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Content Suggestions for Universally Designed Hearing Aids

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Abstract

Nearly 80% of those who could benefit from wearing a hearing aid choose not to use one. This study, completed by an interdisciplinary team for the Victorian Deaf Society in Melbourne, Australia, addresses the social attitudes and other limitations of hearing aids which result in poor market penetration. Based on the principles of universal design, specific recommendations are presented to improve the function and style of hearing aids. Additionally, the study recommends implementation of hearing assistive devices for the hearing.

Acknowledgements

It is with a great sense of pride and accomplishment that we present this finished document to the Victorian Deaf Society (Vicdeaf) and to Worcester Polytechnic Institute (WPI) as an Interactive Qualifying Project (IQP). It is with an even greater sense of gratitude that we acknowledge the many individuals who assisted us in our research and writing before and during our time in Melbourne. Without these individuals our project would not have been successful.

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Authorship

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Abstract	TB, NV	KG
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Glossary	TB	JT
Executive Summary	TB, NV	ALL
1. Introduction	KG	
2. Background	KG	KG
2.1. Types of Hearing Loss	KG	
2.2. Types of Hearing Aids	KG	
2.3. Current Technology	KG, NV	
2.4. New Research	JT	
2.5. Hearing Aid Problems	KG	
2.5.1. User Problems	KG	
2.5.1.1. Problems for the Hard-of-Hearing	KG, NV	
2.5.1.2. Problems Identified by the Hearing and Hard-of-Hearing	KG, JT	
2.5.1.3. Social Stigma	KG, JT, TB	
2.5.2. Current Codes	ALL	
2.5.3. Manufacturer and User Relationship	KG, TB	
2.5.4. Cost	TB, NV	
2.6. Universal Design	NV, KG	
2.7. Summary	KG	
3. Methodology	KG	JT
3.1. Goals and Objectives	KG	
3.2. Social Attitudes Towards the Hard-of-Hearing	KG	
3.3. Universal Hearing Aids	KG	
3.4. Applications of Current Hearing Aid Technology	KG	
3.5. Suggestions for Hearing Aid Universal Design	KG	
3.6. Summary	KG	
4. Results from Interviews and Focus Groups	KG	TB, KG
4.1. Hearing Aid Users	TB	
4.1.1. Stigma	TB	
4.1.2. Problems with Hearing Aids	TB	
4.1.3. Applications of Hearing Devices for the Hearing	TB	
4.2. Audiologists and Rehabilitation Specialists	NV	
4.2.1. Stigma	NV	
4.2.2. Problems	NV	
4.2.3. Ideal Hearing Aid Features	NV	
4.2.4. Difficult Listening Situations	NV	
4.2.5. Economics	NV	
4.3. Hearing Professionals	KG	
4.3.1. Stigma	KG	
4.3.2. User Problems	KG	
4.3.3. Difficult Listening Situations	KG	
4.3.4. Applications of Hearing Assistive Devices for the Hearing	KG	
4.4. Designers	JT	
4.4.1. Design Considerations	TB, JT	
4.4.2. New Designs	TB	
4.4.3. Marketing Considerations	TB, JT	
4.5. Manufacturers	JT	
4.5.1. Current Technology	JT	
4.5.2. Future Technology	TB, JT	
4.6. Summary of Data Collected	KG	NV

5. Analysis	KG	TB, KG
5.1. Stigma	KG	
5.2. Problems and Technology	JT	
5.2.1. Hearing Aid Problems	JT	
5.2.2. Hearing Aid Features	JT	
5.2.3. Difficult Listening Situations	JT	
5.3. Manufacturer Opportunities	KG	
5.3.1. Applications	NV	
5.3.2. Economics and Marketing	TB	
6. Recommendations and Conclusions	KG	KG
6.1. Stigma	KG	
6.2. Problems and Technology	JT	
6.3. Manufacturer Opportunities	JT	
6.3.1. Applications	NV	
6.3.2. Design Considerations	TB	
6.3.3. Economics	TB	
7. References	ALL	KG
Appendix A – Sponsor Description	ALL	KG
Appendix B – Hearing Aid User Interviews	ALL	JT
Appendix C – Audiologist and Rehabilitation Specialists Interviews	ALL	JT
Appendix D – Hearing Professional Interviews	ALL	JT
Appendix E – Designer Interviews	ALL	JT
Appendix F – Manufacturer Interviews	ALL	JT
Appendix G – Oticon's Delta	ALL	N/A
Appendix H – Hearing Aid Design Sketches	ALL	JT

Authorship is credited to the creator of the section that was used in the paper. Primary editor is credited to the member who did the first significant edit of the section. Secondary edits were performed by all members of the group.

Table of Contents

Table of Figures

Table of Tables

Glossary

Audiogram - A diagnostic tool used by audiologists showing, on a graph, a user's specific hearing loss.

Background Noise - Describes other sounds that mask speech during communication; a problem for hearing and hard-of-hearing individuals.

Bluetooth® Wireless Technology - Wireless connectivity standard widely used in mobile phones.

Deaf - Using a capitol 'D' refers to the Deaf Community. Using a lowercase'd' refers to the condition of deafness.

Discrete - Used to describe users' desire to have a hearing aid that is not in plain sight.

Hard-of-hearing - Refers to individuals with hearing loss.

Hearing - Refers to individuals with out a hearing loss.

Market Penetration - Compares the actual amount of hearing aids sold against the theoretical number of sales possible, expressed as a percent.

Occlusion - Problem where hearing aid users report feeling closed off, because the hearing aid mould blocks sound from exiting the ear canal.

Recruitment - Because hearing aid users have a narrow comfort level between too quiet and too loud, amplified loud sounds can cause the user pain.

Stigma - The negative social attitudes expressed towards the Deaf community.

Telecoil - A component, embedded in a hearing aid, which picks up signals in the form of electromagnetic energy from a source such as a microphone or speaker. The user hears only the one source of input free of background noise.

Universal Design - Design to make products as accessible as possible by all regardless of age, disability or other limiting situation.

Executive Summary

Verbal and other audible forms of communication are vital components of social interactions in daily life, but many people are unable to communicate effectively due to hearing losses. In Australia alone, 2,013,000 people reported that they have partial or complete deafness, which is approximately eleven percent of the population. One in six Australians over the age of fifteen suffers from hearing loss and three in four individuals over the age of seventy suffer as well. With an aging population, hearing loss is projected to increase to an astonishing one in every four Australians by 2050.

The Victorian Deaf Society (Vicdeaf) commissioned our team to analyse current hearing aids and propose suggestions for improvements based on the principles of universal design. The ultimate goal of this project was to provide suggestions for functional and stylistic improvements of current hearing aids and to propose content that needs to be considered in universally designed hearing aids, aids that could be used by both the hearing and hard-of-hearing. To achieve this goal, we identified four primary objectives:

- Gather information on the societal attitudes towards hearing aid users
- Identify situations that cause difficulty communicating for the hearing
- Evaluate technology that is currently available and assess its value to a universal design that has the potential to benefit both hard-of-hearing and hearing users
- Propose content that should be included in realistic universal designs to help change the view of hearing aid users in society and allow everyone to benefit from the use of hearing aids

We accomplished these objectives by compiling background research on hearing aids, social attitudes towards the hard-of-hearing, economics relating to hearing aids, new technologies, and the problems current hearing aid users face. The background research raised an astonishing fact that approximately eighty percent of individuals who could be assisted by hearing aids purposely choose not to wear them. To gain data and information to validate the background research, we gathered information from six specific groups. Each group had a set of thematic questions asked to obtain necessary information. The groups and reasons for contacting them are listed in the table below.

Group	Purpose of Contact
Hearing Aid Users	To gather information about social attitudes towards the hard-of-hearing as well as hearing aid problems
Audiologists	To obtain information about difficult listening environments and user problems
Rehabilitation Specialists	To gather further information about user problems
Hearing Professionals	To gather information regarding difficult listening situations and applications of hearing assistive devices for the hearing
Designers	To gain insight about design considerations for hearing assistive devices
Manufacturers	To obtain professional feedback on information and data collected and to understand current capabilities

All of the research conducted and information gathered from the interviews and focus groups were compiled and analysed in order to develop our universal design suggestions. We have concluded that negative social attitudes towards the hard-of-hearing do play a major role in hearing aid use. From our interviews and focus groups we found that the attitudes of the general public are improving towards the hard-of-hearing, but negative attitudes still exist. We recommend that Vicdeaf advocate for a wider range of available hearing aid styles as a step towards eliminating the negative attitudes associated with hearing aids. We have concluded that if aids are treated more as accessories that reflect their users' personalities, rather than obtrusive medical devices, users would feel more comfortable wearing them. In addition to the negative attitudes that exist, we have determined that there are many problems with the hearing aids themselves that can lead to dissatisfaction or limited use.

We recommend partnerships with hearing aid manufacturers in order that these problems be better addressed. We further recommend Vicdeaf should advocate to hearing aid manufacturers so that they may address problems encountered by clients and studies such as this one. We additionally suggest that Vicdeaf advocate to manufacturers to expand their product lines by developing stylish hearing assistive devices for the hearing. This study also concludes that the use of these products by the

hearing population would increase awareness about communication difficulties, further reducing the negative social attitudes towards the hard-of-hearing.

From interviews, we were able to compile many suggestions for hearing assistive devices that could benefit the hearing. Background noise can create difficulties communicating for everyone and an assistive device that featured noise reduction or speech amplification could be potentially useful in multiple scenarios. Workplace environments were also mentioned many times as difficult listening situations, particularly when ear protection is required. We suggest that the most useful application of hearing assistive devices is workplace safety and background noise reduction. Opportunities also exist in the area of synergies with new technologies such as Bluetooth® wireless technology.

Further, we recommend that hearing aids follow a similar selection path as eyeglasses. The user should select the housing of the hearing aid that they find most aesthetically pleasing and a professional would assist in selecting the internal components. This would provide hearing devices that are both appealing in style and that fit each user's specific needs. We discovered that marketing, research, and development are the largest factors attributing to the cost of hearing aids. Developing hearing assistive devices for the hearing allows hearing aid manufacturers to benefit from cross-over funding, which will help lower the cost of all hearing appliances. With hearing aids at lower costs and more individuals using hearing assistive devices, the negative social attitudes associated with hearing loss will be reduced. With fewer negative attitudes about hearing aids, higher market penetration will be achieved and result in improved communication for all. These conclusions and suggestions represent a huge marketing opportunity for hearing aid manufacturers. They also represent an opportunity for Vicdeaf to improve their standing in the hard-of-hearing and Deaf community by advocating for universally designed hearing aids. By implementing these recommendations the Victorian Deaf Society can play a prominent role in reducing negative attitudes towards hearing aid users, providing devices of high quality to clients, and improving communication for all.

The biggest hurdle is public awareness – their hearing loss can be helped

Michael Gordon
Oticon Chief Audiologist
Australia Wholesale Team

1. Introduction

Verbal and other audible forms of communication are vital components of social interactions in daily life, but many people are unable to communicate effectively due to hearing losses. Nobody knows an exact number of hard-of-hearing people in the world, but Professor Adrian Davis of the British MRC Institute of Hearing Research estimates that the total number of people suffering from hearing loss of more than twenty-five decibels (mild hearing loss) will exceed seven hundred million by the year 2015, as seen in Figure 1.1 (qtd. in Hear-it, 2006). In Australia alone, 2,013,000 people reported that they have partial or complete deafness, which is approximately eleven percent of the population (The Victorian Deaf Society, 2005). One in six Australians over the age of fifteen suffers from hearing loss and three in four people over the age of seventy suffer as well(Access Economics Pty Limited, 2006; Hear-it, 2006). With an aging population, hearing loss is projected to increase to one in every four Australians by 2050 (Access Economics Pty Limited, 2006).

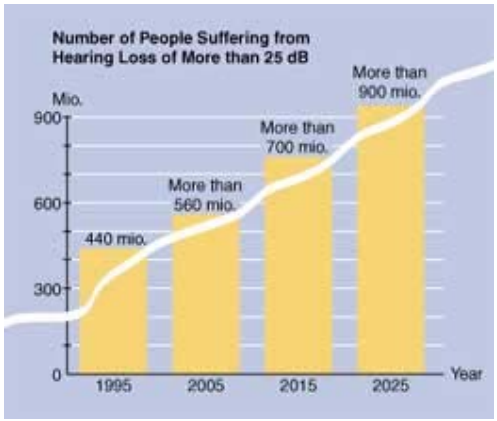


Figure 1.1 - Number of People Suffering from Hearing Loss[1]

Many surveys in both Australia and around the world have shown that one out of ten people suffers from hearing loss and would benefit from the use of hearing aids (Australian Hearing, 2006; Hear-it, 2006; SHHH, 2006). Other surveys indicate that four out of five people that need a hearing aid do not use one (Hear-it, 2006; NIDCD, 2006). In Australia, of the population aged fifty-five or older who suffer from hearing loss, only one out of ten people wears a hearing aid (Australian Hearing, 2006).

The reasons for the high degree of untreated hearing loss range from reluctance among the affected individuals to recognize their loss to common misconceptions about wearing hearing aids and the societal stigma attached to wearing them (Australian

[1] (Hear-it, 2006)

Hearing, 2006). While there has been extensive research on making hearing aids more effective, there has been little research in the area of universal design for hearing aids. This gap in research represents a failure to realize that hearing aid technology should and could be advantageous to all people, not just the hard-of-hearing. For example, those without a hearing loss might benefit from the use of hearing aids in certain situations, such as in a noisy environment. This research gap has been identified by the hearing service community. If universal design principles were applied to the development of hearing aids, it would result in better performing and more aesthetically pleasing aids for the hard-of-hearing and might increase the use of hearing aids among the hearing. In the same way that eyewear has become fashionable in recent years, increasing the use of hearing aids by the hearing may help to remove the stigma felt by the hard-of-hearing who are obliged to wear the current and previous generations of hearing aids.

In spite of numerous efforts to improve hearing aid technology, many users are still left in a deficient state of hearing. Ideally, hearing aid users would be able to hear just as well as the hearing. Furthermore, in an ideal scenario, the hearing would make better use of hearing aid technology. The Victorian Deaf Society charged our group with the task of proposing content for a universal design code for hearing aids. This code would be a step towards the day when all individuals hear equally. The Victorian Deaf Society hopes that hearing aids can be popularized by universal design and thus remove the stigma that is often associated with them. Although the Victorian Deaf Society suggested that the team propose an actual universal design code, the team realized that given only seven weeks, this goal was unrealistic. As a result, this study's ultimate goal was to research and compile data about current issues that needed to be addressed in universally designed hearing aids.

To accomplish this goal, the team identified four primary objectives: gather information on societal attitudes towards the hard-of-hearing; identify situations in which the hearing would benefit from the use of a hearing assistive device; evaluate the applications of current hearing aid technology for use in a universal hearing aid design that encompasses the needs of both the hearing and hard-of-hearing; and propose content that should be included in a realistic universal design code to help change the view of hearing aid users in society and allow everyone to benefit from the use of hearing aids. We accomplished these objectives by reviewing literature and conducting focus groups and interviews with members of the Deaf community, employees of

hearing organizations, designers, and hearing aid manufacturers. The focus groups and interviews identified concerns expressed by the Deaf about limitations of existing technologies, explored some of their proposed solutions, uncovered situations that are difficult for listening, and evaluated what functions were realistic to include in hearing aids.

The following report consists of a background, methodology, data, analysis, and conclusions. The background chapter includes information about hearing loss and hearing aids; a review of the problems involved with hearing aids, including user and manufacturer problems as well as problems with building codes; and information about universal design and its applications. The methodology section outlines the team's actions in achieving the goal of identifying content that would need to be addressed by a universal design code. Interview, analysis, and conclusion chapters discuss and analyse the study's results, conclusions, and recommendations.

2. Background

The following section is a review of literature relating to hearing loss and hearing aids. Included is research regarding the mechanism of hearing loss and what types of hearing aids are currently available. Also, current research and technology, or lack there of, was reviewed to identify consistencies and inconsistencies in the literature which was then analysed. Current user issues were also identified. The stigma associated with the hard-of-hearing as well as the concept of universal design, an approach to making products as accessible to everyone as possible, were researched. Case studies about situations where universal design has been applied were identified and analysed with respect to the project.

2.1. Types of Hearing Loss

There are three ways to define hearing loss: type, degree, and configuration of the hearing loss. First, there are three basic types of hearing loss: conductive, sensorineural, and mixed. The locations of these types of hearing loss can be seen in Figure 2.1. Conductive hearing loss results when sound is not conducted from the outer ear to the eardrum and the ossicles of the middle ear. It is usually correctable with surgery. Some causes of conductive hearing loss are colds, allergies, ear infections, tumours, compacted earwax, the presence of a foreign body, and the absence or malformation of the ear. This type of hearing loss results in reduction of the sound level heard (American Speech-Language-Hearing Association [ASHA], 2005).

Sensorineural hearing loss represents a permanent hearing loss that cannot be corrected. This type of hearing loss occurs due to damage to the inner ear or to the nerve pathways from the inner ear. This kind of hearing loss causes the individual's ability to hear sound to be compromised which can also cause lowered speech comprehension. This loss can be caused by diseases, birth defects, noise exposure, head trauma, and many other environmental factors (ASHA, 2005).

The third type of hearing loss is mixed hearing loss. This is a combination of both conductive and sensorineural hearing loss. It is caused by damage to both the outer and middle ear by the factors mentioned above (ASHA, 2005).

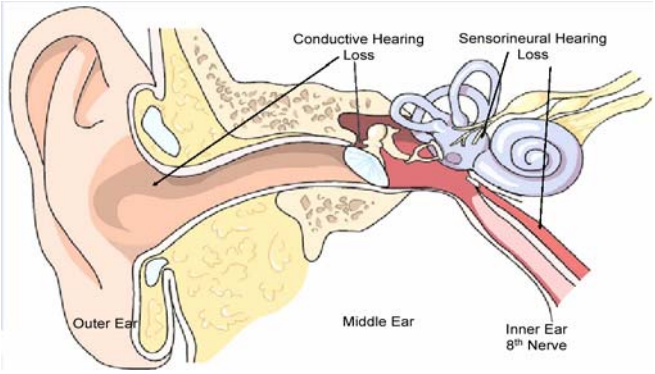


Figure 2.1 - Types of Hearing Loss[1]

Hearing loss is also defined by the degree, or severity, of the loss and by the configuration of the loss. The degree categories are normal range (0 to 24dB), mild loss (25 to 45 dB), moderate loss (46 to 65 dB), severe loss (66 to 85 dB), and profound loss (greater than 86 dB) (Access Economics Pty Limited, 2006). Table 2.1 relates decibels to normal sounds. Configuration refers to the range of loss in each ear as well as the range of frequencies lost in the ear (ASHA, 2005).

Source	Intensity
Threshold of Hearing (TOH)	0 dB
Rustling Leaves	10 dB
Whisper	20 dB
Normal Conversation	60 dB
Busy Street Traffic	70 dB
Vacuum Cleaner	80 dB
Large Orchestra	98 dB
Walkman at Maximum Level	100 dB
Front Rows of Rock Concert	110 dB
Threshold of Pain	130 dB
Military Jet Takeoff	140 dB
Instant Perforation of Eardrum	160 dB

Table 2.1 - Common Sounds in Decibels[2]

2.2. Types of Hearing Aids

Currently, there are many different styles or types of hearing aid, including: in-the-ear, behind-the-ear, in-the-canal, completely-in-the-canal, and body-worn aids (see Figures 2.2 and 2.3, respectively).

1 (CRC for Cochlear Implants and Hearing Aid Innovation, 2006)
[2] Adapted from (Henderson, 2004)

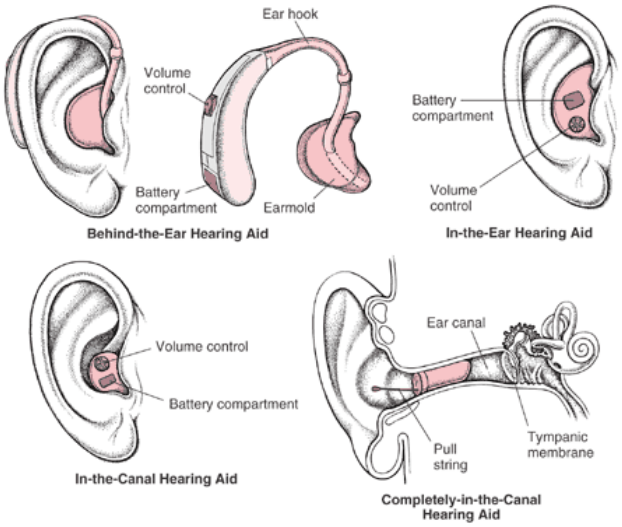


Figure 2.2 - Hearing Aid Types[1]

Figure 2.3 – Body-worn Hearing Aid[2]

Each style has advantages and disadvantages. In-the-ear hearing aids fit completely inside the outer ear and are usually constructed with a hard plastic case. Behind-the-ear aids are worn around the ear and connect to an ear mould that fits inside the outer ear (ASHA, 2005). High powered behind-the-ear aids are the primary choice for clients with severe hearing loss. Open fitting behind-the-ear aids are used for clients who have had difficulty using regular mouldings and leave more of the ear open. (Australian Government Dept. of Health and Aging, 2005). Canal aids are very small hearing aids that actually fit inside the ear canal, and are virtually invisible when viewing the user head on. Body-worn aids are rather large and fit on a belt or in a pocket. These aids connect to the ear by a wire (ASHA, 2005; National Institute on

[1] (Merck, 2003)
[2] (Missionary TECH Team, 2004)

Deafness and Other Communication Disorders, 2001; The Victorian Deaf Society, 2005).

