut the sounds out. The app can also be used to adjust more advanced settings of the product.

To have an interface on the earbuds for controlling the music was something many users wanted. Knobs can be a simple way to control the sound volume. Play/pause and skip tracks can be done using buttons or touch depending on what is easiest to implement into the shape of the earbud.

6.8 Conclusion

The use cases led us to five different key functions that the product in development should have. The first key function is something that many people would like to have according to our questionnaire, a product easing communication in noisy environments. The second function is to be able to control the sounds of the environment to make it easier for the user to focus or relax. Another important focus area is to make the product personalizable as the product has a wide target group. Many users have smartwatches measuring pulse during workout. This can be measured more accurately inside the ear and thus the fourth key function is a health tracker. With sensors it could also be possible to detect certain diseases before visual symptoms are seen by the user.

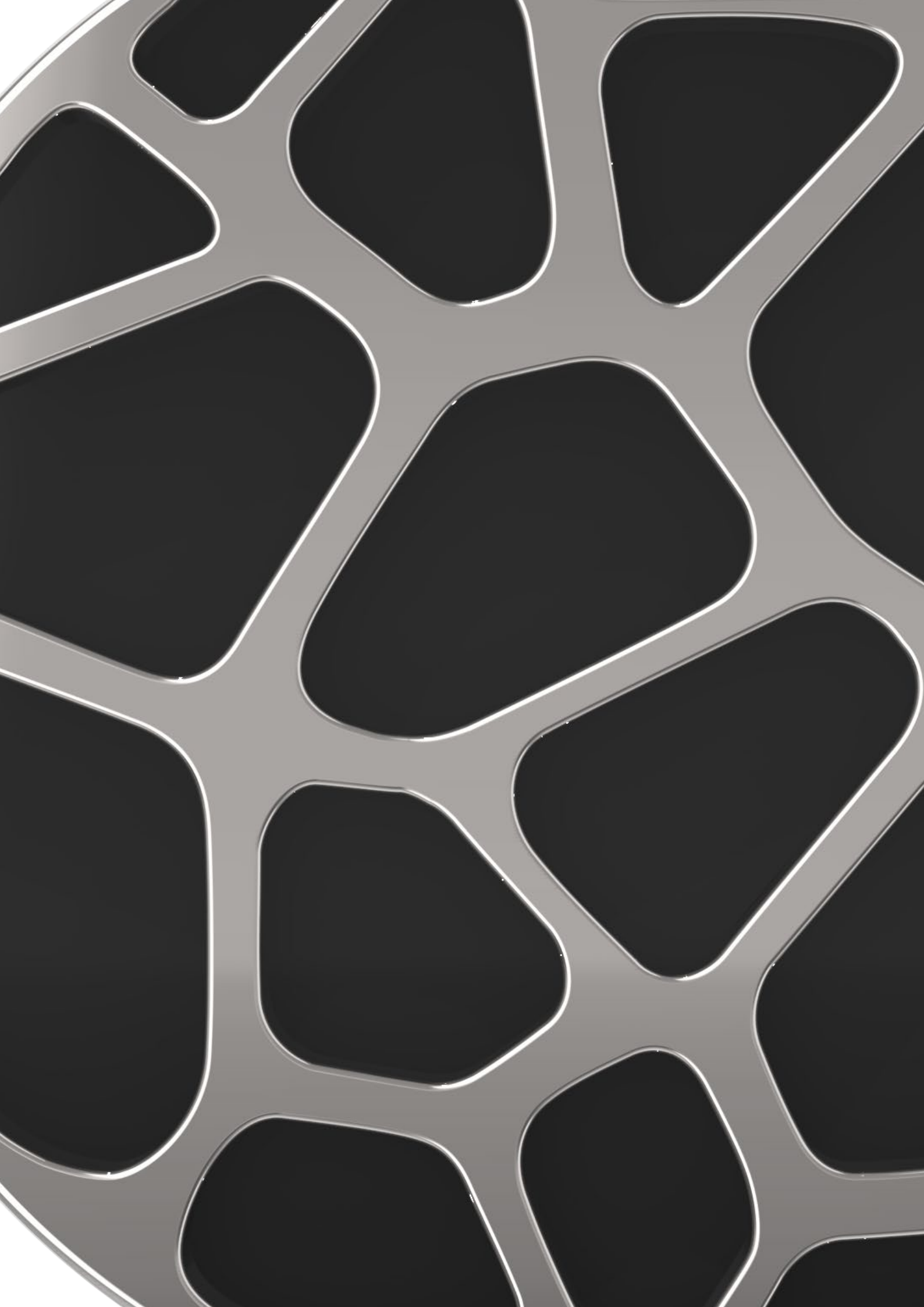
To fully make use of the biosensors and get accurate readings we decided to use a custom fit solution. This gives a comfortable and secure fit without the need of hooks around the ear. This removes some of the options when it comes to modular pieces that can be used to change the style of the product. A modular decorative element was seen as the best option, as it makes it possible to change the expression quite a lot very easily.

To show that sound is passed through to the user, different solutions were explored. Light on the earbuds was seen as a too obtrusive way to communicate this. Mechanical opening and closing mechanisms were seen as too fragile and expensive. Patterns and holes together with the disc creating the visual illusion of the ear canal not being plugged were seen as the best options.

Voice control can be a good way to interact with the product, but it is not possible to use in every situation. Therefore the user should be able to control the most common functions without using the voice. Preferable is if these functions can be controlled without using any external device such as a smartphone. An interface on a smartphone can be used to present information to the user to not cause overload of auditory information.

7. Developing the HearO

In this chapter the final concept the HearO is presented. The product is placed in its context with ideas on retail and branding.



7.1 Developing the Physical Shape

The form of the product in development has been shaped by a number of factors. Much of it is based around technical and functional solutions. The product needs to fit into people's ears in a good way and needs to be large enough to fit all the components inside. Apart from the technical details the product should also be able to express different styles to attract different kinds of users. The different design decisions and final solution is presented below.

7.1.1 Fits Like a Glove

A comfortable and secure fit is important for the product in development. With everyone's ears being unique it is difficult to make a universal product that guarantees a good fit. A custom fit solution is a good way to make the product comfortable and secure. A custom fit also provides more accurate measurements from biosensors. Another advantage with having a custom fit is that it blocks the ear canal and thus provides passive noise cancellation.

The problem with custom fit hearing aids today is that they look revolting when seen outside of the ear. This is due to the hearing aids showing every crease of the user's ear in combination with the colours and materials used. To make the product in development look better in the hand and in the store, the shape of the custom made part has been simplified see figure 7.1. This reduces the creases without compromising the fit. The product will also have another colour and finish compared to the hearing aids of today.

Figure 7.1
Custom made part before and after simplification.