Hearing aids also vary in the type of electronics that control them. Similar to the rest of the electronic world there are two major players, analogue and digital. Analogue technology is the older of the two and, as such, garners an association with being outdated. This is true in the sense that outdated hearing aids used analogue methods to work, but hearing aids utilizing analogue are by no means outdated in general.

A hearing aid, no matter what technology is used internally, has one main goal, to increase the volume of sound for the user. This goal is accomplished in three steps: a microphone picks up audio signal, this audio signal is amplified, and the amplified signal is sent to the user by means of a receiver (Analogue vs. Digital Hearing Aids, 2004). The main difference between analogue and digital aids is the manner in which the second step is carried out.

An analogue hearing aid utilizes the microphone to convert the audio signal into small electronic impulses which are then amplified by transistors. This process amplifies signals linearly; everything gets made louder indiscriminately (Analogue vs. Digital Hearing Aids, 2004). Some of the more expensive devices incorporate automatic gain control which allows a small amount of variation in the gain depending on the input, loud signals get amplified less while quiet ones get amplified more. A basic diagram showing the flow of an analogue hearing aid can be seen in Figure 2.4.

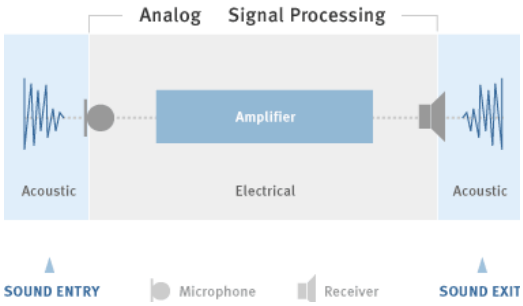


Figure 2.4 - Flow of an Analogue Hearing Aid[1]

A digital hearing aid differs in the sense that it does not work with varying electrical impulses, but instead converts those signals into binary values, ones and zeros. These values can then be interpreted by a tiny computer within the hearing aid. Furthermore, this computer can perform precise calculations and change the signal to

[1] (Analog vs. Digital Hearing Aids, 2004)

make it more comprehensible to the user, filtering out background noise for example. Once these changes are made the binary data signal is then changed back into an acoustic signal and sent to the ear. A diagram showing the basic flow of a digital hearing aid is shown in Figure 2.5.

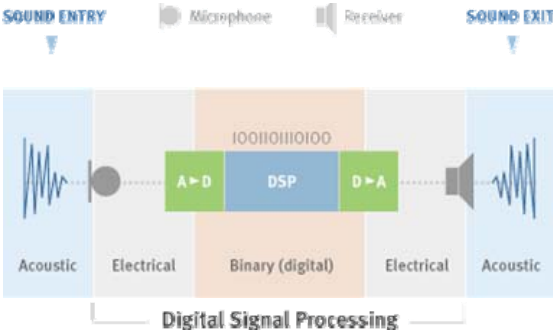


Figure 2.5 - Flow of a Digital Hearing Aid[1]

2.3. Current Technology

Over the years, there have been significant improvements in hearing aids, one of which is the telecoil. This is a device which picks up sound and radiates it in the form of electromagnetic energy (ASHA, 2005). Telecoils reduce contamination with room noise and distortion and can be used with telephones, assistive listening devices, as well as infrared and FM receivers. These devices are effective in large, open areas such as theatres and churches where background noise is present (ASHA, 2005; Kaplan, 1999). When using a telecoil, the hearing aid's microphone is switched off and the hearing aid receives the electromagnetic signal directly from the source, i.e. the telephone or a speaker's microphone. In this way, the hearing aid user only hears the source sound; with the microphone turned off, no surrounding noise interferes (Dillon, 2005).

There are now many more options for consumers to consider when selecting a hearing instrument. Some hearing aids used complex prediction formulas to determine how to process the sound for the user. Though these expressions were successful to some degree, they typically failed thirty percent of the time (Flynn and Lunner, 2005). The latest trend in hearing aid manufacturing is the revolution of digital hearing aids. These aids offer many more features that enhance the user's experience and are backed up with statistical data (Kochkin, 2005).

[1] (Analog vs. Digital Hearing Aids, 2004)

Microphone technology has also improved. Previously, the only advanced type of microphone available to the user was a directional microphone. Now the hard-of-hearing can choose between directional and dual microphone designs. A dual microphone hearing aid allows for greater background noise reduction. Compression technology is also currently available in hearing aids and eliminates sound distortion of loud noises. Multiple channels and memories as well as volume control are also some technological options in advanced hearing aids today (Kaplan, 1999).

The most basic function of a hearing aid is to detect and amplify sound for the user; however, modern hearing aids are capable of considerably more than that (Dillon 2005). There are a number of features and programs available that can make communication and speech comprehension more effective as well as reducing uncomfortable noise levels (ASHA, 1997). Some of the capabilities are available in both analogue and digital hearings aids, and some are digital only; none are available only in analogue.

Hearing loss is not uniform in most patients; it varies with respect to the frequency of the sound. Tone controls and multi-channel compression are used to counteract varied frequency loss. When the hearing loss is diagnosed, the audiologist takes an audiogram, which is essentially a graph showing how well various frequencies are heard by the client. The hearing aid is then programmed to amplify certain frequency ranges more than others. The more channels the hearing aid has, the more precisely the audiologist can fit the varied amplification to the specific client's audiogram (Dillon, 2005).

In order to counteract the fact that hard-of-hearing individuals have a more limited range of sounds which they can hear, the volume on a hearing aid can be increased for soft sounds and decreased for loud noises (ASHA, 2005). If a hearing aid has wide-dynamic range compression it can automatically adjust the amplification based on the volume of the sound it receives. This saves the user from having to constantly manually adjust his or her hearing aid. A minor disadvantage to this capability is that subtle differences in volume between sounds, sometimes used to convey emphasis in speech, are often lost (Dillon, 2005). Since the hearing aid does not always adjust the volume correctly in every situation, best results can often be achieved by using a hearing aid with automatic volume adjustment as well manual volume control.

Hearing aid users have reported background noise as a problem on many occasions (The Hearing Center, 2006). When there is abundant background noise it can

be difficult for the hearing to communicate as well. The first way the body naturally compensates for this is the layout of the human head. Humans have two ears which allow the brain to determine the direction sound is coming from based on the time delay between sound receptions in each ear (Eartech, 2003). When trying to communicate in a noisy environment, the ability to localize sound sources helps subconsciously filter unwanted noise. It has been shown that children with unilateral hearing loss (significant hearing loss in only one ear) have difficulty locating the origin of sounds and understanding speech in noisy situations (Boys Town National Research Hospital, n.d.). The second method of background noise processing is that speech is a redundant signal; while some is lost in surrounding noise, often enough is heard to be able to piece together what was said (Levitt, 2001).

Unfortunately, hearing aid users do not experience normal hearing while using their devices, there is distortion. As a result, some portions of speech that a hearing person would hear in a noisy environment become distorted. This makes it so the user can no longer obtain enough useful information from it to discern what is being communicated (Levitt, 2001). Furthermore, due to processing time and how the sound is transmitted to the ear, there are difficulties in determining sound origin (Eartech, 2003).

Fortunately, there are hearing aids that have features to help minimize the distortion caused by background noise, including directional microphones and adaptive noise suppression. Directional microphones are relatively simple in the way they work, sound entering the forward pointing microphone is amplified more than sound coming from other directions. These microphones are available in both digital and analogue hearing aids. This system is effective when the wearer is looking directly at the sound source, *i.e.* a person speaking to them, because the source is amplified more than other sounds in the area. If there are multiple speakers or the user is in a closed environment with excessive sound reverberation, the directional microphone is not as effective. Also, while outdoors, wind poses problems for directional microphones. Many hearing aids with directional microphones have the option of changing to omni-directional for situations when the user is not having one-on-one conversations (Dillon, 2005; ASHA, 1997).

Adaptive noise suppression is only available in digital hearing aids and is used to further reduce background noise. Most human speech is comprised from the range of frequencies three to four kHz. The hearing aid reduces the volume of sound outside this

range (Dillon, 2005). Unfortunately, sometimes speech tones near the boundaries are filtered out as well. This method does not always make it easier to understand speech, but it does reduce background noise, which in turn makes it easier for the listener to concentrate on the speaker.

Background noise can come from all directions, but there are also problems with the noise emitted by the hearing aid itself. Feedback occurs when microphone picks up sound emitting from the speaker which creates a loop leading to a painful, irritating high pitched noise (Dillon, 2005). There are two ways that hearing aids can adapt for feedback. When the hearing aid is fitted, a test is run to see how much various frequencies can be amplified until feedback occurs. The hearing aid is then programmed to not amplify any sound past the feedback threshold, a method called feedback management. The second method, feedback cancellation, is only available in digital devices. The hearing aid is able to detect feedback sound waves and adds a sound wave in direct opposition to cancel it. The end result is about 10 db more amplification without feedback (Dillon 2005).

There are a variety of listening programs available and based on each user; an audiologist can select two or three on average to program into the client's hearing aid. Each program is tailored to a different listening situation including when there is: soft or no noise, very loud noises, or background noise requiring speech filtering. Additionally, there are programs for listening to music, taking advantage of a telecoil, as well as a number of other scenarios. The user can change between the programs using a button on the hearing aid or with a remote control. Some digital hearing aids are equipped with automatic program switching that enables the hearing aid to analyse the acoustic situation and select the best program (Dillon, 2005).

2.4. New Research

All of these technologies are amazing advancements in hearing aids, but they still have problems. Manufacturers and scientists are always continuing to develop new technologies that will make hearing aids function even better and with fewer problems and compromises of sound quality.

At this point there are many qualities, advantages, and disadvantages to both analogue and digital aids, but the digital arena is where the most variation occurs. Studies published in journals of the Institute of Electrical and Electronics Engineers (IEEE) indicate that digital hearing aids have many advantages over their analogue

counterparts, programmability being the foremost (Mitchell, 1999). This feature allows a standard general design while leaving an opening for customization for each user. Another advantage is that digital hearing aids are able to utilize processors to filter background noise without degrading overall sound quality leading to a better hearing experience for the end-user.

Furthermore, digital hearing aids are more efficient; they consume less power while still creating an accurate representation of the audio signal, in most cases one far better than created by their analogue counterparts. Digital hearing aids also present a possible solution to the issue of variable gain across the frequency spectrum, different levels of amplification to different frequencies. This is because new algorithms are being developed to increase the effectiveness of the conversions between the digital and analogue signals (Sang Min Lee, 2004). Currently, research is being done to create a hearing aid that not only reduces signal to distortion ratio but also helps smooth the gain-frequency curves. Figure 2.6 shows a typical signal to distortion curve, which shows the relationship between frequency and the related amount of distortion created by the typical hearing aid. The three different levels represent the variation among different input levels. Figure 2.7 shows the gain against frequency and demonstrates the different amounts of amplification that a hearing aid can provide; typical speech falls in the three to four kHz range and is the most amplified, but everything else is amplified as well. This creates some of the distortion seen in Figure 2.6.

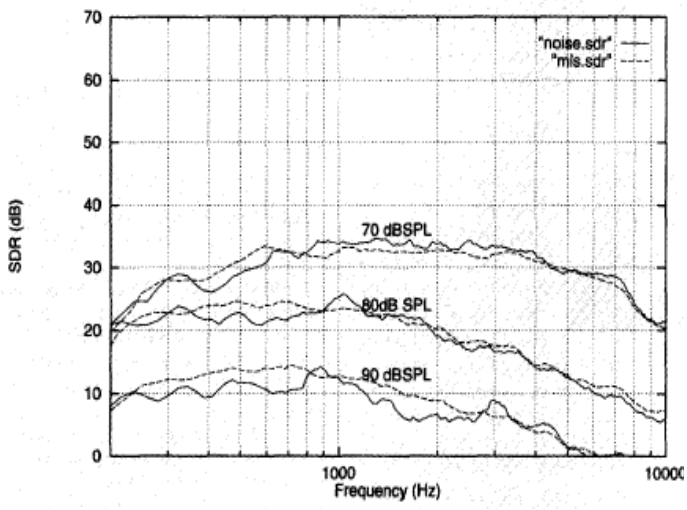


Figure 2.6 - Signal to Distortion Ratio[1]

[1] (Schneider, 1995)

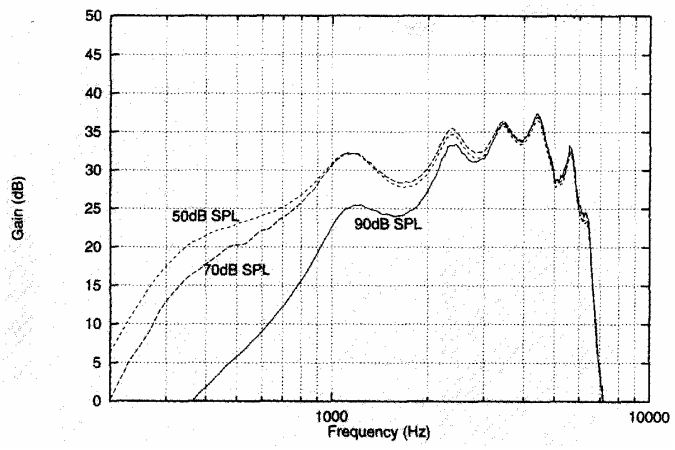


Figure 2.7 - Gain to Frequency Ratio[1]

A final advantage of newer hearing aids is the possible implementation of impermeable membranes to create water-resistant, easy to clean, and therefore maintain, hearing aids. By using the features of new digital hearing aids, particularly the filtering algorithms, the minor distortion created when sound passes through the membrane can be greatly reduced (Ugarte, 2003). These membranes can be used to increase the longevity of hearing aids by preventing foreign substances from being introduced into the hearing aids' inner workings, a problem that now requires professional work to repair.

2.5. Hearing Aid Problems

Although the current technology for hearing aids has greatly advanced, there are many known problems with the functions and applications of current hearing aids which can be classified into three main categories: user problems, codes, and manufacturer and user relationships.

2.5.1. User Problems

A plethora of issues have been identified by hearing aid users and as this project focuses on the application of universal design principles, the needs of both the hearing and hard-of-hearing users must be evaluated. Although this new technology and research on hearing aids is plentiful, there has been as lack of standardization. There needs to implementation of the concepts of universal design that encompass the technological advances in order that any individual can benefit from the technology. Understanding what makes processing speech difficult will lead to better suggestions

[1] (Schneider, 1995)

and understanding the problem of stigma that is associated with the use of hearing aids needs to be understood before it can be addressed.

2.5.1.1. Problems for the Hard-of-Hearing

Although hearing aids have made leaps and bounds at addressing some problems, many issues remain. One concern is that the life span of a hearing aid is only three to five years (Ross, 1999). Also, users have reported that hearing aids break due to shock, extreme temperatures (such as going from heat outdoors to an air conditioned room), high humidity, perspiration, and moisture (Ross, 1999). When it comes to battery life in hearing aids, the same voltage drop in batteries causes different effects in different types of aids. Sometimes poor contacts with batteries cause "frying noises." Also, the tubing in behind-the-ear models can bend or crack and moisture causes functioning to decrease. Another reported problem is that wax decreases functionality and causes irritation. Finally, whistling occasionally occurs from an improper fit (Meier, 1999; Minnesota Department of Human Services, 2005; Ross, 1999).

Other known difficulties include contamination with cosmetics and damage from hair dryers. The high pitched whistling sound and the smell of skin oils from a hearing aid is very attractive to household animals; extreme damage is inflicted on hearing aids that find their way into the mouths of these pets. Even children, playing with their parent's belongings, can cause damage (Minnesota Department of Human Services, 2005).

Another major problem is difficulty in controlling and manipulating hearing aids. They have battery doors, many switches, and are in general very small which makes them difficult to manipulate. As hearing aid technology becomes more miniaturized, these manipulation problems become more pronounced (Abrams, 2005; Danhauer, Johnson, & Krishnamurti, 2000). Adequate vision and general arm functions are necessary to manipulate the aids and their small batteries (Danhauer *et al.*, 2000; Abrams, 2005). This can result in difficulties for elderly users or others that lack in manual dexterity or adequate vision. Research has shown poor manual dexterity to be associated with poorer hearing aid outcome, less use, and lower satisfaction (Abrams, 2005). In fact, the only factor that separated dissatisfied young and elderly clients was the mention of manual dexterity problems (Abrams, 2005). First time elderly clients also identified ease of use as primary reason for selecting a hearing aid (Abrams, 2005). Poor vision does not completely inhibit the use of hearing aids because it can be

overcome with visualization and imagery techniques and a keen sense of touch (Danhauer *et al.*, 2000). Some examples of user problems with hearing aid manipulation are that behind-the-ear hearing aids are often difficult to insert, while completely-in-the-canal aids are difficult to remove and have extremely tiny batteries. Provision of a magnetic tool can make battery changing easier, and colouring battery doors can help users distinguish the left from right hearing aid (Abrams, 2005).

Users with a hearing aid in each ear will often experience occlusion to some degree (Ross, 2004). Occlusion occurs when the ears are completely blocked and the sound of the person's own voice, as well as sound from breathing and chewing, enters the ear canal and is unable to escape because of the hearing aid mould. First time users tend to complain most about this because they are not used to it. Occlusion can amplify the sound of one's own voice by up to twenty dB (Ross, 2004). Hearing aid moulds are often vented to allow airflow into the ear canal to reduce this effect. If the vent is made too large or the hearing loss is severe, requiring high amplification from the hearing aid, feedback may occur. Occlusion is less of a problem for those with severe to profound hearing loss because the sounds that are heard as a result of this effect are generally low frequency and those with more severe hearing loss lose hearing sensitivity to all frequencies. Occlusion is more prevalent in those with minor hearing loss as they generally only have trouble hearing higher frequencies (Ross, 2004).

Recruitment is another problem that needs to be addressed when fitting for a hearing aid. This condition occurs when a client has difficulty hearing soft sounds but is equally or even more sensitive to loud sounds than someone with normal hearing (Hearing Loss Web, 2001). A hearing aid for someone with recruitment must be able to amplify softer sounds while dampening louder noises or the user will experience discomfort. The more severe the user's hearing loss for softer noises, the more precisely the hearing aid has to be tuned in terms of the level of amplitude appropriate for the volume of the sound. Recruitment can be for certain frequencies only or for all sounds above a certain intensity (Hearing Loss Webb, 2001).

2.5.1.2. Problems Identified by the Hearing and Hard-of-Hearing

Identifying the similarities between the hard-of-hearing and the hearing will lead to further progress in hearing aid development. Hearing assistive devices are not just for the hard-of-hearing. There are many environments and situations where hearing can be difficult. Many difficult listening environments for both hard-of-hearing and hearing

individuals have been identified and these include restaurants, pubs, subways, buses, and busy streets. Being able to identify which situations are the most common or bothersome allows further advancement of hearing aids and could lead to devices which are not limited to those who are always in need of the assistance. These hearing assistive devices will be aimed to improve the overall quality of hearing for the general populace.

"*HearWear - The Future of Hearing*, a [recent] exhibition at London's Victoria and Albert Museum, shows off trendy deaf-tech prototypes like gadgets that can filter out annoying noises and memory glasses that replay the last few seconds of conversation -- handy for wearers who might have missed someone's name" (Andrews, 2005). It is not just the hard-of-hearing who can benefit from applications inspired by traditional hearing aids. Hearing is the next sense ripe for a technological revolution, according to the exhibition's organizer, Royal National Institute for the Deaf (RNID). "The exhibit features personal hearing devices, such as aids that enhance conversational speech or filter out ambient noise in a crowded bar. The gadgets illustrate how an effort to redesign conventional deaf assistants might lead to a range of new products for unimpaired consumers increasingly accustomed to wearing iPod® earbuds and Bluetooth® [wireless technology] headsets" (Andrews, 2005). Research has shown that since the 1980s the amount of social noise has tripled. This noise, as reported by Neil Thomas, makes communicating extremely difficult (Andrews, 2005). "These products demonstrate a massive potential for everyone to control and enhance their hearing" (qtd. in Andrews, 2005).

2.5.1.3. Social Stigma

Finally, the social stigma and stereotype of hearing loss is one of the main problems with hearing aids. The stigma, fuelled by stereotypes and incorrect assumptions, is one of the biggest factors that keeps potential consumers from purchasing a hearing aid (Inglis, 2005). "The level of market penetration is extremely low and, over the last 15 years, has continually dropped despite significant advancements in technology and cosmetic appearance of today's hearing aids" (Inglis, 2005). Inglis shows that despite advances in hearing aid function and appearance, market penetration, the relationship between the number of hearing aids sold and the population that exists, is not increasing because users do not want to feel the stigma associated with wearing a hearing aid (Inglis, 2005).

Many hard-of-hearing individuals feel as though they are treated differently than those who are hearing (Sperling, 2000). The Royal National Institute for the Deaf in the UK, RNID, found that fifty-nine percent of deaf people and those who are hard-of-hearing think that the hearing assume they are ignorant (Hear-it, 2005). The hard-of-hearing are sometimes stereotyped as old, less intelligent, or even mentally ill (Hear-it, 2005).

Even the actual hearing aid is stigmatized by society. Many choose not to wear hearing aids because they believe that they do not work or will not help. Further, they believe that the hearing aids are big, unsightly, uncomfortable, and too expensive (Hear-it, 2005). "Despite the leaps and bounds we have made in hearing aid technology we still perceive them as bulky, hideous, awkward, expensive devices. We associate hearing aids and hearing loss with the elderly, while in fact almost 70 percent of people with a hearing loss are under the age of 65" (Inglis, 2005).

While the fact that stigma of hearing loss exists and the general implications of social stigma have been agreed upon in the literature, there are many inconsistencies and disagreements on how to avoid it. One way hearing aid manufacturer Starkey Laboratories is trying to dispel the stigma is by making hearing aids with wireless connectivity using Bluetooth wireless technology. The Ear Level Instrument (ELI) that they produce connects to most standard behind-the-ear hearing aids and makes the hearing aid a wireless headset that is compatible with any electronic device that uses Bluetooth wireless technology (Starkey, 2006). This device was awarded Time Magazine's "Inventions of 2005" award for its innovation and can be seen in Figure 2.8.

Figure 2.8 - Ear Level Instrument[1]

[1] (Starkey, 2006)

Starkey also makes custom earpieces that work with the Apple® iPod®, hoping that they can improve the quality of life for the hearing impaired and unimpaired (Starkey, 2006). SoundPort, also manufactured by Starkey, is designed for hearing individuals using mobile phones compatible with Bluetooth wireless technology who want a more comfortable, custom, wireless communication solution and can be seen in Figure 2.9. "It's [sic] an extremely small and lightweight system that connects directly to a custom earpiece for clear, hands-free telephone communication" (Starkey, 2006).

Figure 2.9 - Sound Port Hearing Aid for the Non-impaired[1]

A few companies have even gone as far as creating devices equipped with Bluetooth wireless technology with hearing assistive capabilities. Gennum Corporation has created Hearphone™ Technology which they have incorporated into a device of the same name. This product, seen in Figure 2.10 acts as both a headset with Bluetooth wireless technology compatibility and a hearing aid for mild loss, a device that "…remains 'always on' to help [the user] hear when [the user is] off the phone as well as enables [the user] to hear streaming audio from Bluetooth® [wireless technology]-enabled devices" (Gennum, 2006). A further advantage of this device is that it is programmable by the user, though Gennum recommends tuning by a professional.

[1] (Starkey, 2006)

Figure 2.10 - Gennum Hearphone™[1]

Some hearing aid manufacturers are beginning to design new products for those with mild, high frequency hearing losses. Theses products are small and discrete (GN ReSound, 2006; Oticon, 2006). GN ReSound has recently come out with ReSoundAIR (see Figure 2.11), which is designed with fashion in mind. It comes with different colour dots that can be either matched to the colour of the hearing aid, or stand out. The ReSoundAIR also offers the user three different carrying cases in which to store the hearing aid. These cases come in three colours and add a way in which ReSoundAIR consumers can personalize their hearing device (GN ReSound, 2006). Because of ReSoundAIR's innovation in product design it was proclaimed the "Best of the Best" and received the prestigious Red Dot award in 2004 for product design (Red Dot Online, 2004).

Figure 2.11 - GN ReSound's ReSoundAIR[2]

Hearing aid manufacturer Oticon also has been praised by Red Dot for their new hearing device, Delta (see Figure 2.12 and Appendix G). It beat out two thousand other entries from forty-one countries to sit as "Best of the Best" and receive the Red Dot Award for product design in 2006 (Oticon, 2006). Delta comes in seventeen different colours, all with a brushed metal finish. The colours give the user a wide range to choose from allowing a colour choice that either conceals his or her hearing aid or

[1] (Gennum, 2006)
[2] (GN ReSound, 2006)

expresses how he or she feels. It is also very discrete with a triangular shaped piece that hides behind the ear (Oticon, 2006). Both Delta and ReSoundAIR are marketed towards individuals with minimal hearing loss and are designed to stand out as a product with great and fashionable design, not just a medical device (Red Dot Online, 2004; Oticon, 2006).

Figure 2.12 - Oticon's Delta[1]

Westone Laboratories and Hearing Components are companies that are introducing hearing devices for the hearing as well. Westone produces ear pieces for musicians and Hearing Components has introduced noise reducing ear buds to the market (Ojeda-Zapata, 2006). Whether it is by integrating new technology or by simply making ear pieces more efficient and comfortable, hearing aid manufacturers are beginning to blur the line between what technologies can be used by which consumers and this is helping to reduce the stigma towards the hard-of-hearing.

2.5.2. Current Codes

Currently, the only types of codes that exist for hearing aids in Australia are electronic compatibility codes, medical device standards, architectural codes, and the standard pensioner's hearing aid codes. These codes must all be considered in order to create a comprehensive set of suggestions for universally designed hearing aids.

With the use of high frequency electronics becoming more commonplace in the modern market, the interference caused by these devices becomes more extreme. One of the main areas where interference can be a problem is with the hard-of-hearing; however, the complication arises from the fact that hearing aid manufacturers and electronics manufacturers do not typically have the same focus and are not concerned with compatibility (Berger, 1997). These differences create a need for external standards to ensure both groups work together to guarantee consumers do not get

[1] (Oticon, 2006)

deprived. These standards not only need to address interfering devices, but also electronics affected by the interference to minimize the potential for problems.

With growing communication developments, come new challenges to the hearing aid user. One item of particular interest is the compatibility of hearing aids with mobile phones. In 1988, the Hearing Aid Compatibility Act was passed mandating that landline phones be hearing aid compatible, but this did not apply to mobile phones (Victorian and Preves, 2004). Since 1988, mobile phones have become much more prevalent than in the late 80s and with this in mind there has been a renewed interest in making hearing aids compatible with mobile phones (Vliet, 2003; Victorian and Preves, 2004). Hearing aids are being shielded much more effectively from the interfering electromagnetic energy given off by mobile phones (Vliet, 2003). Also, compatibility issues are being addressed on both ends from the mobile phone and hearing aid manufacturers. Hearing aid users now have the option of purchasing mobile phones that are compatible with the telecoil in their hearing aid or purchasing an accessory kit with a mobile phone that eliminates interference. CDMA, a new technology being developed already in use in the United States, has the advantage of not causing enough interference to warrant the use of external hardware, according to a study conducted in Australia by the National Acoustics Laboratories (ARPANSA, 2003; Burwood, 1999). Standards Australia has also developed a hearing aid immunity standard (AS/NZS 1088.9:1996) for electronic compatibility that many hearing aids in Australia already meet (ARPANSA, 2003). This general trend in improving mobile phone communication of the hard-of-hearing represents a similar move regarding high frequency interference.

Production of hearing aids in Australia is governed by the Therapeutic Goods Administration, a body that ensures the quality and safety of all medical devices and therapeutic goods produced. The Australian medical device regulatory system was implemented on October, 4, 2002 and ensures that manufacturers of hearing aids are producing safe and high quality goods for the consumer. The problem with these regulations is that their aim is not to increase user satisfaction, but rather to ensure user safety (TGA, 2004).

Every building in Australia that uses sound amplification or makes broad public announcements is required to provide assistive listening devices (ALDs). More specifically, these devices are required in any room used for judicatory purposes, conference rooms larger than one hundred square meters, and any reception area where the public is separated from the service provider (Disability Services Commission,

2002). In areas such as movie theatres where there are separate systems operating in close proximity, for example, two movies playing side-by-side, it is possible for signals from these ALDs to interfere with each other. Hearing aids with telecoils have a magnetic coil that helps filter out the distortion. For those without a telecoil, loop receivers can be used in conjunction with headphones for the same effect (Disability Services Commission, 2002).

The Australian government provides free hearing aids to those who qualify under certain pension programs. These hearing aids offer competitive device technology as described above and can provide very good results when fitted properly (Australian Government Dept. of Health and Ageing, 2005). These hearing aids come free of cost, with only basic features as described in Table 2.2. The behind-the-ear style provides the most features. If a user wants to purchase other features such as a remote control to select programs for the hearing aid or more advanced technology, the cost difference is paid by the client (Australian Government Dept. of Health and Ageing, 2005).

Device Style	Features
Behind the Ear	Adaptive noise Suppression
	Automatic volume control
	Directional Microphone
	Feedback reduction
	Multi-memory
	Telecoil
High Powered Behind the Ear	Adaptive noise Suppression
	Automatic volume control
	Feedback reduction
	Multi-memory
	Telecoil
Open Ear Behind the Ear	Automatic volume control
	Feedback reduction
	Multi-memory
	Telecoil
In the Ear	Automatic volume control
	Feedback reduction
	Multi-memory
	Telecoil
In the Canal	Automatic volume control
	Feedback reduction
	Multi-memory
	Telecoil

Table 2.2 – Free Hearing Aid Designs and Features for Qualifying Clients[1]

[1] (Adapted from Australian Government Dept. of Health and Ageing, 2005)

The building, electronic compatibility, pensioner's hearing aid, and medical device standards for hearing aids are steps in the right direction towards creating a universally designed hearing aid. The main component that is missing from the current standards is what the user wants in his or her hearing aid. This is a key piece of the puzzle that needs to be addressed so that any future research in hearing aid design will directly benefit the users.

2.5.3. Manufacturer and User Relationship

The market for hearing aids is a unique one; it is evolving over time to follow trends in technology. In the early market for hearing aids advertisements were mainly focused in trade and medical catalogues where the aids were sold as medical devices (Washington University School of Medicine, 2005). In the 1930s and 1940s, manufacturers began to aim their products towards the consumer by advertising in newspapers and journals that were accessible by the general public. In the 1950s, as hearing aids became more advanced and miniaturized, the marketing strategy of many manufacturers was to emphasize the new and less bulky hearing aids (Washington University School of Medicine, 2005). Some of the techniques used in those days to illustrate the size of the aids were to compare the aids to the human hand or some household appliance. Also, the name of the aid emphasized its small size. Other techniques used to market hearing aids were to use Hollywood influence or other prominent people, emphasize durability, and make elaborate claims about the aids (Washington University School of Medicine, 2005). As technology continued to advance with the development of integrated circuits, adaptive filtering, directional microphones, digital programming, and the introduction of zinc air batteries in 1977, the hearing aid market began to emphasize technological innovations as well as concealment (Washington University School of Medicine, 2005).

Currently, hearing aids are not marketed towards the consumers, but rather through audiologists. The hearing aid industry has many distinct characteristics in the world of medical devices that make it difficult to understand (Windhover Information Inc., 2002). Company sales and marketing tactics include financial incentives for dispensers, rebates, discounts, and loans. "The most unusual aspect of the hearing aid industry is its fragmented distribution channels, consisting of 8,000 audiologists and 3,000 hearing aid dispensers in 'Mom & Pop' shops and, increasingly, retail audiology chains. These hearing professionals are non-medical personnel who pay their rents and

salaries from the mark-up on devices that they sell and from the fees they get from testing patients and maintaining devices" (Windhover Information Inc., 2002). Audiologists and hearing aid dispensers are the main customers of manufacturers because consumers are not able to purchase custom-fitted and programmed devices without them (Windhover Information Inc., 2002).

The hearing device industry is finally developing products that respond to user feedback. This drive came only after manufacturers lost large sales volume because of unsatisfied users (Kochkin, 1996). Now manufactures are very concerned with how users feel about their product and user feedback is often hailed as the best way to judge a new design (Kladka, 2006). The problem is that manufacturers have no strict guidelines to test the hearing aids before releasing them to the public which leads to a backward design scheme, where a hearing aid is tested in the market by the user after purchasing the device. If the instrument is successful, it is praised, but sometimes the product fails and the result is an unsatisfied user (Kladka, 2006). The user suffers because a faulty product is released into the mainstream market.

Hearing aid manufacturers are not penetrating the market and as a result are unable to sell as many hearing aids as possible (Kochkin, 1999; Bauer, 2000). These lower-than-possible sales leave many who could benefit from a hearing aid without one. In addition to there being a large market and financial interest on behalf of the industry, there is also a large unmet need for hearing aids. Statistics from 1999 suggest that there are over nineteen million people that are not treating their hearing loss (Kochkin, 1999). Of these nineteen million, ninety to ninety-five percent could have their hearing significantly improved without the use of surgery by using a hearing aid. This leaves an astonishing sixteen million users who choose not to obtain the benefits of hearing aids still struggling to hear well (Bauer, 2000).

Another interest to manufacturers is the growing market population. Since former United States President Bill Clinton announced that he has a hearing loss and decided to use a hearing aid, one million others in the baby boomer generation have realized that they too could benefit from a hearing aid. Though the initial surge in sales has calmed, hearing aid manufacturers must figure out how to reach out to the rest of this generation (Kochkin, 1999). In order to do this, it is necessary to review trends of the past.

One misleading fact about hearing aid sales is that sales have been slightly rising. Sales in hearing aids are increasing slightly but only because of the larger user

population (Kochkin, 1999). Comparing penetration rates, the percent of hearing aids sold against the population that exists, is much more telling. In 1997, penetration was at 20.4%, which is virtually unchanged from 1984. Kochkin mentions that new marketing techniques must be implemented as the strategies that worked semi-successfully in the past are not working with the new generation of hearing aid users (1999).

Manufacturers must look at the quality of their product. Users will not continue to use a device that they are not satisfied with so manufacturers must make quality products that give the user a high feeling of satisfaction. In 1997, fifty-four percent of surveyed hearing aid users said they were satisfied with their instrument. This figure is lower than when compared to the same data in 1989, when approximately fifty-nine percent claimed satisfaction. In the same survey sample in 1997, sixty-three percent of users who have had a hearing aid for one year or less expressed satisfaction (Kochkin, 1999). This demonstrates that more users are satisfied with newer hearing aids and that the new technologies are headed in the right direction raising user satisfaction.

Some hearing aid manufacturers are looking for ways to expand the market and are beginning to target the hearing as well as the hard-of-hearing. "… hearing-aid suppliers such as Eden Prairie-based Starkey Laboratories are trying to broaden their appeal with audiological products for all ages. Think custom-moulded earpieces for teenage iPod® junkies along with Bluetooth [wireless technology] cell-phone headsets for their car-commuting moms and dads, to name a few. The idea, according to Starkey, is to get consumers more comfortable with advanced in-the-ear technologies, and to remove the stigma associated with hearing aids, so they'll be likelier to embrace the audio-assistance devices when the time is right" (Ojeda-Zapata, 2006).

When expanding the hearing aid market and reaching out towards hearing users, marketing strategies need to be considered. An excellent example of the importance of marketing comes from one particular manufacturing company, Songbird Hearing Incorporated. This company produced the first disposable hearing aid. This device incorporated a soft tip that reaches into the bony part of the ear canal (University of California, 2000). Robert Sweetow, Ph.D., director of the University of California Audiology Clinic, explains, "This relatively deep placement accomplishes two goals: It produces a very good acoustic seal that minimizes feedback (whistling), and it helps to reduce the common complaint that the user's own voice sounds as if he or she is speaking in a barrel (occlusion effect)" (University of California, 2000). The disposable hearing aids were sold for about forty USD each, which equates to about a dollar a day

based on their expected life span. First-rate digital hearing aids cost more than $2,000 USD per aid, and have a life expectancy of three to five years (University of California, 2000). Two independent studies tested the Songbird Disposable Hearing Aid and results proved that the aid performs equal to or better than even the most advanced traditional hearing aids (Audiology Online Inc., 2001; University of California, 2000). The findings were presented at the American Academy of Audiology's annual conference in San Diego, California (Audiology Online Inc., 2001). This disposable aid represented a wonderful technology that had the potential to greatly increase the market for hearing aids. Frederick Fritz, Songbird Hearing Inc.'s President and CEO explained the marketing strategy,

> "We will begin national television and print advertising for Songbird in January, although many practices are beginning their own advertising and promotional programs this month. They are finding terrific success with direct mail campaigns to lapsed patients and patients who may have visited their practices, but decided to wait rather than purchase a hearing aid - Songbird really seems to fit the needs of these patients very well. Other practices tell us that open houses and newspaper advertising have enabled them to jump-start their Songbird dispensing. In our test market, we saw that the one-two punch of Songbird advertising plus practitioner promotional programs resulted in maximized appointments and fits" (Audiology Online, 2000).

Shortly after its public release, the Songbird Disposable Hearing Aid production was discontinued. Although the aid functioned well, as proven by scientific studies, it failed to gain momentum in the public arena. One of the reasons for this failure rests on the marketing strategy used by Songbird Hearing Inc. (Copithorne, 2005).

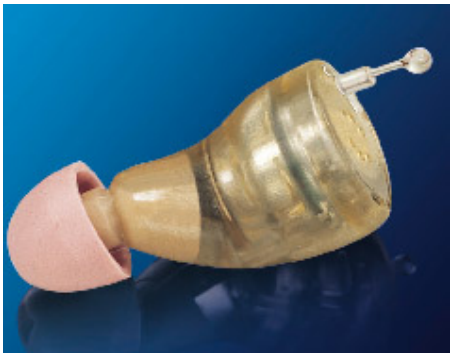


Figure 2.13 - Songbird Disposable Hearing Aid[1]

2.5.4. Cost

The supply chain mentioned above that exists in the world of hearing aid sales makes the costs of hearing aids very high for the consumer and allows manufacturers to

[1] (Ogando, 2002)

gain large profits. The cost of a hearing aid plays a major role in user satisfaction. Users believe that price dictates performance, and this is not always true (Faiers & McCarthy, 2005). Hearing aid consumers reported feeling more satisfied with their hearing instrument when they paid little or nothing compared to those who paid higher costs (Faiers & McCarthy, 2005). Though users felt more satisfied their perceived benefit from the hearing aid was the same (Faiers & McCarthy, 2005). This suggests that it is the cost that influences the satisfaction levels and not the assistance the hearing aid offers.

Hearing aids are very expensive medical devices. In 2003, the average cost of a hearing aid was computed to be $2,400 AUD, but some higher end hearing aids cost $3,400 to even $8,000 AUD (Ross, 2005). There are few specifics about what exactly drives the cost of hearing aids but, as a general rule, smaller hearings aids cost more (Ross, 2005). Also contributing to the final price is the complex technology inside a hearing aid. It has been reported that users are reluctant to purchase hearing aids because of high cost (Ross, 2005). In implementing universal design principles, cost needs to be addressed to ensure accessibility to all, not just those with large savings funds.

The concept of economies of scale is a factor in the expensive price of hearing aids. Hearing aids are relatively high tech devices, but not nearly as complicated as mobile phones. Even still, mobile phones cost thousands of dollars less than even the least expensive hearing aid (Nokia, 2006; Ricketts, 2005; Ross, 2005; Reinhardt and Johnson, 2005). One possible reason why a mobile phone, which can connect two users across the globe, is less costly than a hearing aid, which connects two users face to face, is the principle of economies of scale. In 2003, it was reported that annual sales of hearing aids in the US were around two million units and approximately six million units world wide (Ross, 2005; Appendix F). Though this is a large number it is quickly divided up into smaller sales figures when split between the roughly twenty manufacturers (Ross, 2005). On the other hand, there are approximately two billion mobile phone users world wide and only two major manufactures (Reinhardt and Johnson, 2005). Neil Mawston, a senior analyst with London-based Strategy Analytics, commented that large markets are exactly what big name vendors are looking for to produce many handsets at lower a cost (Reinhardt and Johnson, 2005).

The initial sales of early cochlear implants were also reviewed in order to draw parallels into the marketing considerations for new hearing aids. The cochlear implant

works by sending electronic impulses to the hearing nerve. It has the ability to provide some hearing to bilateral, profoundly deaf individuals (Department of Surgery, n.d.). With the technology available to give hearing to the deaf, manufacturers predicted widespread use and large sales. By 1984, these new implants became public knowledge but they were not selling nearly as well as predicted because of financial concerns and because many in the Deaf community did not see themselves as "potential implantees" (Blume, 1997). Manufacturer 3M began to cut back active marketing on cochlear implants because of these lower than expected sales and stopped the research on future advanced cochlear implants (Blume, 1997).

Though hearing aid sales have large numbers, they are not reaching all of the possible users; there still are an additional sixteen million units that could be sold to the hard of hearing (Bauer, 2000). Though Ross doubts that hearing aids will ever reach such large sales figures as the mobile phone market, he does agree that if hearing aids were as widely used economies of scale could be applied. This would yield lower prices (2005).