7.1.2 Make a Good Impression

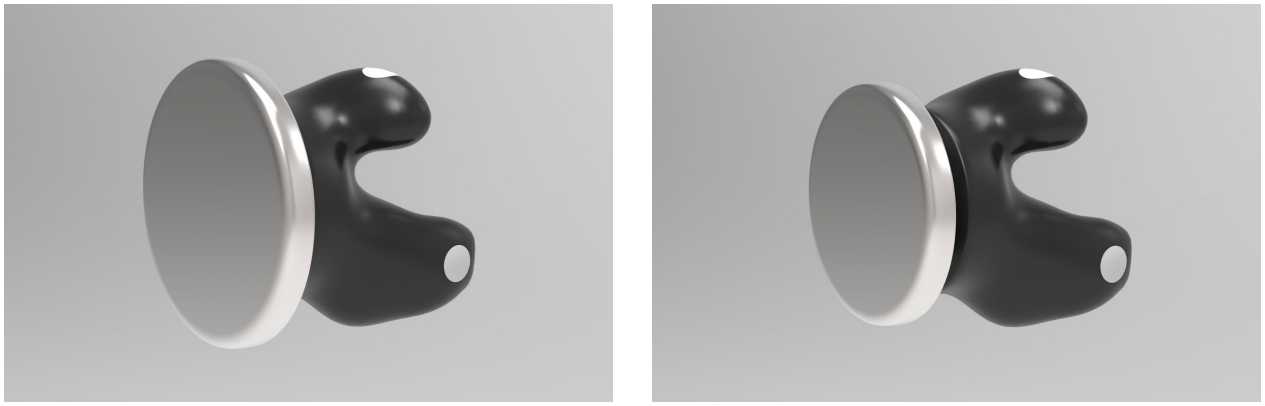
To get a custom fit hearing aid today an impression is made at the audiologist. This is quite an uncomfortable and even painful experience where the audiologist shoots an impression material into the user's ear. The impression material then hardens and is sent to the hearing aid manufacturer where they scan it and make a digital 3D model of the impression.

To make the experience of making an impression more pleasurable and comfortable, other methods have been investigated. One solution that is on the market today is to use a 3D scanner made especially for scanning ears. This reduces the pain as no impression material needs to be shot into the users ear. Another solution is one used in an earphone called Revols. Their product is not on the market yet but had a successful Kickstarter campaign where they promised a custom fit solution at home. The idea is to use a fluid material in the ear tip of the earbuds. The material then hardens when electrical current is put through it. This process is controlled by the user through a smartphone app (Revols, n.d.).

7.1.3 Express Style

As the target group is large with people of different ages and styles it was seen as important to be able to change the expression of the product. This meant creating a modular solution. The best solution for changing the expression of the product was to have a modular disc covering the custom made mould. The discs can be had in many different styles and two different sizes matching the user's style and activity. There will be one larger size of the discs, 30 millimetres in diameter, and one smaller measuring 25 millimetres in diameter, see figure 7.2. The larger is more expressive and visible, and can function like a jewellery. The smaller is less in the way and might be more suitable for training and other physical activities.

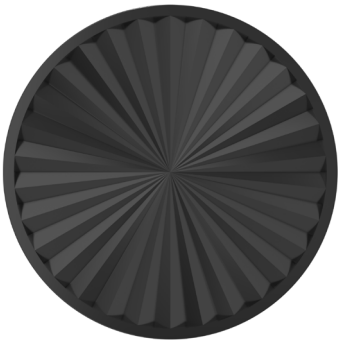
Figure 7.2
The two different disc sizes.

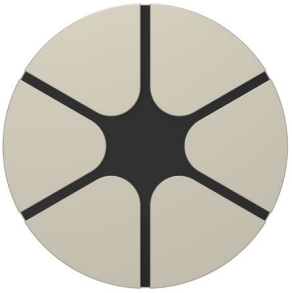
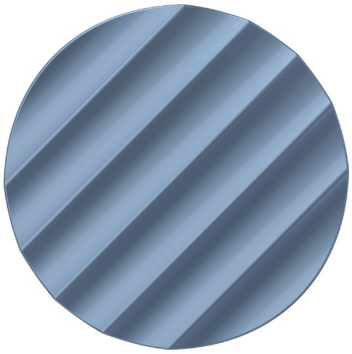
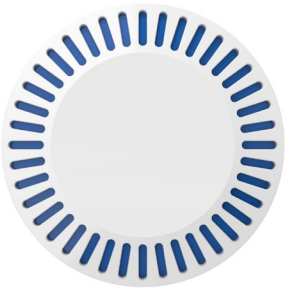
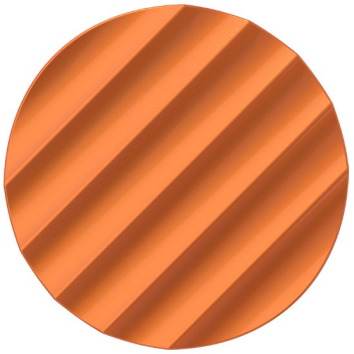


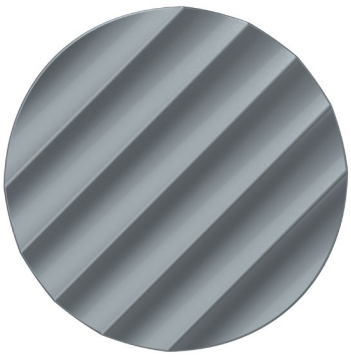
During the development of the discs there were three solutions explored. The first solution was to have an outer ring that could be turned as a control knob for the volume and a fixed centre disc that could be changed. The second solution was similar but with the inner disc spinning together with the control ring. The third solution was to change the whole disc and have it be the control ring.

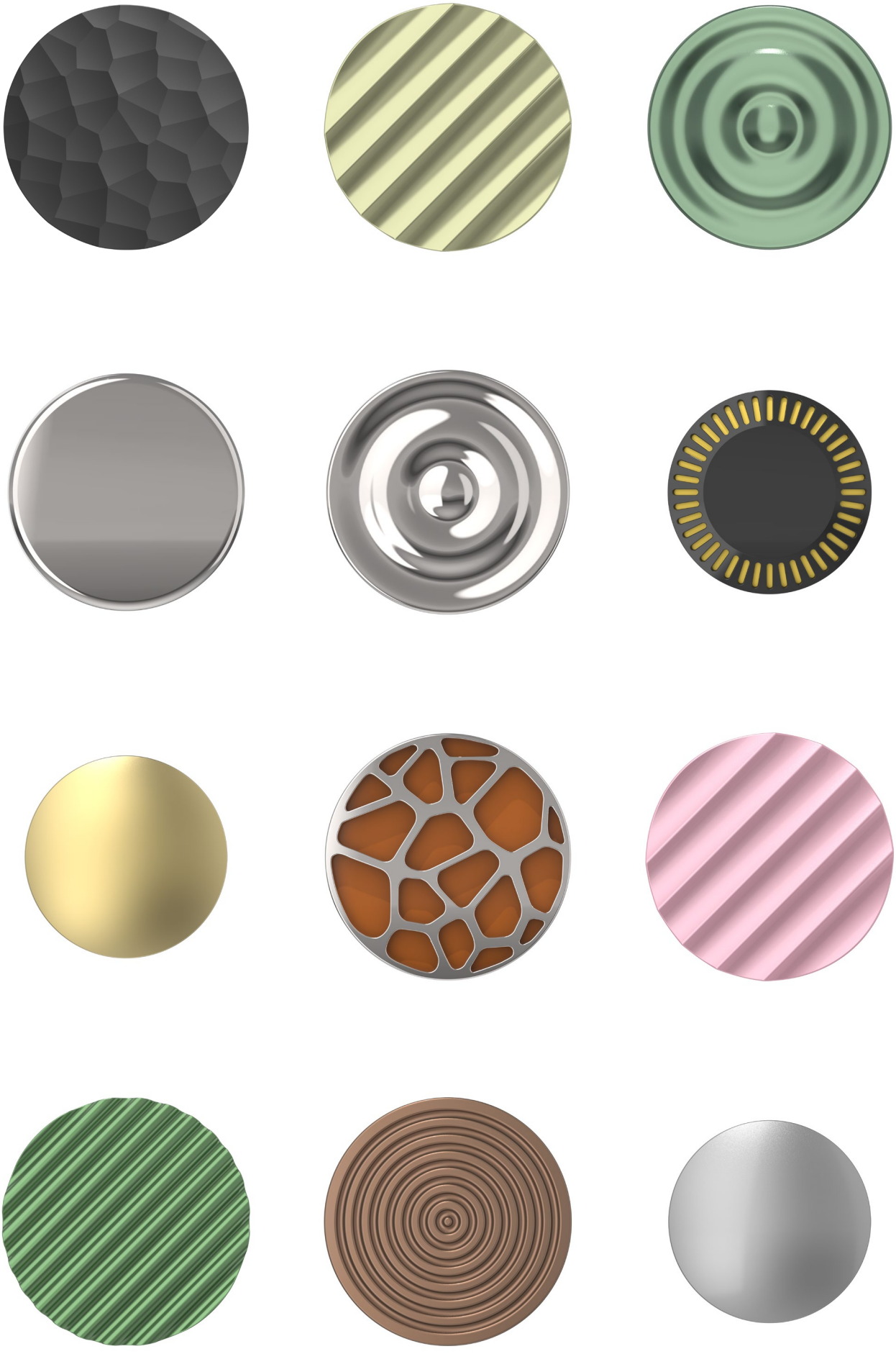
Figure 7.3 (next page)
Different discs.