Despite the cost of hearing aids, the benefits to treating hearing loss far outweigh the expensive prices (Hear-it, 2006). It was found that the societal costs of having a hearing loss for the average person totals about $297,000 USD. Of this total, only eleven percent corresponds to medical costs, including hearing aids. By comparison, sixty-seven percent, or about $200,000 USD, is made up of lost work productivity (Hear-it, 2006). This figure represents an average, taking values from individuals of all ages. The earlier hearing loss develops, the greater the cost to society. The same study found that when hearing loss is diagnosed in children, the total cost to society over that person's lifetime is about $920,000 USD, far less than the cost to treat the loss. When these figures are added up across the entire population, hearing loss in the United States alone represents a $56 billion USD cost to society (National Academy on an Aging Society, 1999). Early detection and treatment with devices such as hearing aids could drastically lower this number.

In Australia, Access Economics Pty Limited estimates that in 2005, the lost taxation revenue alone from the effects of hearing loss on productivity totals $2 billion AUD -- $1.33 billion AUD from income tax and $0.67 billion AUD from consumption tax. Furthermore, there is an additional cost of $0.58 billion AUD due to losses in economic efficiency as a result of the larger tax burden on others to make up for the amounts mentioned above (Access Economics Pty Limited, 2006).

2.6. Universal Design

The concept of universal design provides a solution to many hearing aid problems. In order to apply the concept of universal design to this situation, an understanding of what universal design is and how it has been applied in the past is necessary. The remainder of this section will provide an in depth description of what universal design is and analyse case studies in which it has been applied in the past.

Universal design is a process to make products as accessible as possible for everyone regardless of age, disability, or other limiting situation. Universal design can be achieved by following seven principles (Connell et al. 1997), five of which are applicable to hearing aid design:

- Able to be operated with equal efficacy by all
- Be flexible enough to accommodate varied users
- Be easy to understand with clear instructions
- Have a high tolerance for error
- Be accessible to everyone

In order to satisfy the principle of equitable use, the design must be appealing to all as well as avoid stigmatizing any users. All features must be equally available to everyone. Flexibility is very similar to the previous principle; the design must be able to adapt to the pace of each user as well as their abilities and method of use. In order to be simple and intuitive, it is important that the product eliminate any unnecessary complexity, provides information in order of importance, and allows for varied language skills. Perceptible information entails the use of different means of conveying information, such as verbal, tactile, and visual. Also, important information must stand out in each of these ways to allow for users with sensory limitations. In universal design, tolerance of error is critical. This involves shielding hazardous elements as well as providing clear warnings and minimizing potential for unconscious or accidental actions. Finally, accessibility must allow for variations in hand and grip sizes, as well as users requiring outside assistance (Connell et al., 1997).

It has been noted that achieving perfect universal design is impossible and that there will always be a group that will find a device difficult to access (Vavik, 2003). The range of human ability is too wide to create one design that is both accessible and attractive to everyone. The goal is then to create a design that is as flexible as possible, the majority of the population, and adapts that design for those who still cannot use the

product. Vavik reminds us that it is also important to keep in mind that not only those with disabilities, but the average person may also be utilizing the same design (2003). It is therefore important to find a balance between accessibility for some as well as a practical and efficient design.

The concept of universal design has been implemented in other products to either make them either easier to use for disadvantaged consumers or more socially acceptable. Nokia has gone to great lengths to develop mobile phones that cater to those with disabilities. These phones include larger buttons and displays, variable ring tones based on frequency sensitivity, compatibility with hearing aids and laptops, as well as information manuals available in both text and audio form. As a result of this work and the US Rehabilitation Act, which required that all technology used by federal agencies follow a universal design code, Nokia became an ideal supplier to a $37 billion USD per year customer, the US Government (Nokia Corporation, 2001).

In the area of assistive devices for disabilities and impairments, there have been some key advances in design. These innovations were related to the emotional and aesthetic needs of the consumer, thereby making the products more appealing. Eyeglasses have made the transition from being a medical product and a sign of a defect to being considered stylish. In fact, there are many people who will at times wear eyeglasses who do not even have a visual impairment. There are some designer brands that sell twenty percent of their eyeglasses with clear non-corrective lenses (Clarkson *et. al*., n.d.). This change has benefited manufacturers and consumers alike. In addition, with the development of contact lenses and corrective laser surgery, there is an invisible alternative to eyeglasses that corrects visual impairment, yet there are still millions of people who choose not to take advantage of either one (All About Vision, 2005; Contact Lens Institute, 2003).

Wheelchair design has not yet progressed to a comparable degree. Many current wheelchair designs have changed very little since the 1930s. While the initial design is still functional, style has changed since the 30s and as a result wheelchair users feel even more separated from the general population (Clarkson *et. al.*, n.d). There are a number of factors contributing to the lack of aesthetically pleasing wheelchair designs. Traditionally, wheelchairs have not been designed by users, but rather by engineers who are primarily concerned with functionality and cost. Until very recently, wheelchairs, as a medical assistive device, were chosen by health care providers for their patients

(Clarkson *et. al.*, n.d). There was no consumer driven market to encourage manufacturers to create a variety of more appealing designs.

Engineering and material science advances have made it possible to replace the traditional steel tubing of the frame with lightweight composites. These new materials are stronger and allow for a greater variety of shapes and styles. Sport wheelchairs have been developed for races and games such as wheelchair basketball. These designs have reduced the stigma of wheelchair users being either helpless or lethargic and show that they can be fit, active members of society (Clarkson *et. al.* n.d.). For any assistive technology, there is an association with weakness; furthermore, there is concern for those who are not born with a disability that using such a product is the mark of a defect (Clarkson *et. al.*, n.d). From the success of eyeglasses transitioning from a medical device to "eyewear", it can be seen that allowing consumers a choice in product style is a key first step in making a product more socially acceptable. With consumer choices come manufacturer competition, further innovation, and the potential for a product to become a symbol of style instead of weakness.

The most important part of the case studies involving medical products in the application of universal design is that there seems to be a pattern in the events that lead to the design changes. In the beginning of all the cases, the products were labelled as medical devices and the general belief was that style was not important (Clarkson *et. al*, n.d). The next occurrence was the identification of a stigma or embarrassment associated with the product. Afterwards, users were seen as consumers and their demands began to be considered by manufacturers. The importance of design was identified and then stylish products became available (Clarkson *et. al.*, n.d). Subsequently, the media began to recognize these changes and coverage changed the public opinion of the products. The products became more widely available and people started to use the products for reasons other than medical needs. Finally, the universally designed product is seen as acceptable by society and is no longer associated with the "disabled" community (Clarkson *et. al*, n.d).

2.7. Summary

Current technology has shown progress in design including better signal processing and increased durability of hearing aids, leading to higher overall quality. Some problems of both users and potential users, hearing and hard-of-hearing, have also been found and, though many problems are group specific, there are also some common

general problems. Further researched was the relationship between manufacturers and users which showed low market penetration although user satisfaction levels were increasing. Lastly, though no universal design code exists for hearing assistive devices the principles of universal design can still be applied.

3. Methodology

In an instrument designed to assist hearing and increase communication, manufacturer and user feedback is paramount. Simply stated, user feedback is the best way to assess the efficacy of a hearing aid because it is a direct measure of how well the hearing aid actually assists the user in day-to-day communication. Though laboratory trials and research data are key steps in working to improve the device, they are geared towards a numerical representation of the instrument's output. Universal design guidelines should not be created on laboratory generated results alone. Design guidelines should also include input from a wide variety of other sources, including but not limited to: users, professionals in the field, designers, and manufacturers.

The following is a summary of the strategies used in order to gain the information needed to propose content for a universal design. This design will provide an effective means of incorporating user feedback and current technology in a blend that would best service both the hard-of-hearing and hearing.

3.1. Goals and Objectives

The project is intended to aid the Victorian Deaf Society in their mission to change the view of the hard-of-hearing in society by proposing universal design guidelines for hearing aids. In order to assist the Victorian Deaf Society in becoming advocates for universally designed hearing aids, the primary goal of this project is to identify needs, issues, and problems that need to be addressed in hearing aid design. Four objectives have been identified to accomplish this task:

- Gather information on the social attitudes towards the hard-of-hearing
- Identify situations in which the hearing would benefit from the use of hearing assistive devices
- Evaluate the applications of current hearing aid technology for use in a universal hearing aid design that encompasses the needs of the entire populace
- Propose content that should be included in realistic universal design guidelines to help change the view of hearing aid users in society and allow everyone to benefit from the use of hearing assistive devices

Furthermore, this project is a study of the effects and applications of universal design, "... the design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design. The

intent of universal design is to simplify life for everyone by making products, communications, and the built environment more usable by as many people as possible at little or no extra cost. Universal design benefits people of all ages and abilities" (Mace, 1997). Due to limited time and resources, this project is confined to the Greater Melbourne area, but it is hoped that the ideas and logic behind the recommendations will be generally applicable. Furthermore, with only seven weeks, a design code was not created; instead, a set of recommendations and observations are presented that can be used by the Victorian Deaf Society to advocate for better hearing aids by following these principles of universal design.

3.2. Social Attitudes towards the Hard-of-Hearing

In addition to interviews, further literature was researched. Upon arrival in Melbourne, archival research was performed as well as research into newly discovered literature. This review was essential in order to be knowledgeable in the work that had been done up to this point.

The first objective was to gather information related to Australian and broader societal attitudes towards the hard-of-hearing. Because this project focuses on changing the societal attitudes toward the Deaf and hard-of-hearing, current attitudes needed to be characterized. To achieve this objective, the comprehensive review of literature that was started while in the United States was continued. Many scholarly articles have been published on the subject of the social stigma placed on the hard-of-hearing, consequently, this literature was a key source of information. The method for extracting the data from the literature was to outline the main ideas of each article followed by a comparison of outlines to identify trends.

To validate the findings and ensure that the content was current, employees of the Victorian Deaf Society as well as of other hearing organizations in Melbourne were interviewed. This group was chosen because of their knowledge and first-hand experience with the problems that their clients express. These interviews were conducted in a semi-structured format and focused on gaining qualitative responses rather than quantitative in order to obtain opinions.

The interviews were conducted by two members of the team – one member asking questions while the other member took notes (NOT an exact transcript) on the interview. Some of the topics that were addressed included:

- Thoughts about stigma and other social attitudes towards the Deaf and hard-of-

hearing in society

- Anecdotes that clients have relayed to interviewees about social attitudes, including their feelings of stigmatization
- Thoughts on why stigma and other negative social attitudes persist
- Thoughts on ways to alter social attitudes

To analyse the data from the notes taken in these interviews, main themes were extracted and compiled. Each theme's pros and cons were identified in order to extract the most pertinent data.

3.3. Universal Hearing Aids

The concept of universal design is to make a product accessible to any person, regardless of age, disability, or any other factor. To make recommendations for hearing aid universal design, situations in which *any* person may benefit from hearing aid use must be identified. To accomplish this objective, a focus group was conducted with representative members of the hard-of-hearing community selected by Vicdeaf. Additionally, individual interviews were set up with members of the hard-of-hearing community to gain more insight. Furthermore, interviews with the audiologists employed by the Victorian Deaf Society at hear**service**, Vicdeaf's audiology clinic, were also interviewed. The hard-of-hearing community members were chosen because they are the most in tune with situations problematic to hearing. The focus group was setup by the Victorian Deaf Society and the interviews were setup by the team.

Some interviewees were contacted through the Disability Liaison Units of multiple area universities and selected based on willingness to participate in the project. The audiologists were chosen because they are hearing professionals with a great deal of experience with regard to difficult-listening situations and environments. The interviews and focus groups were both conducted by two to three members of the team, with one member taking notes while the others moderated the discussion. Topics covered by these interviews and focus group included the following:

- Difficult communication situations and examples
- Difficult listening environments and examples
- Opinions on current hearing aid technology, including problems
- Opinions on the *Hearwear* exhibition
- Hearing aids and fashion opinions

Again, to analyse the data from the notes taken in these focus groups, each member of the team went through the process of initial coding, identifying related themes in the notes from the various interviews and assigning those related themes a category. After the team determined the categories, more in-depth focus coding was performed - eliminating, combining, or subdividing coding categories, followed by identifying repeating ideas and larger themes that connect codes (Division of Instructional Information and Assessment, 2005). This method of coding allowed the team to analyse patterns within the interview notes that helped illuminate the problem. In this way, the team was able to efficiently collect data from interviews.

The team met with Kathy Demos of the National Design Centre. Ms. Demos was interviewed on the creative aspects of universal design and the team worked with her to identify problems and ideas that need to be considered when attempting to design a product that would appeal to all populations. Ms. Demos helped bring a designer's perspective to the issue of unattractive hearing aids.

Professor Kevin Lewis from the Royal Melbourne Institute of Technology School of Design Technical and Further Education Institute was contacted. A focus group was set up by Professor Lewis with four design students: Jess Pautting, Brad Ratajczek, Krista Lindetter, and Sarah Cole[1]. The interviewers informed the group of current issues with hearing aids. Problems such as aesthetics, feedback, battery life, size, amplification, background noise, water damage and comfort were all discussed to inform the design group about problems with hearing aids. Recent advances in hearing aids such as open fittings, better feedback management, and newer hearing aid colours were also conveyed to the design group. They were instructed not to worry about technological constraints, but to focus on the design of a hearing aid or hearing device. From the brainstorming session, the RMIT focus group produced over thirty pages of sketches (a selection is included in Section 4.4.2 and all sketches are included in Appendix H).

3.4. Applications of Current Hearing Aid Technology

Current literature was used to create a list of functions available in hearing aids. From this list, the team identified the functions that can be applied universally to enable all people to take advantage of hearing aid technology. After identifying functions that

1 Though not present during the focus group, design student Leanne Bennett joined the group in producing the sketches.

were the most important in a universal hearing aid as shown by data collected, hearing aid manufacturers were interviewed to evaluate the feasibility of the technological advancements.

Furthermore, the team presented sketches of the “stylish” hearing aids to the manufacturers to gather the manufacturers' opinions of whether such designs would be functionally realistic. Manufacturers the team interviewed include: Widex, Oticon, and Dynamic Hearing. These manufacturers are all located in Melbourne within travelling distance for the team or available for contact via email. Two members of the team conducted the interviews, one speaking and one taking notes. The topics that the team discussed with the manufacturers included:

- The status of current hearing aid technology
- Thoughts on improving hearing aids and future designs
- Thoughts on functions that should be included in a universal hearing aid
- The feasibility of implementing suggested improvements from interviews

From these interviews, the team identified which functions manufacturers believed to be desirable and feasible in a universal hearing aid. Also, the features which were not realistic with currently available technology were discussed.

The team coded all of the interview notes, as explained in Section 3.3, in order to consistently and accurately extract data from them. Interview responses were counted in order to quantify the information and rank the most common problems and ideas discussed. Questions and responses were separated into 4 categories based on the types of questions asked: stigma, problems, ideal hearing aids, and non-hearing impaired applications. These categories were further divided into specific responses as can be seen in Tables 4.1, 4.2, 4.3, and 4.4 in Section 4.6. The number of responses was listed along with the subject population, which is the number of people who were asked about that subject.

3.5. Suggestions for Hearing Aid Universal Design

After discussing the options for a universal hearing aid with manufacturers, standards to be suggested were able to be proposed. Vicdeaf’s goal is to use these suggestions to help change the attitudes towards the hard-of-hearing in society. Some possible solutions were recommended to the Victorian Deaf Society; these were determined by analysing previous case studies where universal design had been used in a similar manner. One such example is the stigma towards the visually impaired which

previously existed in society; it was inconvenient and embarrassing to have to wear eyeglasses in public. Over time eyeglasses evolved into a popular fashion statement which eventually became widely accepted by the public. Now, people with perfect vision choose to wear eyeglasses (Clarkson *et. al*, n.d). Although the visually impaired have technologically advanced options such as contacts and laser vision correction to aid them, many choose glasses because they no longer have a negative social stigma attached to them. As the team analyses these case studies, the data was collected into a comprehensive chart that will identify both successes and failures of other universal design attempts. The team used this chart in order to propose the best method to implement universal design for hearing aids to the Victorian Deaf Society.

3.6. Summary

The goal of the project is the suggestion of content to be included in universally designed hearing aids. This content will then be provided to the Victorian Deaf Society to be considered when advocating for hearing assistive devices to encompass all people, hard-of-hearing or not, in hopes of changing the way the hard-of-hearing are perceived in society.

4. Results from Interviews and Focus Groups

Information from email correspondences, interviews, and focus groups was gathered from five predetermined groups. This section represents a broad range of findings gained by speaking with multiple Vicdeaf and Melbourne sources in addition to internationally recognized hearing professionals and manufacturers. Topics such as stigma, user problems, best features, ideal features, difficult listening situations, and uses for the hearing were discussed. The results of these interviews and focus groups were divided in to five main groups based on the source: hearing aid users, audiologists and rehabilitation specialists, hearing professionals, designers, and manufacturers.

4.1. Hearing Aid Users

Information was gathered from hearing aid users regarding their experiences with their assistive devices. These personal accounts provided information about what hearing aid users liked and disliked with respect to their hearing aids. They also provided information about their opinions on the stigma of hearing aid use and how it has affected them personally. The team met with many hearing aid users including: Greig and Marie[1] (two university students), Lyn DeHoedt (the duty worker at Vicdeaf), and Tamara Doyle-Bates (a profoundly deaf Vicdeaf caseworker). The team also approached Senswide Services, a branch of Vicdeaf that offers job placement assistance to the hard-of-hearing. John Donnon, a Service Coordinator of Senswide Services, provided personal experience from working with his clients. Also, a focus group was also conducted consisting of ten members of Vicdeaf's 101 Ways, a support group for elderly hearing aid and cochlear implant users. Relevant background information for each interviewee as well as interview transcripts are given in Appendix B.

4.1.1. Stigma

A major issue discussed during this group of interviews was the stigma attached to wearing a hearing aid. In the interview with Ms. Doyle-Bates, she mentioned that she finds the need to "stand up for herself" more often than a hearing individual. Many participants in 101 Ways expressed overwhelming support for the statement made by one member, "You do what people around you do even if you don't understand what is going on because you don't want to feel different or slow." Another participant emphasized the feeling with the phrase, "If they laugh, you laugh." Other individuals in

[1] Last names omitted for privacy

the group mentioned how insulting it was to have a waiter ask the hearing spouse how the hard-of-hearing partner would take his or her tea or coffee. Frequently, questions and conversations were directed towards the hearing partner, rather than to the hard-of-hearing spouse. The group members identified these situations as being very hurtful and upsetting for them. Ms. DeHoedt mentioned that there is a general stereotype that hearing aid users are "ignorant, stupid, or unable to hear". She also stated that she did not use hearing aids until she began working at Vicdeaf where many of her colleagues wore them.

When asking Melbourne area university students Greig and Marie about the stigma, they both replied that it was not an issue for them. Greig states that he has "[gotten] over it". He reasoned that by the time his peers realized he has hearing aids, they had already gotten to know him and their first impression was not altered by the hearing aids. Marie's comments agree with Greig; she said that most people assume she has a cold when they first meet her. When they realize she has a hearing loss they have already gotten to know her and their opinions towards her are unchanged. Though Greig and Marie do not feel stigmatized by society as a result of their hearing loss, Marie noted that her brother, who also has a hearing loss, mentioned that he had been treated as if he were dumb by some people.

The findings collected also suggest that users purposely choose not to wear their hearing aids. Mr. Donnon stated that one of his clients, who owned two behind-the-ear hearing aids, chose to only wear one hearing aid. The client believed that when people saw him using both aids he would be perceived as "retarded" and "stupid". The client also alluded to the fact that this was a common behaviour with his Deaf and hard-of-hearing peer group. Greig's comments supported this, stating that his friend owns hearing aids but does not wear them in public. Mr. Donnon and Greig provided evidence of internal stigma. Users feel they are going to be treated a certain way when they use their hearing aids. These users chose not to receive the full benefits of their aids for fear of the self imposed stigma.

Parallels to different impairments, such as a broken arm, blindness, or visual impairment were also discussed with 101 Ways. It was mentioned that the same courtesy and understanding extended towards those who are blind and use a guide dog does not exist for the Deaf and hard-of-hearing community. Other members commented on sunglasses, saying that they are a widely accepted product that also

assists the user. Hearing aids, on the other hand, do not have the same acceptance because the public is not educated about the functions and limitations of hearing aids.

4.1.2. Problems with Hearing Aids

After discussing stigma with interviewees, the team identified problems with hearing aids. The most significant problem identified in hearing aids was their functionality in the presence of high levels of background noise. Background noise can come from many sources and the interviewees gave many examples. Ms. DeHoedt pointed out that large air conditioners, restaurants, and crowded pubs were common background noise sources. Other sources of background noise were identified by 101 Ways as the noise while on the tram or at parties. Greig and Marie pointed out that background noise was a major problem for them as well. Well over two thirds of the users in 101 Ways suggested that because background noise was such a problem, one of the best features of current hearing aids was their ability to cancel some, but not all, of the background noise.

Another issue discussed was the whistling noise emitted from the hearing aid caused by feedback. Ms. Doyle-Bates recalled a time while she was shopping with her son when she suddenly noticed that people were looking at her with panicked faces. She could not hear the feedback noise and did not know why everyone was looking at her until her son told her that there was a loud, siren-like noise coming from her hearing aids. Group members of 101 Ways also expressed a strong level of dissatisfaction because of the feedback caused by hearing aids.