The first solution with fixed centre and turning outer ring was seen as too complex to construct in a good way this small. It would most likely be a more expensive solution and possibly harder to handle for the user. The benefit of this could be that the outer ring would be the same all the time and thus creating a consistency for the product.

The second solution was similar to the first, but with the difference that it would be easier to construct as the centre disc is turning together with the outer ring. The expression cannot be altered as much with this solution as with the third solution though as the outer ring stays the same. The choice therefore fell on the third solution which changes the whole disc of the earbud. This makes for many possibilities when it comes to personalization see figure 7.3.

7.1.4 Cut the Wire…or Not?

One design decision taken was if there should be a wire between the earbuds or not. The main reasons for having the wire would be to reduce battery consumption and to make it easier to take the earbuds on and off as they could hang around the user's neck. The battery consumption would be saved as the two earbuds would not have to communicate wirelessly. The wire could also be modular making it a part of the personalization of the product.

A con of having a wire is that it would be in the way for the user at times, getting tangled up in things. It would not provide the true wireless solution which might make it less modern in its expression. Another con of having a wire is that it would take up more space and make it harder to store in a charging case. These reasons led to the decision of cutting the wire and going for the true wireless feeling.

7.1.5 Putting it Together

As seen in chapter 4, there are quite a few components that need to fit inside hearing aids. With the extended functionality in this product there are even more components needed. First there are the regular hearing aid components like a chip for sound processing, mics, receiver and battery. On top of that there needs to be sensors for measuring pulse and EEG. These components need to fit inside the custom made shell.

To illustrate that all components fit inside the developed produc,t a 3D-model has been made with components available today. The placement of the components can be seen in figure 7.4 and 7.5. The battery used in this illustration is of the same size as the largest zinc-air batteries used

in hearing aids called 675. These can be had rechargeable in a silver-zinc version from Z-power. The silver-zinc version from Z-power delivers 211 mWh. This is similar to what RITE hearing aids have today. There is room for a larger battery inside the shell so it is possible to deliver enough power.

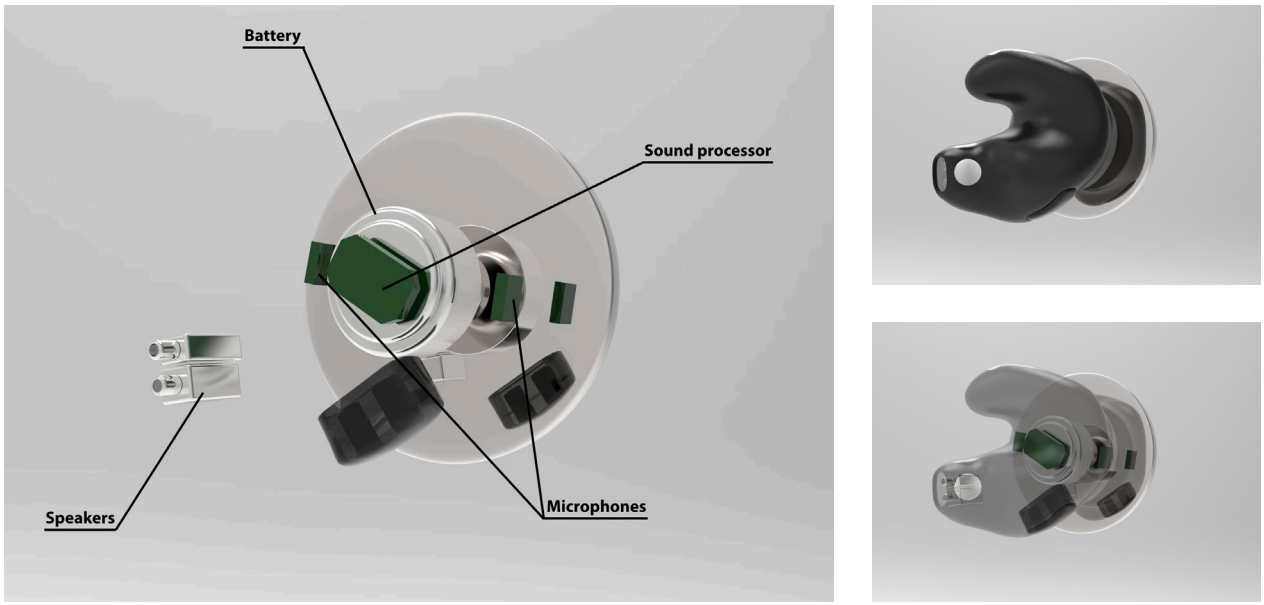


Figure 7.4
Placement of the components inside the shell.

Inside the shell are also two receivers that together deliver a full range sound spectrum. The sizes of the receivers are based on product samples given to us during the visit to Widex. The microphones used in the illustration are two MEMS microphones. The mics are placed one on each side of the earbud, one facing forwards and one backwards, from the users perspective. This placement makes it possible to use beamforming and thus analyse the direction of the sound coming in.

For the blood flow sensor a biometric sensor from Valencell is used as a reference. This sensor is developed to be used in hearables and can continuously measure blood flow. The blood flow signals can then be translated into VO2 max, heart rate and heart rate variability assessments (Valencell, 2017). For the measurement of EEG signals three sensors are distributed around the earbud. Two of them at the tip going into the ear canal and one that measures in the outer ear.

Apart from the components presented above there will also be numerous smaller components such as coils and cables. These components have been left out of the illustration as they are small and easy to fit inside the shell.

The disc used for personalization of the product attaches to the custom earbud with snap fits. This makes it easy to change the appearance of the product as no tools are needed.

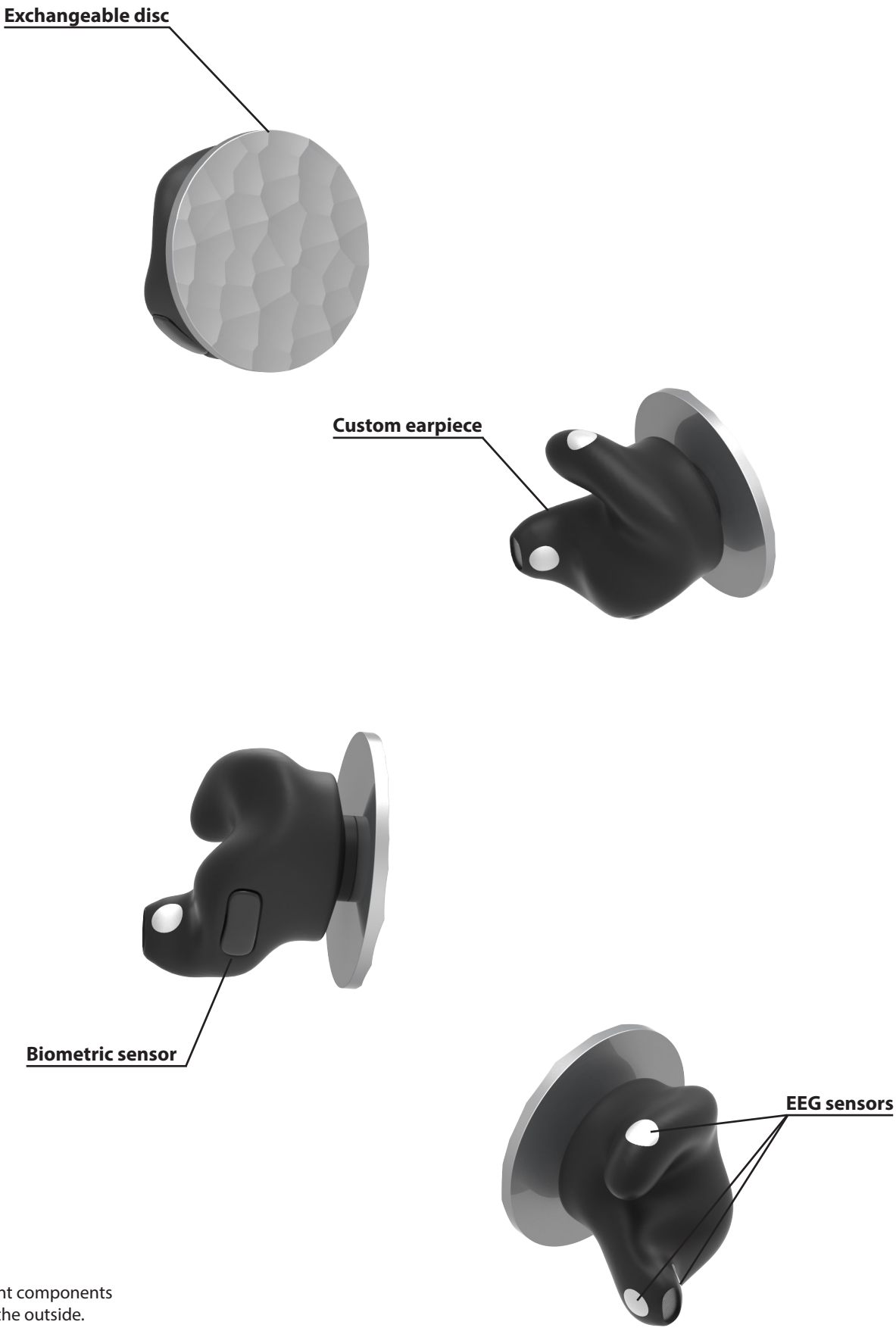


Figure 7.5
The different components seen from the outside.

Figure 7.6
Case with earbuds inside.

7.1.6 Charge It on the Go

The earbuds come in a portable charging case used to store the earbuds when they are not in use, see figure 7.6. The case works as a power bank and can charge the earbuds stored inside. Apart from working as a charger, the case has nine microphones built in, see figure 7.7. The microphone array is used for beamforming in hard listening environments, such as bars and restaurants. The user then places the case on the table and the microphones help sort out the sounds the user wants to hear. These sounds are then sent to the earbuds and other sounds are attenuated, making communication in difficult environments easier.

Figure 7.7
Case with microphones in the lid.

7.2 Defining the Interaction

In chapter 6, the most important ways of interacting with the HearO are discussed. In this chapter these guidelines are developed into solutions.

7.2.1 Interaction Needed

Even though the earbuds are smart and use EEG signals to sort out different sounds there needs to be a way for the users to control certain things. One thing the users want to control, found in chapter 6.2.2, is the music player streaming music to the earbuds. Common controls for music players are pause/play, change track and music volume.

The product in development can adjust the volume of sounds coming from the environment. The user should be able to control this volume. In a situation where the user needs to focus, the volume could be turned down. Apart from adjusting the volume of the environment the earbuds can filter out sounds that the user wants to hear based on EEG-signals. The level of filtering though is something that the users should be able to control themselves.

Another way of communication between the user and the product involves exchange of information. The earbud receives data like pulse and movement from the different sensors on the product. The data is then analysed and the product needs a way to communicate the results to the user.

7.2.2 User Interface

The product in development offers voice control letting the user control the earbuds with their voice. This can be useful when the user cannot use their hands, for example when cooking or driving. The voice control can be used to control most of the things the earbuds can do and is tightly connected to the assistant. There are times when it is not possible or wanted to control the earbuds using the voice. Therefore there needs to be another way to control the product as well.

It should be possible to control the most important functions easily and without the user having to speak. The music player and the volume of the surrounding soundscape can therefore be controlled on the earbud, see figure 7.8. The music is controlled on the right earbud. The disc works as a volume knob, that the user turns physically to change the volume. Pushing in the centre of the disc pauses or plays the music. To change track the user pushes in the front of the disc to play the next song and in the back of the disc to play the previous.

The left earbud is used to control the surrounding soundscape. The disc works as a volume control making it easy to quickly adjust the environmental sound sent into the ear of the user. Pushing up or down on the disc adjusts the smart filtering of the surrounding sounds. This means how much noise is heard in comparison to speech.

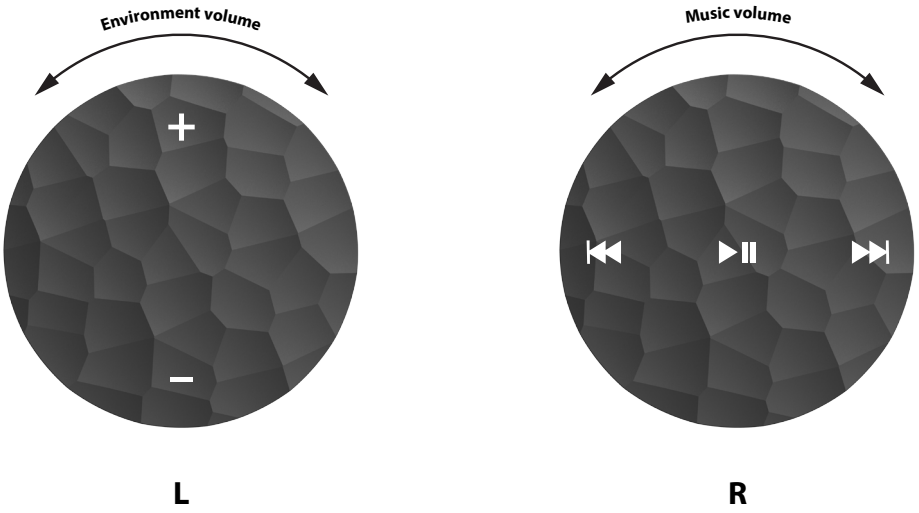


Figure 7.8
The interface of the two HearO buds.