Problems with maintenance were also identified. One of the main concerns of the users was that hearing aids are not waterproof and can be damaged if they become wet. Ms. Doyle-Bates stated that every day situations such as taking a shower, being out in a windy rain storm, or even perspiration could damage the aid. University student Greig echoed Ms. Doyle-Bates' concerns. He emphasized that as child it was particularly difficult to remember to take the aids out before a shower or in the rain. Marie participated in water sports and had to take her hearing aids out during the activity rendering her unable to hear while engaged in the team sport.

Comfort of hearing aids was also a topic discussed with users. Ms. DeHoedt brought up the issue of allergies to the materials used to make the hearing aid moulds. Some clients, herself included, had adverse reactions to the hearing aid mould leading to a lessened state of comfort. Ms. Doyle-Bates mentioned that to keep the hearing aid

comfortable it is required to have the mould remade approximately every two years and that the process becomes quite costly.

The cost of hearing aids was another concern to the users. Ms. Doyle-Bates stated that in addition to the initial cost there were many other expenses that result from owning a hearing aid. She mentioned additional expenses such as changing her batteries every fortnight. At the time of the interview with Marie, she was using hearing aids provided free of cost as mentioned in Table 2.1 and decided to top up (upgrade) for additional features. She was grateful her parents were able to pay for the difference.

The topic of hearing aid design was also addressed in the interviews with users. Greig and other users said that they would prefer a small, unnoticeable hearing aid. Ms. Doyle-Bates mentioned that she liked the colour of her new hearing aid because it blended in with the natural colour of her hair. A member of 101 Ways said that she would like a small hearing aid that she could easily cover with her hair. Though Marie agreed that she would prefer smaller hearing aids, she also cautioned that a hearing aid that was too small would be impractical, especially for those with poor manual dexterity.

Another problem identified was difficult listening situations. One difficult situation arises when there are multiple people speaking at the same time. Marie specifically identified this situation and Greig agreed that hearing in a group of friends was difficult if the speaker constantly switches. Ms. DeHoedt brought up a similar problem of listening in places with many people speaking at once.

4.1.3. Applications of Hearing Devices for the Hearing

Lastly, hearing aid users were asked to share their opinions about developing hearing devices for the hearing. All clients unanimously agreed that the hearing would not benefit from a current hearing aid. Clients such as Marie and members of 101 Ways suggested that hearing clients would be reluctant to wear a device that assisted them in difficult listening situations. This was attributed to users not wanting to be seen as having a hearing loss. Members suggested that possible users would not purchase a hearing assistive device because these users would not worry about a problem with which they were not diagnosed. Members recognized that a possible use for the device could be filtering background noise. Even if people were wearing more devices in the ears, Ms. DeHoedt stated that, “The design [of hearing aids] sets them apart,” and that

certain colours and styles are unique to hearing aids so they are still recognizable as aids.

4.2. Audiologists and Rehabilitation Specialists

Audiologists are certified professionals who work with clients to diagnose hearing loss and select a hearing aid. They also program the hearing aid to meet the individual needs of the user based on the client's specific hearing loss. Rehabilitation specialists work with the client after they have been fitted with the hearing aid, teach the client how to cope with their hearing loss, and give strategies on how to better manage their hearing aid. The team interviewed three audiologists Fiona Savati, Leanne Nolte, and Candice Payne. Fiona Savati and Leanne Nolte are audiologists for hear**service**, a division of Vicdeaf, and both have more than ten years of experience. Candice Payne also works for hear**service** and has experience both as an audiologist and as a rehabilitation specialist. The team also met with two Vicdeaf hear**service** rehabilitation specialists, Nicole McRae and Sarah Newstead. Interview transcripts can be found in Appendix C. The information obtained from the interviews was varied due to their differences in background; however, there were common threads. In all interviews stigma, problems, ideal hearing aid features, difficult listening situations, and economics were addressed.

4.2.1. Stigma

Because of the professional relationship audiologists and rehabilitation specialists develop, the team identified these groups as key information sources about hearing aid stigma. Ms. McRae said that hearing aids are stereotyped as a device for older people. Ms. Newstead mentioned that not only are the hard-of-hearing considered stupid, not understanding, and emotional, but they are also treated differently.

Ms. Payne reported that while there is still a stigma in society towards the hard-of-hearing, it has fortunately been declining in recent years. There is ignorance about hearing problems that can lead to awkward situations. She cited a number of her clients' experiences where they had either misinterpreted what was said or did not hear at all and the person speaking to them grew angry or frustrated. Often, people would speak much slower or louder to a hearing aid user. While speaking clearly does help communication, if it is exaggerated it becomes condescending and offensive because the hearing aid user is treated as less intelligent.

4.2.2. Problems

The audiologists and rehabilitation specialists agreed that background noise was a leading problem in hearing aids and that an ideal device would include an option for noise reduction. Background noise makes it very difficult to understand speech, especially for someone with hearing aids. The audiologists believed the user should be able to choose between focusing on a conversation they are in and being aware of all sounds around them.

All three audiologists and both rehabilitation specialists identified current hearing aid switches and device manipulation as a problem. Ms. McRae said that management of the hearing aid, such as changing the programs, is very difficult, particularly for the elderly users. Ms. Newstead agreed and added that comfort is another major problem. Manual dexterity issues are explained in detail in Section 2.5.1.1. These management issues caused damage to the hearing aid power switches resulting in the removal of them from hearing aid designs.

Ms. Payne has heard from many users about specific problems with their hearing aids. Maintenance, such as wax removal and battery replacement, was brought up and she demonstrated how difficult it is to change the battery. Feedback and whistling were also brought up as technical problems; however, she reported that this is decreasing in modern devices. An ideal hearing aid would include effective feedback management and longer battery life. According to Ms. Payne, a good audiologist will not try to push the client to conceal a hearing aid, but allow him or her to choose a style and even colour that suits them best. By emphasizing discreteness, the audiologist is subtly encouraging an internal stigma that hearing loss is something to hide and be embarrassed of.

4.2.3. Ideal Hearing Aid Features

Ms. Nolte and Ms. Savati listed several ideas to help improve the aesthetic appeal of the aids. Miniaturization, to make the hearing aid easier to conceal, was chief among their suggestions. Likewise, better design for the ear moulds was mentioned to address comfort and appearance. Ms. McRae said the best current features in hearing aids are multidirectional microphones, frequency filtering, and miniaturization. She disagreed with the idea of an ideal hearing aid due to the wide range of needs and degrees of hearing loss. Also, depending on the user, many features may be unnecessary and should not be included because they would increase the cost. Another difficulty

Ms. McRae brought up was that many users have unrealistic expectations of what the hearing aid will achieve. Ms. Newstead said the best currently available technologies are feedback reduction, background noise reduction, programmability, and automation (automatic program changes depending on the surroundings). Her ideal hearing aid would be waterproof and work well in noisy situations such as pubs.

4.2.4. Difficult Listening Situations

Many different situations in which even the hearing have trouble communicating were discussed. Ms. McRae identified a noisy restaurant, a great distance between two speakers, and situations in which there are no visual cues (such as on the telephone) as difficult listening situations. Ms. Newstead identified similar situations and added trams and rooms with bad acoustics. Ms. Savati and Ms. Nolte agreed with the rehabilitation specialists and added that television and theatre could all cause hearing difficulties. Modern architecture has led to poor acoustic environments; polished furniture and floors with few fabrics such as curtains and carpet to absorb sounds create echoing which disrupts sound. Audiologists stated that accents were barriers to communication as well.

These difficult listening situations cause clients to believe they have a hearing loss. They then visit Ms. Savati and Ms. Nolte when in reality they do not have an actual loss. These clients add up to approximately five percent of total cliental. Ms. Newstead believed that hearing aids for the hearing could help but it would depend on the situation. Ms. Savati and Ms. Nolte recommend that a mainstream hearing aid should concentrate on correcting a mild, high frequency loss in order to reach the greatest market.

4.2.5. Economics

A problem identified by both rehabilitation specialists and audiologists was cost. All three audiologists as well as Ms. Newstead agreed that one of the main reasons hearing aids are so expensive is the marketing costs incurred by the manufacturing companies. Ms. McRae also said that some users do not purchase the hearing aid that is right for them due to high price.

Another factor contributing to the overall cost is research and development. This includes programming for digital hearing aids and the miniaturization of the technology to be placed in the device. According to Ms. Payne, miniaturization is not as much of a factor in modern hearing aids as it used to be. She citied the fact that the

price of an in-the-ear hearing aid is roughly on par with a larger behind-the-ear device with similar capabilities.

In addition, the concept of economies of scale was brought up. Both Ms. Nolte and Ms. Savati believed that the relatively small number of hearing aid users is a factor in why hearing aids are expensive. They also mentioned the audiologists needed to be reimbursed for their time spent with clients, providing professional consultation, and administering hearing exams. These consults, leading up to getting a hearing aid, involve five to six hours of time at a rate of about $120 AUD per hour. The user pays for both the device and the services rendered by the audiologists, in part explaining the high cost.

4.3. Hearing Professionals

Hearing professionals were another group the team interviewed. The professionals range from Vicdeaf Managers to professors to Chief Executive Officers of hearing aid research companies and include: Di Attard (Vicdeaf Administration Officer for the Rehabilitation and Information Team), Gina Bertsch (Vicdeaf Manager of Rehabilitation and Information), Margaret Robertson (Chairperson of the Deafness Forum), Neil Thomas (Head of Product Development at the Royal National Institute for the Deaf), Professor Adrian Davis, and Dr. Robert Cowan (Director and CEO of the Cooperative Research Centre for Cochlear Implant and Hearing Aid Innovation (CRC HEAR), and Managing Director of HearWorks Pty Limited, CRC HEAR's commercialization company). Relevant background information about each interviewee as well as interview transcripts are available in Appendix D. The major themes identified in these interviews were: stigma, user problems, difficult listening situations, and hearing assistive device applications for the hearing.

4.3.1. Stigma

The team spoke with these hearing professionals about stigma associated with hearing aids, as discussed in the Section 2.5.1.3. One of the main points mentioned in the interviews was that hearing aid use was associated with being elderly; Ms. Bertsch, Ms. Attard, and Ms. Robertson mentioned that hearing aid users are considered old. Ms. Robertson explained that the hard-of-hearing community has a diminished identity and a hidden disability, not the type of disability that they would like to tell others about.

Ms. Bertsch said that the hard-of-hearing also have feelings of depression, anxiety, and fear because of the stigma that is attached to hearing aids.

The team also learned about the ignorance the general public has involving hearing aids. The general public does not understand how hearing aids work and erroneously believes that hearing aids restore one hundred percent hearing. Ms. Bertsch noted that people often put the burden of communication completely on the hard-of-hearing person, not recognizing that it should be shared by both parties. Ms. Attard mentioned that people often assume that they need to yell and/or speak very slowly in order for the hard-of-hearing person to understand. Ms. Bertsch said that people are blatantly rude to the hard-of-hearing and that there is a lack of compassion with hearing loss. While Mr. Thomas agreed that a stigma towards the hard-of-hearing does exist, he mentioned in an email, "…although I think it's less that people treat hearing aid users as elderly (this is changing) and more that people will 'think' that they will be viewed this way if they have a hearing aid – this is the problem."

4.3.2. User Problems

The team discussed user problems with these hearing professionals as well. The problem identified in every interview was background noise. These results coincide with Section 2.3 which discusses, in detail, user problems involving background noise. Ms. Bertsch summed up the issue of background noise with one light-hearted phrase, "background noise is evil." She further mentioned that recruitment is a problem for hearing aid users. Recruitment describes the very narrow comfort range between too quiet and too loud and if a loud sound is amplified this sometimes causes the user pain. She added that users who have two hearing aids often feel "closed off" because there are two devices over their ears. Ms. Robertson said that the only major problem she could think of was equipment failure. Based on her personal experience, she did not believe that maintenance or feedback was a problem.

A large problem identified by Ms. Bertsch and supported by the low hearing aid market penetration noted near the end of Section 2.5.3 is that users believe their hearing aids will not help them. Common complaints she has received are quite to the point, "my hearing aids don't work." She also stated that the speech gets distorted because, "With hearing aids you are poorly amplifying a sound than shoving it down an already damaged [auditory] system." Ms. Attard mentioned that some users are told about a negative experience a friend or colleague had with a hearing aid. As a result of this, she

says, “[a potential] user is highly unlikely to spend several thousand dollars for a device…they have heard does not help.”

Dr. Cowan and Professor Davis addressed these problems in their visions for an ideal hearing aid. Dr. Cowan believes that a hearing aid that is automatically adjusting, fully implanted, and invisible would suit the users best. Professor Davis stated that an ideal hearing aid should be simple and easy to use as well as be reliable and contain high quality components that do not distort the sound. Their suggestions are supported by the coinciding data discussed in Section 2.5.1

4.3.3. Difficult Listening Situations

The team interviewed these professionals about situations in which it is difficult to hear. Ms. Bertsch agreed with the comments from audiologists and rehabilitation specialists that background noise and distance between two speakers can hamper communication. Ms. Attard also added that traffic and parties where there is loud music and many people speaking at once are difficult communicating situations. Mr. Thomas identified, “multiple speakers (such as conversation around a table) and situations when the speaker can’t [sic] be seen (most people lip-read a little), such as when people are behind a screen, or the other end of an intercom or phone line and also when the quality of speech is poor, such as over a mobile phone etc.” Dr. Cowan said that the most difficult situations are reverberant areas where there are poor signal to noise ratios. As an example, he said that there could be a restaurant with poor signal to noise ratio which is made worse with high ceilings and closed seating. He also noted that work environments can cause difficulties because hearing protection is “dumb”. For example, airport security workers must wear hearing protection by Australian law, but the ear muffs that provide the protection do not allow conversation to be heard so the workers take them off and risk damaging their hearing.

4.3.4. Applications of Hearing Assistive Devices for the Hearing

After identifying these difficult listening situations with the hearing professionals, the applications of universal design for hearing aids for both the hard-of-hearing and hearing were discussed. Dr. Cowan believed that the concept of universal design for hearing aids is a great idea but would be met with some resistance due to the occlusion effect. He also noted that care should be taken in the way in which a device for the hearing is marketed. He said that the Songbird hearing aid for the mildly impaired (Section 2.5.3) was a well founded hearing device that functioned with

appropriate technology. He said that although the idea behind the device was well thought out, the aid failed because the marketing strategy was not well planned. Dr. Cowan suggested that marketing a device for those with a mild loss through audiologists is not the best way to reach the greatest market. Ms. Bertsch said people who rely on their hearing, such as those who are visually impaired, could be greatly helped by a type of hearing assistive device. When asked whether he believed that a universal design for hearing aids would help alleviate some of the stigma associated with the aids, Mr. Thomas responded, "Very possibly, but only if hearing 'aids' were included in this revolution, not left as the 'disability' products they are now." Ms. Robertson disagreed with this idea saying that whether or not people accept devices on the ears, the hard-of-hearing will still have trouble hearing and therefore be stigmatized.

4.4. Designers

The group learned about the process of design and fashion trends from three different sources: a meeting with designer Kathy Demos, director of the National Centre of Design; email correspondence with Neil Thomas, co-curator of the "Hearwear" exhibition and mentioned in Section 4.3; and a focus group arranged by Kevin Lewis, a professor at the Royal Melbourne Institute of Technology (RMIT) School of Design Institute TAFE. The focus group consisted of Mr. Lewis along with four selected students. Chief audiologist for Oticon Australia Wholesale Team and National Audiological and Sales Manager Michael Gordon contributed design related information, particularly about Oticon's newest product, Delta. All background information as well as interview transcripts are available in Appendix E. All parties were enthusiastic about the idea of moving away from the standard hearing aid design and moving towards something more acceptable and fashionable, something users would wear not only because they needed to, but also because they wanted to. The two main topics discussed with these groups were design and manufacturing considerations.

4.4.1. Design Considerations

One of the main points that Ms. Demos brought up was that designers must remember two things when creating any device – it must be functional and appealing. Mr. Gordon supported this point by stating that Delta integrates form and function (see Figure 2.12 and Appendix G) by providing an appealing hearing aid that also offers great sound quality. He further wrote that Oticon is continuing to develop hearing aids

that focus on form and function. These two items go hand-in-hand and must be worked on in conjunction to ensure the final product will be able to compete in the marketplace.

Both Mr. Thomas and Ms. Demos pointed out that devices such as hearing aids, in order to ensure acceptance in society, must be extensions of the users' personalities if they are to be seen. Mr. Gordon agreed that hearing aids should be an extension of the user and reflect his or her personality, but he also stated that devices such as these could also be hidden from public view and still serve their purpose. He used the metaphor of a secret tattoo nobody knows about; though the tattoo is hidden, it still makes the individual feel unique.

Another item discussed with designers was identifying trends in fashion. Ms. Demos said trends are identified before they come to the market; they must be found before the consumers realize them so they can be taken advantage of. She also mentioned that these trends occur because of cultural and social changes and issues, which can make them change frequently. Participants in the RMIT focus group agreed that culture has a very influential impact on trends and is an ideal indicator about what influences will affect design trends in the future.

A common item that interviewees agreed on was the stigma associated with hearing aid use. "There's a certain stigma, if you like. [Hearing aid users] are seen as 'different,'" commented Professor Lewis. Mr. Gordon wrote that one of goals of Delta is to remove the stigma associated with the typical hearing aid. Ms. Demos and Mr. Thomas both said that there is a negative connotation that simply has not been able to be removed. Ms. Demos noted that earrings are worn as embellishments and that hearing aids have not reached that point. Many assistive devices such as eyeglasses have gotten past this stigma by becoming individualized; Ms. Demos and Mr. Thomas wondered why hearing aids have not done this as well.

When designing something that is to be worn, particularly on the ear, there are extra guidelines that need to be followed in order to ensure success. Members of the RMIT focus group stressed that balance and comfort are paramount when designing a product for the ear. Professor Lewis brought up the concern of sanitation because the ear perspires and also accumulates wax. He suggested that a device designed for the ear should take this into consideration. Members of the focus group also used the eyeglasses analogy. They said that at first eyeglasses were an inconvenience but now

those with visual impairments, corrected by eyeglasses, have grown accustomed to their device and the users forget they are wearing them. Professor Lewis and his students commented that a design for a hearing aid should ensure that the hearing aid user will not feel self conscious when wearing it.

4.4.2. New Designs

The RMIT focus group produced many sketches of hearing aids and hearing devices, some of which have never been produced before. The sketches incorporate new possible synergies such as Bluetooth wireless technology and USB, universal serial bus, connectivity and a device that links to a mobile phone and mp3 player (Figure 4.1). These sketches include hearing aids that look like fashionable jewellery. In Figure 4.2, panels c and d, the hearing aids are designed as jewellery but also have a self replenishing energy source. Panel c is an example of a solar powered hearing aid, and Panel d is a kinetic powered hearing aid that charges every time the aid swings up or down.

The designs also reflect the potential user's individuality. Figure 4.3 is designed to blend in as a piercing. Figure 4.4 is a hearing device that would have LED lights that would dance along with the beat of the music or surroundings. Figure 4.5 displays a hearing aid similar to most behind-the-ear styles, but with different curves and angles emphasizing the hearing aid as an embellishment. Figure 4.6 incorporates an open fit, is minimally intrusive, and is made of light weight materials that would be available in many modern colours, such as gold, titanium, carbon, or a clear gel gloss. Figure 4.7 is designed to be large on purpose. The designer describes the large design with the ability to have, "extended battery life and more technology for 'super hearing'. [This design would] create appeal for people with perfect hearing." The designers also explored spectacle aids, or hearing aids built into eyeglasses. Figure 4.8 illustrates a pair of sunglasses that could be transformed into a hearing aid. Figure 4.9 points to the future of hearing assistive devices, blending modern mobile phone technology, a personal digital assistant, a digital camera, and a heads up display all into one well balanced and comfortable unit. Over 90 sketches were provided and all are included in Appendix H.

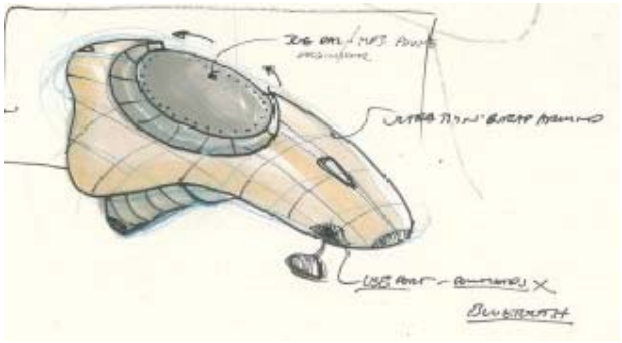
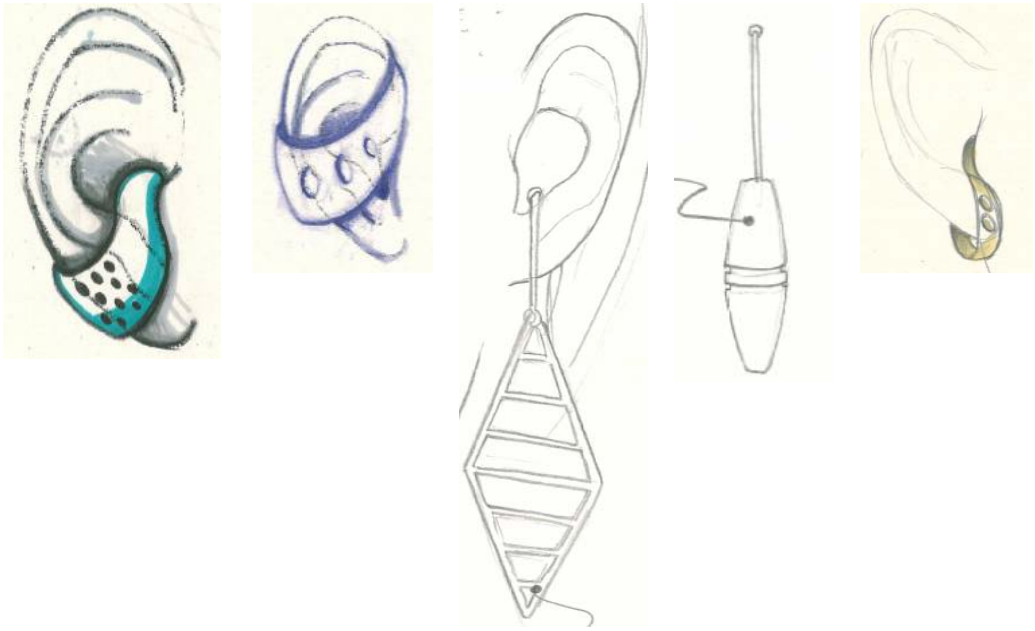


Figure 4.1 - Hearing Device with Bluetooth Wireless and USB Connectivity



Panel a Panel b Panel c Panel d Panel e

Figure 4.2 - Hearing Aids Designed as Jewellery

Figure 4.3 - Hearing Aid with LEDs

Figure 4.4 - Hearing Aid to Blend with Piercings

Figure 4.5 - Hearing Aid Designed as an Embellishment

Figure 4.6 - Open Fit Hearing Aid.
Shown in the ear (left) and out (right) of the ear

Figure 4.7 - Hearing Aid (left) with Large Covering (right)

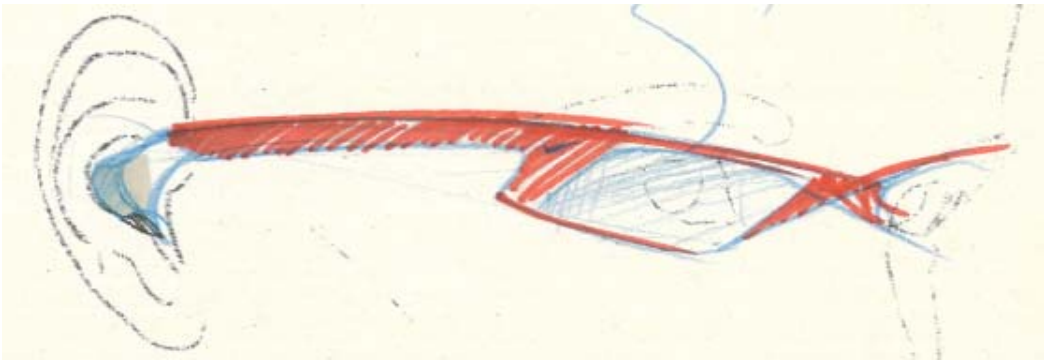


Figure 4.8 - Sunglasses with Built-in Hearing Devices

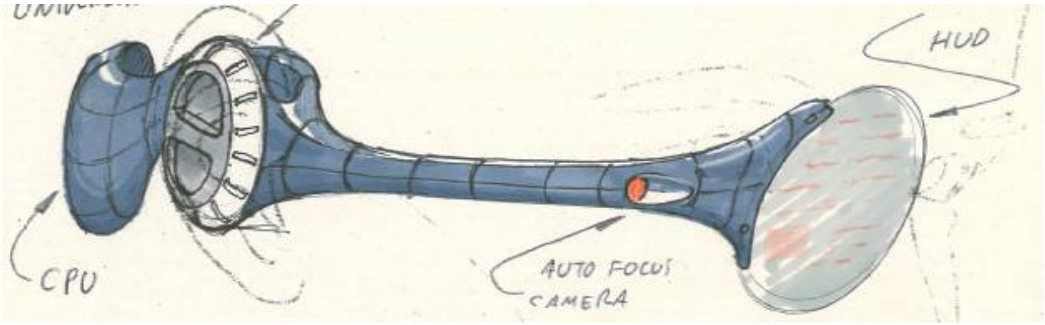


Figure 4.9 - Hearing Device Built with New Technology Synergies

4.4.3. Marketing Considerations

This series of design-oriented interviews and focus groups also revealed ways to market and effectively sell new hearing aids. As noted in Appendix G, Oticon's slogan for Delta is "To wear a Delta means keeping your edge." Mr. Gordon agreed that this slogan was different than other hearing aid slogans and was created intentionally to capture a new market. Both Mr. Gordon and Ms. Demos agreed that hearing aids are considered to be devices worn only by the elderly and that hearing aid users do not like

to be considered old. Both agree that the line between young and old is blurring and that people no longer categorize themselves as young or old based on age, but based on how old they feel. Mr. Gordon wrote that Oticon recognizes those who are using hearing aids live active lifestyles and came up with a slogan that conveys his product's message.

Ms. Demos explained that clients are different and that marketing needs to reflect each group's differences. These differences could be in age, sex, or interests. Members in the RMIT focus group suggested different styles of hearing aid designs based on a user's lifestyle. They reinforced that children may want one particular style of hearing aid with a favourite cartoon character while older users at a night club might want flashing LEDs that were in sync with the music around them.

Members of the RMIT focus group also suggested ways to popularize new hearing products. They said that distributing any new product to a television or movie celebrity would increase the product's visibility and help with sales. Not only giving the celebrities the product, but also having them use the devices in public and media would help the product sell. These members also said that adding features or synergies to hearing aids, such as the ability to listen to music or communicate with a mobile phone though a hearing aid would shed positive light on the device. Professor Lewis mentioned that bringing prototypes to groups with common interests, such as a club or support group for families with a hard-of-hearing member, would help the product gain positive publicity.

4.5. Manufacturers

By interviewing manufacturers, insight into the design process and the problems inherent to research and development were gained. Two manufacturers were contacted, Dynamic Hearing and Widex. Dynamic Hearing is a company based in Melbourne that specializes in creating digital signal processing, DSP, software to license to hearing aid companies while Widex is a manufacturer. The group spoke with two members of the Dynamic Hearing team, Anthony Shilton, the chief operations officer, as well as Christi Wise, an audiologist. Additionally, the group spoke to Patrice Lockwood and Craig Curtis at Widex Australia.

4.5.1. Current Technology

Mr. Shilton was very enthusiastic about the Adaptive Dynamic Range Optimization technology, ADRO, which Dynamic Hearing has developed. As a replacement for the old method of amplification used in hearing aids, ADRO works to optimize sound output dynamically by collecting data and using DSP to analyse the input and create an optimal listening scenario for the user. This, in his opinion which Ms. Wise echoed, would be an excellent technology to incorporate into future hearing aids as it helps resolve the issue of recruitment.

The original solution to the problem of recruitment was to place a limiter on the hearing aid to prevent output over a certain level, but this created distortion. Mr. Shilton said that the perfect amplifier is linear but hearing loss is nonlinear. This creates a conundrum as hearing aids cannot be perfect and fit both of these criteria. ADRO works to create adaptive linear amplification to improve the quality of sound the listener is hearing; it changes the output depending on the surroundings. For example, if the surroundings are loud in a certain frequency range, ADRO compensates by lowering the amplification in that range to maintain a comfortable level.

The representatives from Widex also mentioned their latest product, Inteo. This device differs from other hearing aids in the way that sound is processed. Rather than having individual filters working independently, all the processes work together. By doing this, audio artefactss, small sounds that are inserted by poorly processed signals, are reduced dramatically. Another advantage is that it allows for frequency transposition, modulating sounds from a problem area in a customer's hearing spectrum to a different one with a more normal hearing level.

4.5.2. Future Technology

Mr. Shilton stated that hearing aids will continue to improve as they become more like computers. Once the hearing aid has an internal computer that one can load multiple programs into, manufacturers can begin to focus on creating comfortable, user-friendly housings. Also, he said, "Lots of people would like to be more involved in the process. They don't want to be administered to." Ms. Wise agreed; she hears a lot of strange requests and clients become frustrated when the audiologists do not understand what is needed. Furthermore, if the hearing aid has a standard, open source processor, all the greatest minds could work together to create the best algorithms.

When the group showed the sketches from the design students to the Widex representatives, they were well received. The kinetic energy hearing aid was thought to be a good idea in particular. They also said that the USB connectivity features included were good ideas, similar to that of remote controlled aids. They repeated what Mr. Shilton and Ms. Wise brought up about users preferring to be involved in the process but also mentioned that some people prefer to be completely isolated and they must also be catered to.

In addition, Mr. Curtis and Ms. Lockwood thought that the eyeglasses model would be well received and work towards reducing stigma. By giving consumers choices in their models, more potential users would be willing to get one. "As time progresses it becomes more acceptable." Currently people are changing back to behind-the-ear aids as they become more open-fitted even though they have a stigma attached to them.

4.6. Summary of Data Collected

The data that has been collected has been summarized into a series of tables. These tables represent the common themes that were brought up in all interviews and focus groups. Table 4.1 represents the number of times that stigma associated with hearing aid use is mentioned and shows the five different categories that the stigma can be divided into. Table 4.2 represents the number of times the problems that current hearing aids have were mentioned. Table 4.3 represents the qualities of an ideal hearing aid. Table 4.4 represents the most popular applications of hearing assistive devices for the hearing. The common themes identified in these tables are analysed in detail in the next chapter.

Response	Number of Responses	Sample Population
Ignorance	5	12
Impatient	4	12
Internal	8	13
Old	8	14
Stupid	7	12

Table 4.1 - Data for Stigma in Interviews

Response	Number of Responses	Sample Population
Background Noise	14	16
Comfort	4	14
Cosmetic	5	16
Distortion	4	14

Feedback	8	17
Maintenance	9	15
Multiple Sources	4	14
Occlusion	7	16
Recruitment	3	15

Table 4.2 - Data for Problems in Interviews

Response	Number of Responses	Sample Population
Comfort	2	12
Easy/Automated Adaptability	4	11
Invisible/Discrete	7	11
Waterproof	6	13

Table 4.3 - Data for Ideal Features of Hearing Aids in Interviews

Response	Number of Responses	Sample Population
Background Noise	9	16
Distance	5	15
Synergies	6	16
Work Environments	8	17

Table 4.4 - Data for Applications for the Hearing in Interviews

5. Analysis

The collected data was analysed using interview transcripts and gathering common themes as identified in the tables in the previous chapter. Common themes identified in the interviews and focus groups were: stigma, user problems, current and ideal features, difficult listening situations, and applications of hearing assistive devices for the hearing. As these themes were analysed in the context of universal design, it was observed the negative attitudes associated with the hearing aids would diminish with the inclusion of the concepts of universal design.

A major finding of this research is that the hard-of-hearing are not satisfied with their hearing aids. Problems such as background noise and feedback persist while other problems, such as water resistance, have yet to be solved. Many ideal characteristics for hearing aids were suggested to improve current problems. The high cost of hearing aids is an issue for many users. A hearing aid created with the concepts of universal design should address all potential problems with the end result being the best possible product for the consumer.

5.1. Stigma

Stigma has been found to be a major issue for hearing aid users as well as a barrier for the wide spread use of hearing aids. As all of the issues that were found in research are addressed, the stigma will slowly disappear for the reasons illustrated below. The most common categories of stigma people identified in the interviews were ignorance about hearing loss, impatience towards hearing aid users, a persisting internal feeling of stigma, and the stereotypes of stupidity and old age.

The information gathered illuminates the different aspects of the attitudes towards the hard-of-hearing in society that were initially identified in Section 2.5.1.3. The negative attitudes assumed by the general population place an automatic label of old age and/or mental impairment on hearing aid users. Negative views come from a lack of understanding about hearing aids and hearing losses. This ignorance leads to impatience when communicating with the Deaf and hard-of-hearing. Because hearing aid users ask for clarification during conversation or their speech sounds different or slower, society believes that they have a mental handicap. Ageing causes a natural hearing loss which means a large share of hearing aid users are in their later years; this is where the stereotype that hearing aid users are old stems from. Hearing aid users are aware that people view them as old or mentally incapable. They feel the stigma

internally and base many of their daily actions on trying to avoid being treated differently by others. Many users felt that if hearing aids were smaller or more discrete then people would not be able to see the aid causing immediate and erroneous judgment.

All of these attitudes make it difficult for the public to accept hearing aids as devices that can have applications for everyone rather than placing them in the category of medical products. If the barrier of stigma can be overcome, hearing aids will be one step closer to being designed for widespread use. There are three main points that can be drawn from the team's research that will help break through the hearing aid stigma. These points relate to the public's acceptance of hearing aids and hearing assistive devices, having more choices in hearing aid style, and better technology.

When the public accepts wearing devices in their ears, the line between a hearing accessory and a hearing aid will become blurred. The sketches drawn by the RMIT focus group, shown in Section 4.4.2, illustrate that hearing devices can indeed become fashionable. As more people make the conscious decision to use a assistive hearing device because they want to, hearing aid users will be better understood. This will reduce the stigma towards users who *need* a hearing aid. If more hearing individuals began to wear hearing assistive devices in their ears and begin to use them as part of their daily lives, a hearing aid will become less noticed and hopefully less stigmatized. It will also become harder to distinguish between a device that was created for the hearing and an actual hearing aid. When hearing aids become indistinguishable from assistive devices created for the hearing, it will become impossible to stigmatize hearing aid users.

In the case studies of universal design discussed in Section 2.6, one of the final steps that occurred to have the observed devices considered universally designed was that users were given more stylistic and functional options. Similar choices need to be available for hearing aids; these choices will allow hearing aids to become an extension of the personality rather than a medical device. This will help hearing aids become less stigmatized because they will be more like accessories; this is the same way that the products in the case studies became universal.

Better and more advanced technology will also help break down the barrier of stigma. As hearing aids become more advanced, there will be fewer problems with the aids and the hard-of-hearing will benefit from better and more natural sound. When

hearing aids function well, users will no longer miss pieces of conversations, thus helping to eliminate the stigma towards them.

5.2. Problems and Technology

Although hearing aids are improving, there are still many problems that remain. Also, many hearing aid users have identified the features in the aids that work best for the users. Furthermore, many users have identified features that they would like to be improved on with more research.

5.2.1. Hearing Aid Problems

This study has discovered numerous problems with hearing aids as reported by users, rehabilitation specialists, audiologists, and hearing professionals through contact with clients as well as background research (Section 2.5.1). The problems brought up for users include difficulties hearing in certain situations, discomfort, distortion, feedback and whistling, maintenance, as well as cosmetic issues. The ranking for most frequently mentioned problems can be seen in Table 4.2.

Background noise was the most frequently mentioned problem encountered with hearing aids. In a noisy environment, hearing aids render it nearly impossible to determine the direction of sound. This makes it extremely difficult to focus on sounds coming from a particular direction, such as in a conversation. The problems with background noise are described in more detail in Section 2.3. Discomfort from hearing aid moulds, feedback, recruitment, and occlusion were more problems that were mentioned in the interviews and also researched in Sections 2.3 and 2.5.1.1. Hearing aids are very small and delicate and maintenance can be a problem especially for elderly users or individuals with poor manual dexterity. Maintenance difficulties, such as battery replacement, cleaning of the hearing aids, and water damage, were also identified as a problem for hearing aid users in both the interviews and focus groups as well as in Section 2.5.1.1. Finally, one of the most common problems discussed in the interviews and focus groups were the cosmetic issues of hearing aids. Hearing aids are still considered ugly and bulky and many people choose not to wear them for these reasons. These facts were researched in Section 2.5.1.3.

5.2.2. Hearing Aid Features

Key findings identified from the interviews and focus groups included the best features hearing aids currently offer and also those features that users would like to see

in future hearing aids. Hearing aid users consistently wished their hearing aids had more features and many users identified which currently available features that they preferred. The features that many users identified as the best currently available were feedback management, noise reduction, and miniaturization. These features were also identified in Section 2.3. Although these features were identified as the best implemented at this time, there is still room for improvement.

These three features, as well as waterproofing hearing aids, were found to be the most commonly recommended topics for further research. Furthermore, waterproofing was the feature mentioned most often in interviews and therefore has been identified as the highest priority for research. Currently water damage causes multiple malfunctions in hearing aids and introducing a way to make hearing aids waterproof or even water resistant would be a significant advancement. The problem of water damage was discussed in Section 2.5.1.1 and the research on waterproofing hearing aids is examined in Section 2.4.

Another suggestion that was often brought up was to improve feedback management and noise reduction with further research. By creating new ways to implement these features or improving upon the current technologies, hearing aids will function better for users and become more accepted by the hard-of-hearing community. The final suggestion made by multiple sources was to continue to decrease the visibility of hearing aids, making them more transparent to the rest of the world. A caution was presented; hearing aids must remain manageable as they become smaller.

5.2.3. Difficult Listening Situations

Another problem examined by the team was difficult listening situations. The team found that the most difficult listening situations were caused by noisy environments, background noise, and multiple sound sources. Virtually all of the interviewees mentioned noisy places as a problem for hearing and communicating.

Another factor identified as a major inhibitor of communication was background noise. This issue arises because the background noise masks both high and low frequency sounds. Hearing aids amplify background noise in the same manner as other sounds and make it almost impossible to hear and distinguish speech as mentioned in Section 2.3.

Similar to background noise, another cause of communication difficulties is multiple sound sources. Section 2.3 describes the problems that arise when speech is coming from more than one person and from many different directions. It is hard for the listener to determine which direction to focus on at the correct time. Also, since every person relies, at least partially, on visual cues for communication, instances when the speaker is not in plain sight cause difficulties in hearing. Some examples of these situations are when a speaker is in a different room, on a telephone, or a great distance away.

5.3. Manufacturer Opportunities

Though many problems were identified though the course of the research, new possibilities for hearing assistive devices were uncovered. Information obtained from all interview groups in addition to Sections 2.3 and 2.5.1 confirms that manufacturers need to improve certain aspects of hearing aid technology. This same information also points manufacturers in a new direction, creating hearing assistive devices that could be used by the hearing. The positive economic impact is also discussed.

5.3.1. Applications

After identifying these situations in which both the hard-of-hearing and hearing have difficulties communicating, the team identified what applications of hearing assistive devices would be best for the hearing. The key findings from interviews with users and hearing professionals were that background noise filtering and user controlled amplification were the two capabilities deemed most important. Background noise filtering would be helpful to everyone, as all people have difficulties communicating in background noise. User controlled amplification would allow the user to switch on amplification in times of need to aid his or her hearing.

Audiologists and other hearing professionals agreed that while the capabilities mentioned above can be helpful in certain situations, a device for the hearing would be even more helpful if it had synergies with other technologies. In order to make the hearing assistive devices more appealing and more applicable, research into incorporating other technologies such as Bluetooth wireless technology or other wireless capability should be completed. Headsets for mobile phones incorporating Bluetooth wireless technology are already available which shows an interest in this technology. This study concluded that incorporating wireless connectivity to electronics

into a hearing assistive device that is capable of amplifying speech and filtering background noise would create an appealing device consumers would want to wear.

Analysis of interviews reveals that the professionals and designers believe workplace safety and sound dampening will be one of the more useful applications for hearing assistive devices for the hearing. In order to protect their hearing, many people use some kind of ear protection, *i.e.* ear plugs or ear muffs, while at work. These jobs include construction and transportation or other scenarios where there is loud machinery. Firearms, whether for sport or military purposes, also pose a serious threat to unprotected ears. While ear plugs protect the users' hearing from damage, the lack of a sense of sound can leave workers unaware of other hazards. From this information, it can be seen that there is an opportunity for manufacturers to create hearing assistive devices for the hearing. By utilizing this avenue the manufacturers will gain new markets which can be used to lower prices for the users.

5.3.2. Economics and Marketing

Cost is one of the main problems identified by the research. If a universal hearing aid is too expensive for the general public to afford, the design will fail because no consumers will purchase it. Currently, hearing aids are sold though audiologists as described in Section 2.5.3. Section 2.5.4 discusses the cost of hearing aids, such as research and development costs, and Sections 4.3.4 and 4.4.3 contain data about marketing strategies collected from interviews and focus groups. Two main marketing considerations were identified by the interviewees: desirable design and audience.

The first point necessary to address in a marketing strategy for a universally designed hearing aid is to create a product that is desired by the consumer. The product should become an extension of the user's personality and also reflect the user's lifestyle. A hearing aid that expresses the uniqueness and individuality of the user will be more successful than a standardized aid. There should be no "one size fits all" hearing aid. These points were brought up by designers Kathy Demos as well as in the RMIT focus group (Section 4.4.3).

The audience that a universally designed hearing aid is marketed towards will make a difference in the manner that the aid is received. As mentioned in Section 4.3.4, Dr. Cowan suggested that marketing a hearing assistive device for those with a slight hearing loss through audiologists is not the best strategy. In fact, Dr. Cowan noted that it

failed in the past, which is also discussed in Section 2.5.3. A better strategy would be to market a universally designed hearing aid directly to the consumer.