With the measurements of heart rate, heart rate variability and VO2 max the earbuds can monitor the user's physical and mental status. The data is used to help the user stay healthy. This is done both through physical exercise, personalised for the specific user, and through monitoring of mental stress levels. This information is presented in a graphical interface to not overload the user with auditory stimuli.

The app will also function as a way to build trust for the product service system in that the user can get support through the app. The user should be able to get in contact with a professional audiologist via the app. The audiologist can answer the user's question and make adjustments to the product.

7.3 Building the Brand

Widex is a brand with a long history of making hearing aids. They have a lot of knowledge about sound processing and technology in hearing aids. For the branding of the product in development we considered whether the history of Widex should be incorporated or not. Our conclusion was that the Widex brand is too tightly associated with hearing aids and therefore also stigma.

The product in development is a new type of product that we do not want to associate with hearing aids. This made us think that the creation of a new brand would be the best thing to do. A new brand means a fresh start and gives the opportunity to build a brand that does not suffer from the stigma of the hearing aid industry.

Brainstorming was done to come up with the name of the new brand. The name should have a connection to the auditory field as well as expressing the power of the product. After a few short brainstorming sessions we landed on the name HearO. The name plays with the words hear and hero. A suitable combination for the product in development as it makes people control their hearing and got some extra functions.

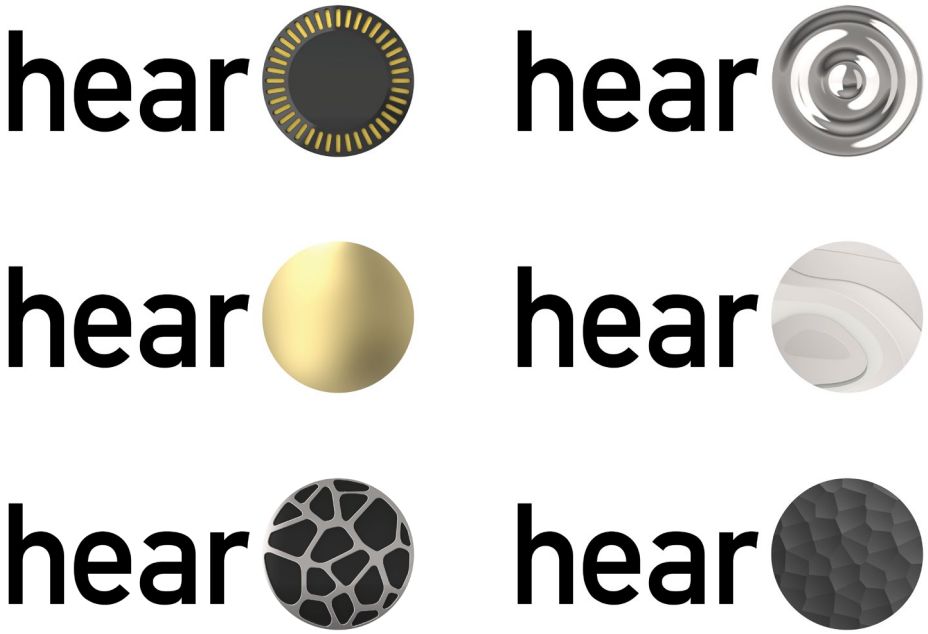


Figure 7.9
Different versions of the dynamic logotype.

When the name was decided, a dynamic visual identity was developed. A dynamic identity opens up one or more of the visual elements for dynamic influence. This was used in the HearO logotype where the O is dynamic. The O takes the shape of the personalized discs used on the earbuds, see figure 7.9. The logo can change appearance based on situation. In the smartphone app it could for example change to display the disc that the user currently has on the earbuds. This creates a personalized visual identity for a personalizable product.

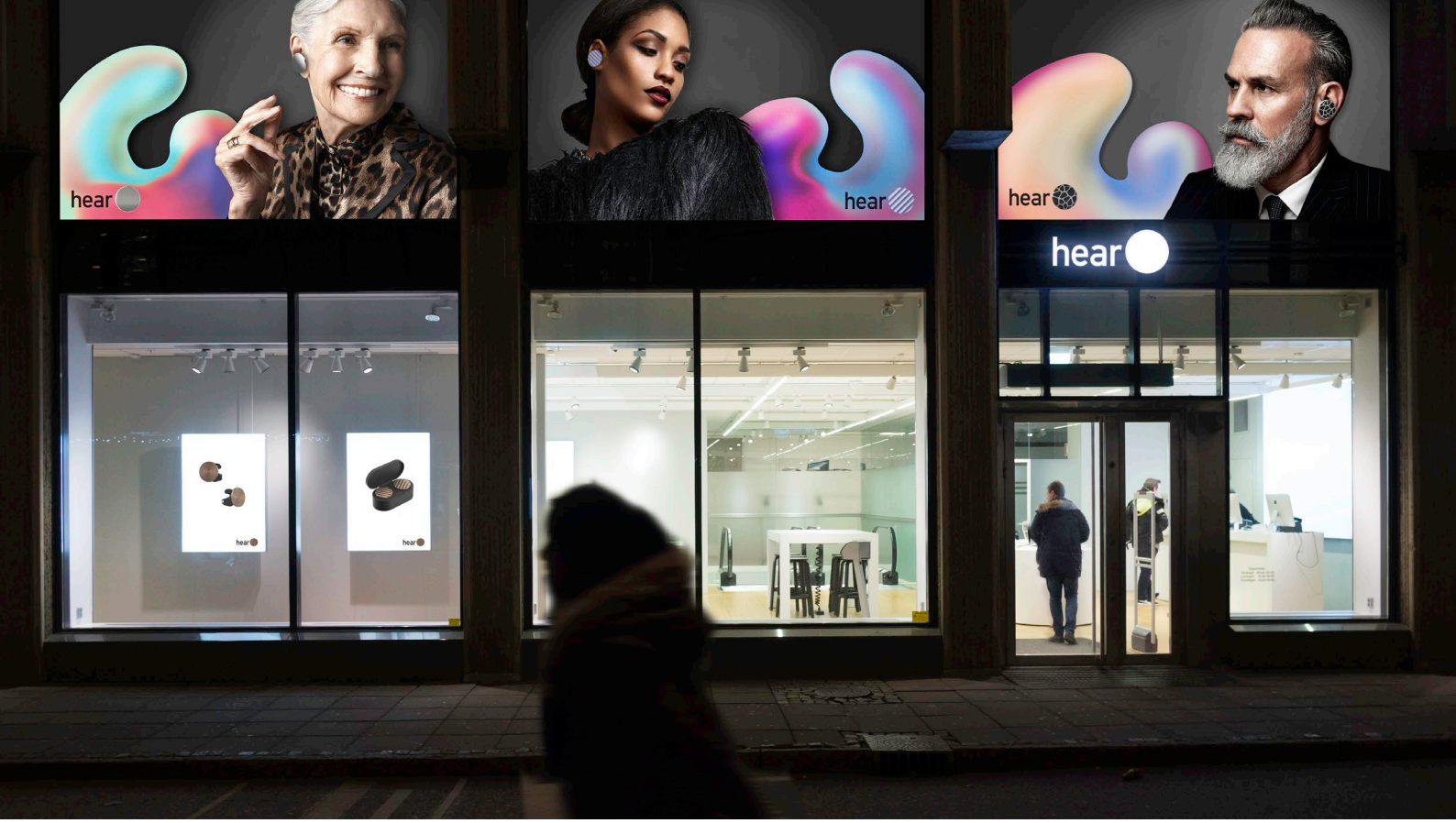


Figure 7.10
The HearO store.

7.4 Selling the HearO

The HearO needs a new sales channel to get rid of the stigma associated to hearing aids today. It should not be associated with healthcare which is the case today both for public and private clinics. We believe that the HearO should be sold in stores with better locations and window displays. This would make it easier to access and people might even come in just to see what it is. To illustrate how this could be done we have created a concept for a HearO store, see figure 7.10.

To create a more pleasant experience inside the store, compared to the clinics of today, inspiration was taken from the eyewear industry. The stores selling glasses today are usually placed in the city centre and promote style. The HearO store is also about style and the personalization of the product maybe even more so than eyewear stores, as the product is unique for each user with the custom fit. The customers can go around the store and explore all the discs and find those best matching their style. Marketing posters were created to enhance the feeling of style and fashion, see figure 7.11.

To build trust for the brand and the product, professional audiologists are working in the stores. The audiologists have much knowledge about hearing and hearing loss and will be able to answer the customers questions. This also makes it possible to sell the product to people with hear-

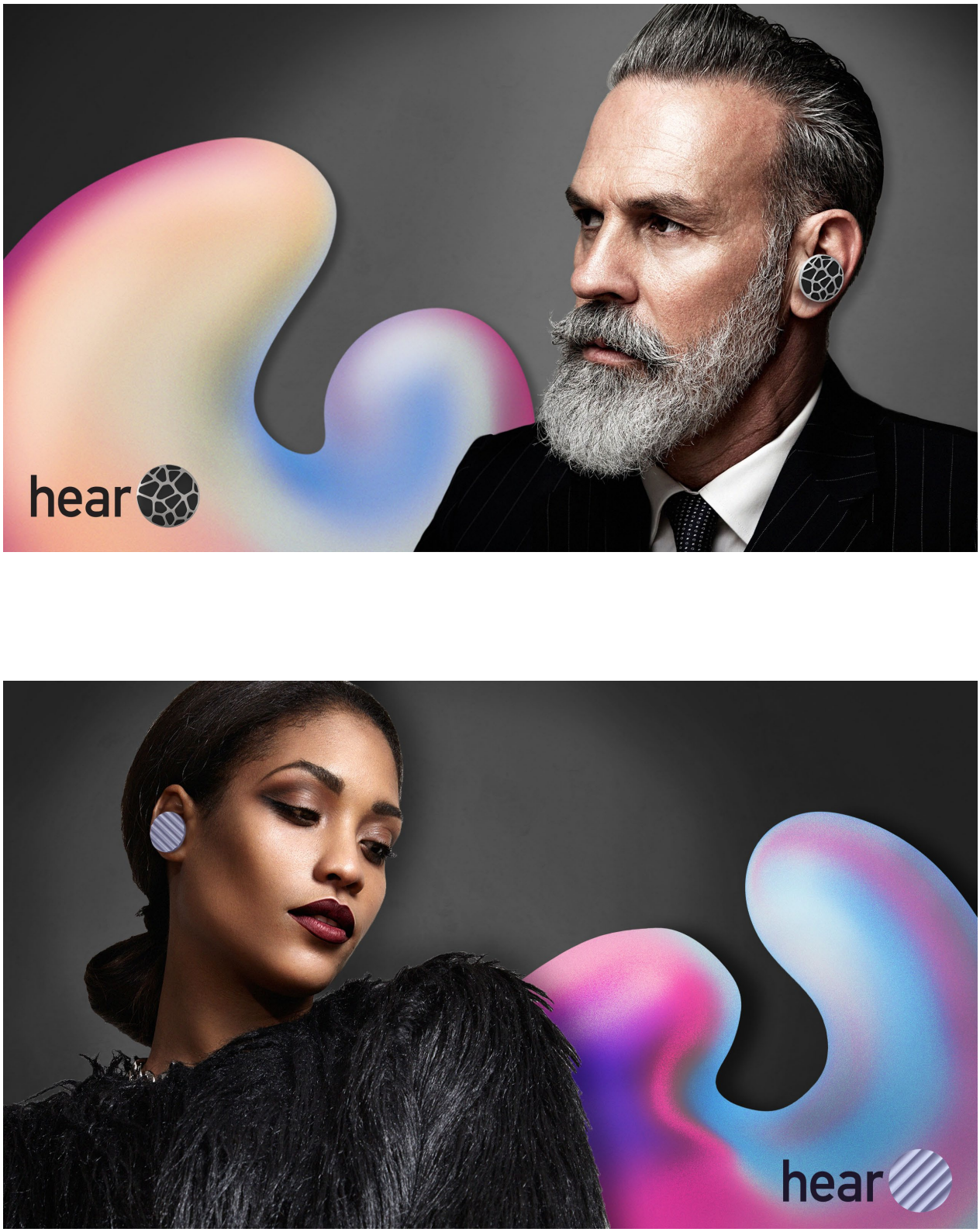


Figure 7.11
Marketing posters.

ing loss without breaking the regulations, before the OTC-law is in place. In the store other products related to sound could also be sold to create a store that attracts an even wider group of people.

Instead of making impressions of the ears as done today, the audiologist will use a 3D-scanner to scan the customers ears. This is a less painful experience for the customer, contributing to a more pleasant overall experience. The 3D-scans of the customers ears are then 3D-printed using 3D-printers on display in the store. The user can then have the finished product sent to their home or come back and pick it up when the product is finished.

The hearing test is done at home by the user. This is done using the smartphone app and the earbuds themselves. The earbuds will play sounds and the user responds using the app when the sounds are heard. The result of the hearing test is not presented to the user as a value of hearing loss. The result is only used to create a custom sound profile for the user.

8. Discussion

The results are discussed in this chapter together with ideas on how the industry could evolve are presented.

Major findings in this project are based on ways to handle the stigmatization and inconvenience of hearing aids. The end product is developed on this base, but does not claim to be neither the only nor the best solution. It is a solution firmly based on the research, and is one good and valid solution. The created vision together with the five focus areas create a solid base for development of products that solve people's hearing loss. This base can be used for future developments as well with different ambitions in terms of disrupting the way hearing aids are produced today. One way would be to implement the vision and the focus areas in a development process of a hearing aid brand today. By doing so a solution closer to the user's needs than the solutions of today would be created. One could also see these five focus areas in a wider context, where they might be applicable for other product developments fighting stigmatization. One example could be the design of prostheses.