The team's data and analysis sections address the high price of hearing aids. Through background research and confirmed by interviews with clients, the team identified the cost as a limiting factor when choosing a hearing aid. Hearing aids are expensive devices, and though the Australian Government does subsidize some hearing aids, it does not provide a wide enough range of features at the no cost option. With little government funding available it is necessary to look at other options to lower the price consumers pay to be afforded better hearing.

6. Recommendations and Conclusions

After analysing the collected information and data, we have drawn major conclusions about universally designed hearing aids. The following section is based on connections drawn from our background research, information and data collection, and analysis. The conclusions and recommendations are divided into three major categories: stigma, problems and technology, and manufacturer opportunities.

6.1. Stigma

We suggest that universal design be applied to hearing aids in order to alleviate the stigma associated with them. Stigma has been determined as a major issue for hearing aid users as well as a barrier for the progression of hearing aids towards wide spread use. There are three main conclusions that can be drawn from our research; these conclusions relate to the general public's acceptance of hearing aids and hearing devices, having more choices in hearing aid style, and better technology.

We conclude that once hearing aids follow the principles of universal design, they will become more accepted by the public. Through universal design, hearing aid users will have more choices both stylistically and functionally. The stylistic improvements will encourage hearing aid use by providing choices that represent the users' individuality. The functional improvements will provide technologies specifically suited towards the individual. These advanced, as well as appropriate, technologies will allow all users to enjoy the best possible sound quality with minimal problems. Due to more advanced technologies and specialization, the sound quality of a universally designed hearing aid will be superior to what is available now. This will create a better listening environment for the user and reduce the associated stigma garnered by users from missing parts of conversations and other sounds.

6.2. Problems and Technology

Universally designed hearing aids should address all user problems uncovered by our research; however, solving the multiple problems revealed would make current hearing aids too large and cumbersome to be realistic. As technology improves, manufacturers will have the ability to produce "ideal" hearing aids, devices that have addressed all user problems. Until then, **we suggest manufacturers focus on technological improvements in background noise management and feedback cancellation as the highest priority for future research. Manufacturers should also**

continue research in the area of water resistance to resolve the issue of water damage.

We suggest that Vicdeaf develop partnerships with hearing aid manufacturers to help advocate for the advancement of background noise management and feedback cancellation. As a communication advocacy agency, Vicdeaf is well suited to assist manufacturers in addressing user problems. This is because of their extensive knowledge and direct contact with their clients. These partnerships would provide Vicdeaf's clientele with better hearing aid technology, improving the quality of life for the hard-of-hearing community, Vicdeaf's overall mission (Appendix A).

One example of a partnership would be with Melbourne-based Dynamic Hearing. Dynamic Hearing's unique ADRO technology is ideally suited to address the DSP needs of hearing aid users. A partnership would enable Vicdeaf to assist Dynamic Hearing in identifying drawbacks in the current implementation as well as other avenues to pursue in future research. This research should include background noise management as well as other issues such as recruitment and feedback cancellation.

A universally designed aid would apply to both the hearing and hard-of-hearing. Our research has shown that creating one universal aid and applying it to all users is inappropriate as well as infeasible as different degrees of hearing loss require different technologies. Instead, **we suggest universally designed hearing assistive devices should be created and modelled after an example such as eyeglasses**. As with eyeglasses, the user should be able to choose the correct "prescription" for his or her specific needs. If the patient is hard-of-hearing, he or she should choose the best technologies for their hearing loss and be guided in these decisions by an audiologist. If the user is hearing, he or she will choose the technologies that are best suited to them. **We recommend that a chart be created by Vicdeaf with assistance from hearing aid manufacturers** listing the components and technologies available for hearing assistive devices. The chart should include information on what each technology does as well as when it is most appropriately used. We suggest that Vicdeaf promote these charts in their Rehabilitation Information and Services program, as the department's goal is to educate the public. With these charts, users will be able to choose their "prescription" for the hearing aid with technologies that are most suited towards the users' needs. This chart will be most helpful for the hearing but an audiologist may find the chart helpful to explain to their clients what components are best for them. An example of this type of chart can be seen in Table 6.1. These charts would need to be

updated to reflect current technology as time passes. By promotion through Vicdeaf's Rehabilitation Information and Services program the chart would reach both the hearing and hard-of-hearing promoting public awareness.

In addition to technical requirements, aesthetic qualities must also be addressed. By creating more fashionable hearing assistive devices users would be less resistant to wearing them. This would lead to larger market penetration which, in turn, would allow lower prices. The conclusions about market penetration and cost are discussed in Section 6.3.3. W**e recommend that these fashionable hearing aids be created as an independent external case.** The user will then have the ability to choose a housing that is as visually pleasing or discrete as desired. Once the housing is selected, the internal components of a hearing aid could be inserted. This is similar in execution to how frames are chosen for eyeglasses with lenses added to fit the user's needs. This allows the user to have a hearing aid that he or she would want to wear, one that could be an extension of their personality in addition to a medical device.

Feature	What it does	When you'd need it
Noise Reduction	Reduces background noise to allow better focusing on people speaking to you	If you use your hearing aid in environments where large amounts of background noise is interfering with communication
Feedback Cancellation	Reduces the feedback caused when the hearing aid microphone picks up sound already amplified by the speaker	If you need your hearing aid to amplify sound to a point where the microphone can hear it
Directional Microphones	Helps limit background noise and allow the user to discern the direction sounds are coming from	If you use your hearing aid in environments where there are multiple sound sources
Automatic Gain Control	Prevents sudden jumps in volume	If you use your hearing aid in environments where sudden loud noises are frequent occurrences
Multiple Channels	Allows for different levels of compression for different frequencies	If you have much more significant loss in a certain frequency range
Speech Enhancement	Boosts the portion of the sound spectrum which relates to speech	If you have trouble hearing people speaking
Frequency Shaping	Creates specialized equalization settings to tailor a hearing aid to your individual needs	If certain sounds create difficult listening situations but other do not

Table 6.1 - Feature Chart

6.3. Manufacturer Opportunities

Many avenues for manufacturers remain unexplored. These opportunities represent a large untapped consumer base which, if taken advantage of, would present new income for the manufacturers. This potential revenue could be used for further enhancement of existing products. This situation creates beneficial scenarios for all parties involved.

6.3.1. Applications

A universally designed hearing aid will have applications for both hearing and hard-of-hearing users as there are numerous situations in society that cause communication difficulties regardless of hearing ability. Due to the varying degrees of severity of hearing loss and the variety of daily needs among the population, we conclude that one device designed to fit everyone is undesirable and impossible.

Background noise cancellation and speech amplification were features discussed in Section 5.3.1 as being potentially useful for the hearing. While these devices are helpful, audiologists and other hearing professionals agreed that devices with these capabilities alone would not experience much use. In order to make such a device more

marketable, **we suggest manufacturers conduct research into possible synergies with new technologies** such as Bluetooth wireless technology to connect with electronic devices. Although there are current products on the market that begin to work with the synergies, the Gennum Hearphone for example, they have yet to gain widespread support and use.

We suggest that Vicdeaf, as a communication advocacy group, work with hearing aid manufacturers to encourage continuing and meaningful research into these types product opportunities the hearing. As an outside agency, Vicdeaf's contributions to hearing aid manufacturers, such as this report, could provide an unbiased third party study about products that would benefit the manufacturers and their current and future clients. With further research we feel that synergies with new technologies would create opportunities for market expansion and stigma reduction. Additionally, these applications represent a unique opportunity for hearing aid manufacturers to expand their markets.

Based on analysis of the interviews and background research, hearing protection in noisy environments will also be an important practical application of technology for the hearing. A hearing assistive device which dampens sounds loud enough to be painful or damaging to hearing while still allowing important and softer ambient sounds would improve the safety of the user. Many noisy situations, particularly workplaces, can be hazardous so it is important to be able to hear warnings and alarms while protecting against hearing loss. **We suggest that Vicdeaf advocate for hearing protection products** by partnering with hearing aid manufacturers as described above.

6.3.2. Design Considerations

The design sketches in Section 4.4.2 and Appendix H illustrate examples of stylish hearing assistive devices that would represent a user's personality. Though they cover a wide range of designs, we feel that they are only a fraction of the possibilities that could be achieved if designers and engineers worked together. By working side by side, a hearing product will have a balance between form and function. **We encourage and support the concept of designers and engineers working together to produce a hearing product.**

Following the path to becoming a universally designed product will result in greater product diversity (Section 2.6). This selection allows the user to be more involved in hearing aid selection process, which was identified as a positive attribute in

Sections 4.5.2 and 5.1. With improved cosmetic and functional design the stigma associated with hearing aids will be reduced as they become desirable devices.

6.3.3. Economics

We have found through our background research, interviews, and focus groups that the market for hearing aids is small and that this causes hearing aids to carry a high price tag. The market penetration rates have remained at a relatively constant twenty percent, showing that many consumers who could benefit from a hearing aid are not being reached. These possible users normally have mild hearing loss or difficulty hearing in very specific situations and are not willing to admit or believe that a hearing aid will help them. **We recognize this as an opportunity for hearing aid manufacturers to expand their product lines to hearing assistive devices for the hearing.** The products should be devices that address users with very mild hearing losses and those developing losses in the high frequency range. This product expansion is an opportunity for cross-over funding. Hearing aid manufacturers could recoup development costs of a single technology or piece of hardware on both hearing aids and hearing assistive devices for the hearing. This will fulfil one of the key principles of universal design – to create a product which is accessible to all. By lowering the cost of hearing aids and hearing assistive devices, a greater number of users will be able to take advantage of them.

One way to achieve lower costs would be to take advantage of economies of scale. Hearing aid manufacturers have the opportunity to use existing infrastructure, manufacturing techniques, and similar components to create hearing assistive devices for the hearing. By doing this, the static costs associated with creating products can be spread amongst all devices. Further applications of economies of scale can occur with the increased acceptance of hearing aids by the public. Greater acceptance will lead to greater market penetration, possibly reaching the documented eighty percent not currently purchasing hearing aids, yielding higher sales for the manufacturers. This increase in sales can then be applied to reduce production costs across the entire hearing assistive device market creating lower prices for the consumer.

We have also explored how to market new hearing assistive devices for the hearing by reviewing previous and current models. Currently the majority of hearing aids are sold though an audiologist who, after an extensive examination, assists the client in picking out a hearing aid that would most appropriately suit the client's needs.

Though we strongly support this current service model for those with a diagnosed hearing loss, **we have observed that hearing assistive devices marketed towards the hearing should be sold directly to the consumer.** We believe that those without a hearing loss will not visit an audiologist and because of the audience which the assistive device is aimed at, it would then be unsuccessful. These new hearing assistive devices should be aimed at individuals who have difficulty listening in specific situations, and will be modern in design. Possible retailers would include electronic stores or online marketplaces. The multi-purpose nature of the hearing assistive devices and possible synergies associated with mobile phones could also lead to mobile phone retailers promoting these new devices.

These conclusions and suggestions represent a significant marketing opportunity for hearing aid manufacturers. They also represent an opportunity for Vicdeaf to improve their standing in the hard-of-hearing and Deaf community by advocating for universally designed hearing aids. By implementing these recommendations the Victorian Deaf Society can play a prominent role in reducing negative social attitudes towards hearing aid users, providing devices of high quality to its clients, and improving communication for all.

It's like a dream.
Even though it's not feasible now, we can design anything that we can dream of because it might happen

Brad Ratajczek
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Appendix A – Sponsor Description

The Victorian Deaf Society (Vicdeaf) is a non-profit organization that is dedicated to serving Deaf and hard of hearing people. Vicdeaf began its services in 1884 and provides reference, referral, advice, and support for three main groups of Victorians: those who are born deaf and communicate through Auslan (Australian sign language); those with acquired deafness; and, those who use their residual hearing and speech as a means of communication.

Mission and Values

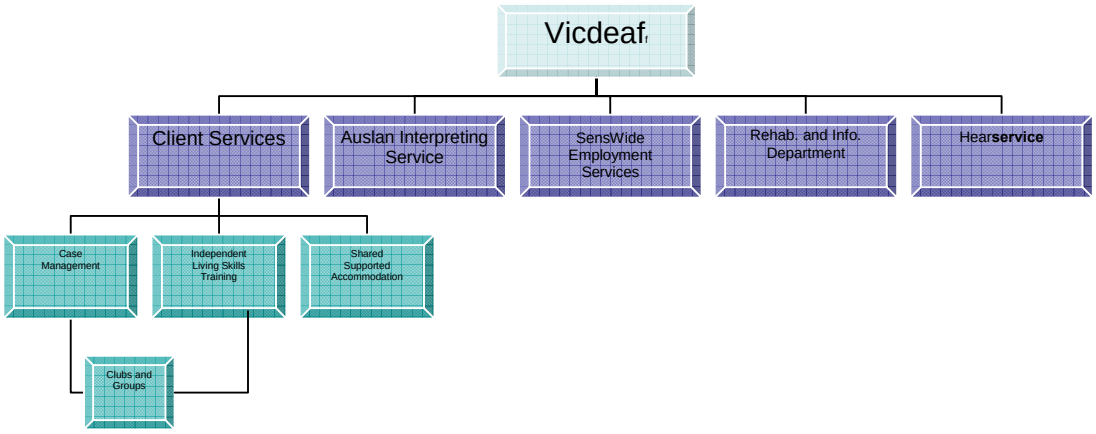
Simply put, Vicdeaf serves all hard-of-hearing individuals. The vision of the organization was changed in 2006 to be 'Vicdeaf… Leading the way in social justice and equity for Deaf and hard-of-hearing people.' Vicdeaf's mission is to improve the quality of life for deaf people by: breaking down communication barriers and improving access to services; increasing the status and participation of deaf people in society; and, providing specialist support and community services (The Victorian Deaf Society, 2005). Also, Vicdeaf aims to be the leader in providing welfare and communication services to Deaf and hard-of-hearing people in Victoria, directly or through alliances with other organizations. They would like to be the first point of reference for these individuals and to be a comprehensive resource for them. Vicdeaf also strives to be a coordinating point for government departments, statutory authorities, and parliamentary and other bodies to consult on, and gain information about issues affecting these individuals in Victoria. Five core values permeate Vicdeaf's mission; they are committed to being: professional, welcoming, efficient, trustworthy, and sustainable (The Victorian Deaf Society, 2005).

Services

Vicdeaf serves over sixteen thousand people every year. It receives forty-five percent of its operating costs from state and federal governments, with the remaining fifty-five percent coming from the Society's fundraising initiatives, business enterprises, income from investments and service fees. Vicdeaf provides five primary services to its clients, which are supported by the Administration and Finance Department: Client Services; Auslan and Interpreting Services; Employment Services; Rehabilitation and Information Services; and Audiology Services.

A multitude of services are provided by these five branches. First, Client Services consists of staff who provide case management and independent living skills training. The case managers are available to provide assistance in advocacy and referral, as well as help with everyday issues for Deaf people. In addition, case managers and counselors are also on hand to provide aid in legal, financial, and personal issues that may arise in day-to-day living.

Figure 1. Organization Chart of Vicdeaf's Services



In addition, Vicdeaf also provides client support workers as well as a "duty system" as a part of its Case Management Program. Client support workers are only available to clients that are Deaf and have another disability, whether physical, intellectual or mental. The client must also be between the ages of sixteen and sixty years of age. The majority of services are provided in the Melbourne metropolitan area but regional services are also located in Geelong; Ballarat; Bendigo; Wangaratta; and Sale. The purpose of the client support workers is to promote independent living in the general community by profoundly Deaf people.

Each branch of Vicdeaf does something slightly unique, but the overarching goal is to help the user improve communication with the hearing community. The Shared Supported Accommodation provides individuals who are Deaf and have other disabilities with support and enables them to participate in other programs and services in the community (including employment), while the Independent Living Skills offers training to those who are deaf and with other disabilities, to enable them to live a more independent lifestyle. The Club and Groups services provided by Vicdeaf consists of Club 101, Club 30+, the Vision and Hearing Support Club (VHSC), and Hyperdeafies.

These four groups all service a different population. Club 101 is a social group for young deaf adults (aged 18-30) with disabilities. Club 30+ is a similar group, except it is focused of those aged above 30. VHSC is aimed at those with visual as well as hearing deficiencies. Finally, Hyperdeafies is for teenagers.

Vicdeaf's Auslan and Interpreting services provide opportunities within the community for people to learn Auslan (Australian Sign language) the language of the Deaf. Vicdeaf is also the largest provide of Auslan Interpreters in the State and provides around 10,000 hours of service each year. Vicdeaf receives no funding from the Government to support the interpreting service.

Vicdeaf provides employment services through its business known as SensWide Services, located within the Melbourne CBD. Employment services are provided to people who are Deaf and/or hard of hearing as well as people who are blind and vision impaired, or a combination of deaf and blind. The Services is funded by the Federal Department of Employment and Workplace Relations.

Vicdeaf focuses not only on aiding those with hearing impairments, but also promotes public awareness on all issues concerning hearing loss, through two departments. One is the Rehabilitation and Information Department and the other is called ***hearService.*** These Departments provide general information about hearing loss, tinnitus and other conditions affecting hearing as well as providing a comprehensive range of audiological services including the sale of hearing aids and sale of augmentation devices.

This is only Vicdeaf's second year as an IQP sponsor, but the students, and advisors are pleased with the sponsorship they have offered in the past, and are glad to be working with Vicdeaf once more.

Appendix B – Hearing Aid User Interviews

Interview with: Elderly Focus Group, 101Ways
Title: Hearing Aid Users
Contact: Gina Bertsch

Position	Manager -- Rehabilitation and Information
Email	gbertsch@vicdeaf.com.au
Phone (Voice)	03 9473 1127

Conducted: March 22, 2006 at 2:45pm in 3rd Floor Large Room at Vicdeaf
Interviewer: Nick Verlinden
Notes: Tim Buck and Kerri George

What are the biggest problems that you have with your hearing aids?

- I just can't hear
- background noise
  - it takes over, drives you mad
  - significant on train rides
  - at parties
- switch for background noise helps on cochlear implants help, but only some hearing aids have this switch
- they switched to cochlear when there is not much else to lose
- distortion
- user became more outgoing and confident when the background noise was eliminated
- shopping a problem because many people don't understand and need to have a lot of things repeated
- feedback(in meetings, weddings with bands, loud music, warm/sweaty ears make the moulds fit poorly, in small spaces like cabinets or when covered with hats)
- tram announcements are too quick and very unclear
- hearing aids don't have eyes, but people rely on visual cues like lip reading and hand motions
- turn down hearing aid when too loud or turn off one hearing aid in social situations

Do you feel as though you are treated differently by members of society because you wear a hearing aid? Can you give examples of how you have been treated?

- holding back, in a shell
- only catch part of conversations, makes me feel stupid
- iris said it's "like living on the fringes of the hearing world"
- you do what the people around you do even if you don't understand what is going on because you don't want to feel different or slow
- people direct questions to the partner because they assume that we are stupid and will not understand
  - for example does she take sugar? Directed towards husband instead of towards person

- if we miss part of a conversation then people say “it doesn’t matter” or “forget it”, they do not repeat it, this makes people feel very bad (need to reeducate how to communicate with each other)
- its tiring to miss pieces of conversations
- people speak slowly to you as soon as they see your hearing aids, they make assumptions that you will not be able to hear otherwise
- when shopping, don’t really want to say I beg your pardon because still may not understand
- “if they laugh, you laugh”
- well she had a hearing aid, why can’t they hear me?

If you were to create the ideal hearing aid, what would some of its features be? What style would it have? Would you like a brightly colored hearing aid or would you prefer a small discrete one?

- try to cover it up with hair
- would prefer small, discrete ones
- some people don’t care because they have accepted the fact that they need it and are just happy to be able to hear
- people accept seeing eye dogs because they understand them

What, in your opinion, are the best technologies available in hearing aids today?

- The switch for background noise

In what situations or environments do you find that your hearing aids function poorly? For example, a noisy restaurant.

- shopping
- cars, dances, crowds
- tv’s (accents and fast speech make it more difficult to understand)
- telephones (accents)
- trams
- in company, I hold back

Can you think of any situations in which a non-hearing impaired person may benefit from using a hearing aid?

- not really because don’t worry about it if not impaired
- background noise
- one person’s friend was jealous because the hearing aid user could hear over the background noise better than the non-impaired person
- not as accepted as sunglasses (which are more excepted because they are more visible and people are more educated about them)

Interview with: Lyn Dehoedt
Title: Hearing Aid User
Email ldehoedt@vicdeaf.com.au
Phone (TTY) 03 9473 1112
Conducted: Wednesday March 22, 2006 at 11 AM
Interviewer: Tim Buck
Notes: Kerri George

What are the major problems that clients have come to you with, with respect to their hearing aids?

No clients with hearing aids, culturally deaf, communication language issues (translated into Auslan)

Do you have any personal experience with hearing aid problems? What are they?

Fitting of the mould
allergies to moulds
adjusting of the moulds (cutting)
main problems
sensitivity
Air conditioning
Background noise makes lip reading difficult
Rely on lipreading
Directions
Sounds are unnatural

What would the ideal hearing aid have as features? What type of styles would it have? Would you like a brightly colored hearing aid, or a small and discreet one?