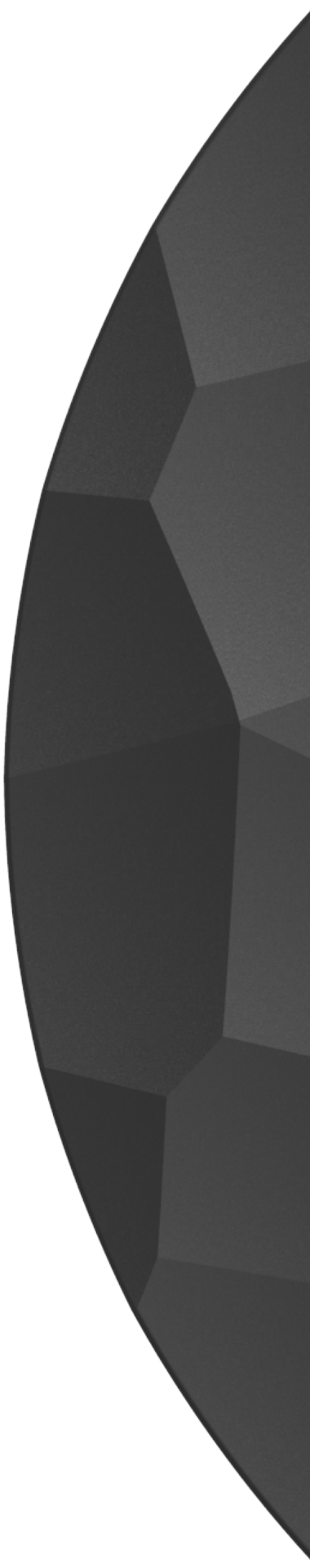
Throughout the project the connection to the cooperation partner Widex weakened. This was partly due to difficulties in communication, but also due to where the major findings pointed the development. The strategies for new development that are developed in this project are not fully compatible with the innovation process at Widex. The reason for this is that innovation at Widex has a focus on new technology within the same products that are produced today and little development of radical solutions that question the market of today. The drawback of a weak connection to Widex is that there is no clear implementation path for the developed ideas and the product. For us it has been clear that we either formulate a product strategy that fits into the portfolio of Widex or we do a product strategy aimed at the user's needs and the situation in the society today. We saw that doing a product strategy for the user would benefit the industry more by being a good example instead of developing a product directly for Widex.

There seems to be a change in hearing aid regulations with the introduction of the OTC hearing aid act in the USA. We see the hearing aid market today as very conservative, with little innovation on how the products are experienced. We believe that the ones breaking the stigmatization of hearing aids will not be the hearing aid companies, but tech companies working with headphones today. This is because they already have a strong brand associated with positive attributes, which the hearing aid companies lack. The tech companies are today developing technologies for noise cancellation close to how hearing aids work, and with less regulations, the market will open up for them.

The custom fit and the advanced sensing techniques in the developed product means that more research is needed. This leads to high costs for

research and development which in turn results in a high retail price. As this project in its current state more aims at showing how future solutions could benefit users rather than being a solid example of a producible product, the pricing is less important. Following, the pricing can also be more aggressive for such a product that is new in its kind. It aims more towards early adopters than being a product for the big masses in its current state. However, with future technological advancements within sound processing and custom fitting at home, the pricing can be more moderate.

This project's reliability lies on a solid background research done with users. The users have been heavily involved up until the development of the vision and focus areas. However, the end product developed together with its case and how it is to be sold are not as tightly validated with users. Due to limited resources in this project the end product was developed with the research base and to a degree where it can be communicated well. In a product development directly aiming at a producible product, it would be beneficial to involve and test the ideas more during the concept creation and especially validating the end result with the criteria set. However, the concept developed in this project fulfils its aims by being communicable to others for the underlying research.



9. Conclusions

In this chapter the conclusions are presented in a bullet list.

The developed product HearO showcases how the future may look for people suffering from hearing loss. It handles the stigma associated with hearing aids in an efficient way by being a product not just for the specific group of people with hearing loss but bringing benefits to everyone. HearO is an example of how strategies to fight existing stigmas can be manifested. Below is a list concluding the findings of the project.

- Most products on the hearing aid market are similar, it is difficult for the user to distinguish between different brands.
- New wireless earphones possess much of the needed technology to act as hearing aids.
- Hearing aid wearers are seen as old, stupid and handicapped. This is experienced by individuals wearing hearing aids and expressed by people not using hearing aids.
- Hearing aid wearers want to hide their hearing aids as they imagine they will be more stigmatized by showing them.
- The first impressions of wearing hearing aids are often bad.
- Audiologist clinics are obsolete compared to how eyeglasses are sold.
- Five focus areas to consider in the development of hearing aids: Have power over the choice, Self esteem, Equal value, Adaptation and Trust.
- A product for those with hearing loss should be used by people without hearing loss to reduce stigma quickly and effectively
- Everyone has a need to hear better in some situations, regardless of their hearing loss.
- To provide an extra function that goes beyond hearing better would make more people motivated to use the product.
- Hearing technology is moving forward fast. Hearing aids will soon be able to know what you want to listen to.
- The ear is a good place for biosensors.
- A function that controls the soundscape around you is a much wanted function by the users.
- Wellbeing together with speech enhancement is the core functions in a product solving the barriers related to hearing aids.
- How people acquire their hearing aids is important in a new solution. In a new concept, the store should not be connected to health care.
- Different style expressions is an important attribute to make a user proud and willing to show the product.
- Interaction on the worn product is important if it blocks outside sounds, in order to change the listening experience quickly.

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10.2 Expert Interviews

Filip Gunnelid (Audiologist at Sahlgrenska University Hospital) Interviewed by the authors August 22, 2017.

Fredrik Ahlström (Chief Marketing Officer at Bellman & Symfon) Interviewed by the authors Spetember 26, 2017.

Göran Karlsson (CEO at yovinn) Interviewed by the authors November 6, 2017.

Joe Jensen (Electroacoustic Engineer at Widex) Interviewed by the authors October 4, 2017.

Kim Hjortgaard Nielsen (Director, Innovation and Frontend Portfolio at Widex) Interviewed by the authors October 5, 2017.

Lena Thelin (Audiologist at Audionova Gothenburg) Interviewed by the authors August 15, 2017.

Magnus Nørgaard (Signal Processing System Architect at Widex) Interviewed by the authors October 9, 2017.

Maja Bülow (Senior Innovation Audiologist at Widex) Interviewed by the authors October 4, 2017.

Marie Grunditz (Audiologist at Sahlgrenska University Hospital) Interviewed by the authors August 22, 2017.

Svend Vitting (Senior Innovation Architect at Widex) Interviewed by the authors October 3, 2017.

Tomas Lunner (Senior Scientist and Professor at Cocoha) Interviewed by the authors October 26, 2017.

10.3 Images

The uncredited images are property of the authors.

Chris F. (2014). *The Dash Wireless Smart In-Ear Headphones.* [image] Available at: https://www.flickr.com/photos/114264438@N03/12739887565 [Accessed 20 Dec. 2017].

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Widex (2016). Marketing imagery sent to the authors from the Senior Art Director at Widex. Copyright belongs to Widex A/S.

Appendix

Appendix 1

- Ålder
- Sysselsättning
- Kön
- Får vi spela in?

Hörselnedsättning

- Upplever du att du hör dåligt?
    - När?
    - Hur och när upptäckte du din hörselnedsättning?
        - Märkte du det själv eller andra som påpekade?
- Hur hanterar du din hörselnedsättning? Kompenserar/döljer?
    - Använder du hörapparat?
    - Har du testat att använda hörapparat?
    - Hur känner du dig när du använder hörapparater?
- När/om du skulle skaffa hörapparat hur kände/känner du inför det?
    - (om personen har glasögon, fråga om den upplevelsen)
    - Vad är det som gör att det tar emot? (fråga ordentligt om bakomliggande orsaker) (bara egen uppfattning eller upplevt?)
- Hur känner du inför att visa upp hörapparater?
    - Finns det något du skulle vilja ändra på för att vilja visa upp dem mer?
- Har du sökt hjälp för din hörselnedsättning?
    - Varför sökte du (inte) hjälp?
    - Hur känner/kände du för att söka hjälp?
    - Hur lång tid innan du sökte hjälp?
- Skulle du vilja att det fanns alternativ till att söka hjälp genom sjukvården? Av vilken anledning?
    - Skulle du hellre besöka en privat klinik?
    - Finns det fördelar med att betala för sin vård?
    - Köpa i butik/internet?
    - Skulle du vara bekväm med att testa hemma?
- **Fördjupad patientresa???**
    - Hur lång tid tar hela processen till att få hörapparat tror du?

Uppfattning kring hörapparater

- Vad anser du om dagens hörapparater?
    - Utseende?
    - Ljud?

    - Visa de som vi har med, ändrad uppfattning?
- **Hur** är hanteringen?
    - Sätta in i öronen?
    - Höja och sänka volymen?
    - Byta batterier?
    - Rengöring?
- Hur upplever du ljudet i dina hörapparater?
    - Hur upplevde du det första gången du använde dem?
    - Har du vant dig vid ljudet?
    - När funkar de bra? När funkar de dåligt? Lyssningssituationer
    - I vilka situationer använder du hörapparat? Vilka undviker du?
    - Finns det några situationer du skulle vilja använda hörapparat där du inte gör det?
- Kan du tänka dig att betala för en produkt som hjälper dig att höra bättre?
    - Hur mycket skulle du betala?
    - Vilken funktionalitet skulle du då vilja ha?
- Vad prioriterar du högst hos hörapparater?
- Vad skulle vara en acceptabel batteritid för ett hörhjälpmedel?

Önskvärda uttryck hos hörapparater

- Hur tror du att du ser på användare av hörapparater?
- Hur tror du att andra ser på dig när du använder hörapparater?
- Vad vill du att hörapparaterna ska förmedla?
- Är det ok om de uttrycker hörhjälpmedel?

Förslag på förbättringar

- Vad skulle kunna bli bättre med hörapparater?
- Är det några funktioner som du skulle vilja utvecklades?

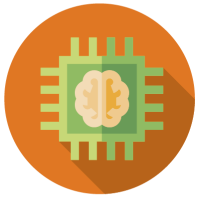
https://irp-cdn.multiscreensite.com/a2517fd6/dms3rep/multi/desktop/Sirion-beauty-earmold-behind-the-ear-hearing-aid-2000x1900.jpg

Appendix 2

Requirement	Wish
Emotional	**Emotional**
Wearers of the product should not be seen as stupid	It should not be embarrassing to adjust the volume on the product
Wearers of the product should not be seen as handicapped	It should not be embarrassing to put on or take off the product
Wearers of the product should not be seen as old	Hearing tests should not be embarrassing
Self worthiness and self esteem should not be lowered by the product	Treating hearing loss should not be harder than treating bad eyesight
The product should express that the wearer is listening to external sounds	It should be easy to accept your hearing loss
The product should be comfortable to wear	The environment of getting the product should not express health care
Needing the product should not be experienced as a tough diagnosis	Wearing the product should not depend on discreteness
It should be a positive experience using the product for the first time	Fashion and style should be considered in the product
The process to start using the product should not be tiresome	The product should express smartness and wow-factor
Romance should not be restricted by the product	The product should express cool
The product should not be scary when not worn	Feeling of cleanliness should be strived for in the product
Functional	**Functional**
Wearers of the product should not need to be handled in a different way than regular hearing people	Adjusting settings by mistake should be prevented in the product
The user should be assured of the precision of a hearing test performed by the product	Bad cleaning should not be a big reason for maintenance of the product
Handling the product must be easy for new users	Feedback should be minimized in the product
Handling the product must be easy for people with age deterioration	Occlusion effect should be minimized in the product
The product should enhance hearing for those with mild hearing loss	The product should provide good sound in environments using tele coils
The product should be adjustable to the hearing impairment of the user without the need of a third party	People should know the procedure of getting the product
The product should provide the ability to interact with others not dependent on the soundscape	It should be easy to notice when the product need maintenance
Battery anxiety with the product should be limited	Should be possible to connect the product to other devices
The product should provide status indication (on/off)	Listening to music should not need an extra action when wearing the product
Users should not be afraid of the products falling off	The product should be possible to use during activity sports
It should not be possible to adjust the product by yourself to a bad setting	It should be easy to speak on the phone while wearing the product
There should be prevention from losing the product	
The user should be assured of that all treatment options are given with an examination	
Wearers of the product should be able to make the same assessment of a sound (loudness and direction) compared to a normal hearing	

Appendix 3

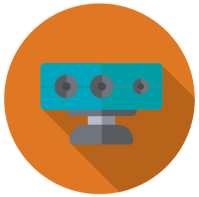
TEKNOLOGI



Artificiell intelligens (AI)

Utnyttja att maskiner snart kan ha mänsklig intelligens för att komma fram med nya spännande funktioner.

TEKNOLOGI



Sensorer

Hur kan sensorer som samlar in data från användaren och omgivningen användas i framtidens produkt?

TEKNOLOGI

Uppkoppling

Vad händer när nästan alla produkter är uppkopplade och kan kommunicera med varandra? Vilken funktionalitet kan det leda till?

TEKNOLOGI

Lära sig vanor

Hur kan vi uttnyttja att produkten kan lära sig användarens beteenden och mönster utifrån insamlad data.

TEKNOLOGI

Biometric ID

Hörselgången är lika unik som ett fingeravtryck och kan användas för att identifiera individer. Hur kan det vara användbart?

TEKNOLOGI

Biomimicry

Hämta inspiration från former, funktioner och strategier i naturen för att komma upp med nya idéer.

TEKNOLOGI

Brusreducering

Uttnyttja att produkten kan filtrera ut vad som är önskat och oönskat ljud.

OMRÅDE

Träning och hälsa

Vilka funktioner kan en produkt anpassad för träning och hälsa ha?

OMRÅDE

Avslappning

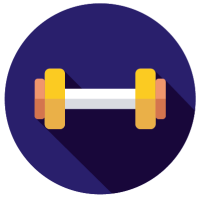
Hur kan produkten hjälpa användaren att slappna av?

OMRÅDE

Underhållning

Hur kan produkten skapa eller förhöja olika typer av underhållning?

OMRÅDE



Träning av hörsel

Visste ni att man kan träna sig till att höra bättre? Vilken nytta kan det ge i vår produkt?

OMRÅDE

Skydd av hörsel

Det är viktigt att skydda hörseln. När och hur kan produkten skydda användarens hörsel?

OMRÅDE

Fokusering

Hur och i vilka sammanhang kan produkten hjälpa användaren att fokusera?