Comfort, no background noise, fit
Style= invisible (don't like people to stare),

Do you feel as though people treat you differently because you use a cochlear implant? In what ways?

Yes, people are ignorant, stupid, unable to hear
Didn't start wearing a hearing aid until she came to work for Vicdeaf, because all of her colleagues were wearing them.

In what situations do you find it most difficult to hear in?

Restaurants, movies without captions, crowded places, parties, places with many people, announcements at tram/train stations

Do you think a person with no hearing impairment would have difficulty in these situations as well?

yes

Can you think of any reasons, like the ones above, that a non-hearing impaired person may benefit from the use of a hearing aid?

No.

Do you think if more people began to wear hearing aid-like devices in theirs ears, that hearing aids would become more understood and accepted by the public?

No, I couldn’t imagine it doing so

The design sets them apart, colours, styles

Interview with: Tamara Doyle-Bates
Title: Vicdeaf Case Manager, and Hearing Aid User.
Email Tdoyle-Bates@vicdeaf.com.au
Phone (TTY) 03 9473 1131
Conducted: March 23, 2006 at 2:00pm in 4th Floor Translator Room at Vicdeaf
Interviewer: Tim Buck
Notes: Kerri George

What are the major problems that clients have come to you with, with respect to their hearing aids?

Case manager for 13 years, 7 years as independent living skills, Whistling, the moulds, AHS for free batteries or hearing aids

Do you have any personal experience with hearing aid problems? What are they?

Whistling, the cost (pay for herself 2,150 each), no government help, waterproof hearing aids for safety (shower, rain, wind, persiperation), I have to pay for the damage that happens like rust so life is easier, batteries are expensive, moulds need to be redone every 2 years, some health insurances help but not for the good hearing aids

What would the ideal hearing aid have as features? What type of styles would it have?

Colored to blend into the hair, lighter ones are to distracting

Do you feel as though people treat you differently because you use a hearing aid? In what ways?

Yes, I have to stand up for myself and say not to be afraid me, Whistling disturbs people, Shopping with son I cant hear the whistling only low pitched sounds, People looking at her with panic because thought it was a siren

Do you think if more people began to wear hearing aid-like devices in theirs ears, that hearing aids would become more understood and accepted by the public?

I don't know, everyone is different, I like new technology, A deaf expo, employment and technology, New technology is the good

Never wore hearing aids before, just wore fm radios but some people don't want to wear hearing aids at all

Interview with: Greig
Title: University Student, Hearing Aid User
Conducted: Friday, March 31, 2006 at 2:00pm at Monash Universiy, Clayton Campus
Interviewer: Jeremy Turner
Notes: Nick Verlinden

Background

Was diagnosed with hearing loss at the age of 3 and was fitted with hearing aids. Originally had the basic cream colored standard model, but switched to his current analogue/digital programmable hearing aids in high school. Another model he had tried had a hiss that could be heard in quiet situations. Previously had used FM units which were large and bulky, but is looking forward to getting Microlink in new digital aids.

What are the biggest problems that you have with your hearing aids?

As a child, the fact that the hearing aids weren't waterproof was a problem. Would forget that he had them in when going to take a shower or while out in the rain. The switches were also poorly designed and placed and while trying to manipulate the hearing aid would sometimes accidentally pop the battery out. He preferred the FM unit attachment on the older models because they could be detached more easily.

Do you feel as though you are treated differently by your peers, or anyone else, because you wear a hearing aid? Can you give examples of how you have been treated? Has this changed as you've grown older?

No, not usually. Most people do not notice the hearing aids right away and by the time they do, he's already made a first impression on them that is not affected by the hearing aids. His "personality gets over it."

If you were to create the ideal hearing aid, what would some of its features be? What style would it have? Would you like a brightly colored hearing aid or would you prefer a small discrete one?

Compatibility with radios and MP3 players would be great, it can be currently done with FM units, but there is not a standard connector for such devices. The Microlink will be a definite improvement.

What, in your opinion, are the best technologies available in hearing aids today?

Never had a multiple channel digital hearing aid; he had talked to a friend who likewise uses hearing aids who did not think that the multiple channels thing was a big deal. The current digital/analogue hearing aid is an improvement over the older devices, he likes being able to control the volume.

Slimmer and taller designs would be preferred over shorter and fatter behind the ear hearing aids because the thicker aids push the ears out and make it more obvious. He's never used directional microphones, but thinks they would help with background noise problems.

The beeping when the battery is running low should be able to be temporarily disabled. If he had forgotten to change the battery and was either working on something or was away from home, the beeping was annoying and distracting

and many times he does not need to hear anyway (like when working on homework). When the battery is low, the hearing aid will also shut on and off occasionally.

In what situations or environments do you find that your hearing aids function poorly? For example, a noisy restaurant.
What other limitations does it have?

It is difficult to hear when there is a group of people and the same person is not speaking the whole time. In addition, any situation that involves a lot of background noise or when there are echoes or reverberation is difficult as well.

Can you think of any situations in which a non-hearing impaired person may benefit from using a hearing aid?

Many people might like to benefit from Microlink technology that can connect to either a music player or cell phone. When going to see movies in the cinema, with the microphone function disabled and only the receiver on, the audience noise is removed. It could help for watching TV and listening to what is going on, even when moving about the house.

Follow-up:

Producing more hearing aids would most likely drive the cost down, and stigma is a reason for the poor market penetration. He has a friend who owns hearing aids but won't wear them. A more concealed behind the ear aid would be preferred over an in the ear aid, because if the ear shape or mould changes, the whole hearing aid does not have to be replaced. The tubing should somehow be replaced, however, to be less noticeable. Glasses have style now, no longer "four eyes" stigma, hopefully hearing aids can do the same. Integrating Microlink with an additional switch would be great; have the option of microphone only, receiver only, or both together. Also, it would be nice if there were an option to have sound received by the hearing aid in the bad ear (more severe hearing loss) could be transmitted to the aid in the good ear at times.

When out with friends, he tries to sit at the end of the table to be able to see everyone and choose a quieter corner of the room, if possible. If he is in a cinema/theatre situation, he will casually try to have as many people as possible sitting to his left (his left ear has less hearing loss).

Interview with: Marie
Title: University Student, Hearing Aid User
Conducted: Monday, April 2, 2006 at 2:00pm at the University of Melbourne Parkville Campus Library
Interviewer: Tim
Notes: Kerri

Could you tell us some more about yourself? How old are you? What do you do on campus? What is your major field of study? What year are you at Uni?

- a 2nd year of study
- Biochemistry and Microbiology major at the University of Melbourne
- Involved in Christian Union
- Has done Chocolate Lovers Society

What are the biggest problems that you have with your hearing aids?

- Background noise
- Multiple people talking
- Considers the hearing aids provided by Australian government to be the "base line" hearing aid models.

How satisfied are you with your hearing aids?

- "I can communicate, so I'm happy"

Do you feel as though you are treated differently by your peers, or anyone else, because you wear a hearing aid?

- Stigma is not such a problem, most people get to know her before they realize that she has a hearing loss.
- Mentions that her brother (with more serious hearing loss) has been treated as if he were 'dumb'

What, in your opinion, are the best technologies available in hearing aids today?

- Multiple channels
- Small size
- Volume control (wants to control the level of volume her self)
- Feedback reduction, but not a problem with her type of hearing aids

If you were to create the ideal hearing aid, what would some of its features be? Both functionally and cosmetically.

- Too small is impractical
- Waterproof for use in water sports

In what situations or environments do you find that your hearing aids function poorly?

- Areas with lots of background noise, busy streets
- Distance, the closer the communicating parties are the better
- Communicating with heavy accents, makes putting key words into context more difficult.

Can you think of any situations in which a non-hearing impaired person may benefit from using a hearing aid?

- Would not want a hearing aid
- People won't see the point, they might think that a device wouldn't help them at all

Marie consented to using her first name in our final report.

Appendix C – Audiologist and Rehabilitation Specialists Interviews

Interview with: Candice Payne

Title	Hear Service Speech Pathologist and Audiologist
Email	cpayne@vicdeaf.com.au
Phone (Voice)	03 8080 8615
(TTY)	03 8080 8616

Conducted: Friday, March 25, 2006 at 2pm in Box Hill
Interviewer: Nick Verlinden
Notes: Tim Buck

What are the major problems that clients have come to you with, with respect to their hearing aids?

As an audiologist problems such as feedback, and whistling were identified although newer hearing aids with better reduction systems are helping. Also people are struggling to accept their loss. They believe that its a sign that you're getting old. Losing some of their independence." Also maintenance such as removing wax, and changing the batteries.

Cosmetically people complain that it looks too big and that it's visible. Experienced users are used to having a hearing loss and don't have as many cosmetic issues.

A good Audiologist won't try to help the client hide the hearing aid, but will allow them to let it match their clothing/accessories/lifestyle. Don't push to hide, push to help

Do they have trouble with loudspeakers?

Distortion is a problem and people with accents are difficult to understand with a hearing aid.

Interference buzz from telecoil caused by electronics

Recruitment – Loud sounds are painful, dampening hearing aids are a necessity.

Occulsion effect causes users to seem like they're talking too loud, and their chewing is too loud. To Fix this mos hearing aids are vented, though with severe hearing losses venting isn't possible because it would cause feedback

Reasons against UD:

Auds and Rehab are necessary because some clients have different ear sizes, different hearing needs, and a UD hearing aid won't address everyone correctly.

The more features you put into hearing aids the more lazy your brain becomes.

UD/Commerical hearing aids might loose both Auds and Rehab who help to specifically select hearing aids that match that person

What, in your opinion, is the attitude towards the hearing impaired in society?

Attitudes are changing becoming more positive. Younger people are seeing the baby boomers generation with hearing aids and it's helping the acceptance of hearing aids.

There is also ignorance, people seeing a hearing aid user sometimes speak up or talk slow, they think the hearing aid user is slower and not able to understand. Some people get frustrated and just won't communicate. Doctors and Nurses get frustrated because they're changing hearing aid Batteries for patients who aren't able to.

More younger people coming to audiologists. There's more BG noise now and you tend to see mild High Freq loss are coming in now that this mild hearing loss is able to be treated.

Gun metal gray hearing aids look more modern, younger users like these

What types of education are causing hearing aid acceptance

It's a very informal education problem. Ways such as TV networks doing shows on noise induced hearing loss, band members wearing ear plugs, causing their fans to consider hearing loss as well. Business men don't want to loose job so they need their hearing, even if it is only a slight hearing loss. This helps understanding.

How do you believe hearing aid users are treated differently in society? Any specific examples?

Many users complain of being addressed though their unimpaired partner.

There was a case of a lady who needed her hearing aid repairs, she misinterpreted what the store clerk said, and when she responded the clerk flipped out and told the woman she wasn't wanted in the store. He didn't know she has a hearing problem and she didn't say that she had one. When she came back the next day, wearing her hearing aids, she explained what happened. When he realized the communication issue was because of her hearing loss he felt awful.

People can't immediately recognize a hearing loss. This can cause a dangerous situation if a hard of hearing person walked away from somebody, and the other person thought he was just being ignored.

Does not see a lot of clients who identify a lot of these issues, but this could be because she sees lots of assertive clients.

What are the most common misconceptions about hearing aids? For example, that they will restore 100% hearing.

Typical restore hearing to 100%
Only for old people

People think that Hearing Aid users aren't as intelligent. Clients find it hard to interview because a potential employer may think that he not as capable. Discrimination is also an issue.

What are the best technologies available in hearing aids currently?

Slim fit tubes that have a dome that reduce occultion, and do not require an ear impression. This type can fit High Freq losses and is good for people who are having "slight" trouble

Feedback reduction systems, give less whisteling

Startup delays. To avoid painful noises when you first put the aid in the ear. People, in the past, have put it in the ear, then closed the battery door. Now the hearing aid has a delay before it starts up.

Features really are hearing aid dependant. Some have Echo block which is great for communicating on tiled surfaces.

Data logging – showing frequency of use, and volume boosts.

If you were going to create the ideal hearing aid, what features would it include?

Almost any hearing aid should have:

- Feedback management
- Nosie reduction option
- Something that can adapt to the situation that you're in from very loud environment to a very soft one.
- Perhaps one battery that fits all hearing aids. But this doesn't always work because of hearing aid sizes. Also, older clients like the bigger batteries, because they're easier to change. But battery needs to fit small cosmetically hidden hearing aids.
- The Batteries only last for 7-10 days. Would be nice to connect to hearing aids to computers to check battery level, amoung other features.
- To reduce tinnitus, perhaps hearing aids can produce a neutral sound, as an extra program.
- Should have on/off switches, but believes that they were removed because clients kept breaking them because they were so frail.

In what situations, i.e. a noisy restaurant, do hearing aids function poorly? Do you know why?

Expectations vs hearing aid users

Users are still going to have noise

The question arises, why would you want to remove all BG noise? Sometimes it is desirable to listen to the noise around the speaker.

Do you think that those situations are also hard for the non-impaired to communicate in? Can you think of any other situations in which non-impaired people would have trouble hearing?

Things like meeting rooms with bad PA systems.
If there was something

- Regulating noise levels
- Clear sound w/o large volumes
- Amplifying normal hearing might be dangerous.
- Ears are designed for soft sounds.

In your opinion what specifically drives up the cost of a hearing aid?

The cost is partly the research and the man power they have for marketing – that costs a lot. Of course profit plays a role.

Miniaturization use to play a role, but not as much today. Now or days the ITEs, are on par with BTE as far as price.

What did you think of the VA exhibition

The "Pub talk" is good because there are situations where you would only want to listen to a few close friends.
These devices could aid people with a mild loss.

Mood enhancing devices are bad. Keep your feelings to yourself. But the principle of trying to link hearing to communication was good.

The idea of turning hearing aids into Jewlrey was also an exciting idea. Also designing hearing aids in a modern fashion. Cosmetics, when designing hearing aids are very important. Talk to clients about their lifestyle. One female client tended to wear purple, so she chose the purple hearing aid. People think that colored hearing aids are too expensive and they're not. Perhaps cartoon characters for kids hearing aids

Words of caution, is that a universal design code for hearing aids, may cause a loss of forward innovation because you would remove the competition between manufacturers.

Interview with: Fionna Savati and Leanne Nolte
Title: Audiologists
Email fsavati@vicdeaf.com.au , lnolte@vicdeaf.com.au
Phone (Voice) 03 9567 0400
Conducted: Monday, March 27, 2006 at 11:00AM at HearService in Oakleigh
Interviewer: Tim Buck
Notes: Kerri George

Can you describe your job? How long have you been here?

Fiona -12 yrs experience
Job - to assess hearing and advise about hearing loss, medical referral and rehab program (device programming or oral rehab), follow up with hearing aids

In your professional career have you have been approached by clients who believed they may have had a hearing impairment but actually did not?

It happens all the time: hearing in noise, phone ringers (mobile phones), social functions (parties, restaurants), accents (words sound differently, ears not used to different pronunciations)

2-5% of people come in thinking they have a hearing loss, but actually do not

Sometimes people present with more severe symptoms than what their actual lose is (in the beginning stages of hearing loss)

In what listening environments do you believe non hearing impaired have difficulty hearing?

Noise, theatre, television (because of accents and speed of speech), generational (younger people tend to speak more quickly), distance (different rooms, like when couple speak to each other from different parts of a house)

What in the auditory system causes this difficulty?

Noise: sounds that provide clarity in speech are consonance (high frequency, soft noise) and are usually not vocalized
Vowel sounds are vocalized (they are higher intensity and travel further)
The problem with background noise is that it covers up all frequencies

Are there devices available on the market today that address these problems? If not, do you think some type of hearing device would be available to solve this problem?

Yes, Children with central processing problems use FM systems (this just brings all the noise to them and takes care of the problem of distance). GN Resound used to market the Advance, which was a high frequency amplifying device

In our research we have found that noise pollution has substantially increased in the past few years, how does this affect the way that both the impaired and non-impaired hear? Why?

Audiologists teach clients to get out of these situations
Modernized architecture and interior design has lead to more windows, polished furniture and floors, no curtains which makes sound echo and make it more difficult to hear

We have also found that background noise is a major inhibitor of communication, how do you think this problem could be remedied for a non impaired person in a situation with background noise?

Directionality, but the technology is not close enough yet
Multi directional microphones for everyone and FM systems

Do you believe that a hearing device that filters out background noise would help in this instance?

There are amplifiers but they are ugly and bulky and no one wants to wear them
Problem is that they may be providing inappropriate amplification that gives the wrong frequencies to a person

Many people that could benefit from a hearing aid do not wear one. For these people, that have a minimal hearing loss, do you think a standardized hearing aid would benefit them?

The most common loss is high frequencies
Gn resound (advance)
Went to open-fit hearing aids instead (keeps the ear canal open and minimizes occlusion, for minimal loss, around for about 4 yrs but popularity has increased in the last 2 yrs

We've found in our research that there is a large, virtually untapped, market for hearing devices for the non hearing impaired. Would you agree with this? Why do you believe there are not more devices that could benefit clients like you and me?

Everything is more noisy, people "resistant" to technology, price, level of hearing loss
Market could be increased by blending aids with technology (like Bluetooth)
People might like to be able to switch between Bluetooth and amplification modes in their hearing device

We have found that people's hearing loss is very unique to each individual. We know that people have different losses of certain frequency ranges. Is there one band of frequencies that would be more easily treated by a standardized hearing aid?

High frequency loss is the most common, so a standardized aid would serve more people if it was aimed at restoration of high frequency hearing

Why this type of loss, in terms of the auditory system?

High frequency is the most delicate part of the ear. The hair in the cochlea becomes damaged in hearing loss and can be effected by drugs, age, etc. high frequency is located at the beginning of the cochlea, where it is subject to more intensity

There is a ½ octave shift up in hearing loss, normal hearing is around 2-3 kHz and it is the shift up that causes the high frequency damage

We know that different types of hearing losses need to be treated differently, but why?

Its like prescribing glasses, you compensate for the individual difference in hearing

Unlike glasses, where you are dealing with muscle, hearing loss deals with nerves. Therefore audiologist must compensate for lifestyle, tolerance, past experience

Shifting gears, we'd also like to ask you some questions about hearing aids. We've discovered that hearing aids are extremely expensive. What, specifically, do you believe drives up the cost?

Marketing and R/D

Small number of users

Audiological cost(5-6 hrs per fitting @120 per hr) which is incorporated into the cost of the hearing aid (sometimes initial fitting only and sometimes a whole yrs worth of follow ups)

High pressure to make more advanced aids makes for competition

What features do you believe should be included in every hearing aid?

Noise reduction

Prettier hearing aids

Miniaturization

Alternative designs/better moulds

Switches that are easier to manipulate

Never have the complete package, always compromising for the most important feature for a client

Anything else you would like to add?

Telecoils cut out background noise, but buzzing problem, not good loops anymore

We need to think about usability (ELI has too many steps to make it useful), manageability, people will always choose what is easier

Interview with: Nicole McRae
Title: Rehabilitation Specialist
Phone (Voice) 03 9567 0400
Conducted: 10:00am Friday, March 24 at Oakleigh Hearservice Office
Interviewer: Kerri George
Note taker: Nick Verlinden

What are the major problems your clients have come to you with, with respect to their hearing aids?

- Many users have unrealistic expectations of what the hearing aid will achieve.
- People want in the ear models for cosmetic reasons although in many cases they would benefit more from a behind the hear device.
- Background noise
- Management of the hearing, such as changing programs, is difficult especially for elderly users.
- Some people choose to wear only one hearing aid due to cost.
    - **Do they have trouble with loudspeakers?**
        - It has not come up in her experience
    - **Do they feel "closed off" when wearing two aids?**
        - Yes, she has heard that complaint from other clinicians
    - **Any troubles with allergies?**
        - Some users complain of itching with the moulds (more common with in the ear hearing aids)

What, in your opinion, is the attitude towards the hearing impaired in society?

- Hearing aids are stereotyped as very much an older person device
- The older "big and clunky" hearing aids are what most people think of.
- Clients are typically older, but there are many younger users as well

How do you believe hearing aid users are treated differently in society? Any specific examples?

- When talking to a hearing aid user, some people will speak slower due to the belief that they cannot understand as well.

What are the most common misconceptions about hearing aids? For example, that they will restore 100% hearing.

- Users do not know what to expect.
- Clients are given a speech discrimination test at just about hearing threshold to determine what percentage of speech is correctly heard. What is not often enough explained is that this percentage will be the same when they are wearing the hearing aid.

What are the best technologies available in hearing aids currently?

- Multidirectional microphones
- Frequency filtering; amplifying some frequencies and not others.
- Decreasing size of hearing aids.

If you were going to create the ideal hearing aid, what features would it include?

- Due to the wide range of needs and degrees of hearing loss, there is no “ideal hearing aid”
- Depending on user, many features may be unnecessary and should not be included and drive up the cost of the hearing aid.

In what situations, i.e. a noisy restaurant, do hearing aids function poorly? Do you know why?

- A basic hearing aid will not do well with background noise.
- All sound is amplified an equal amount, be it a whisper or a loud noise.

Do you think that those situations are also hard for the non-impaired to communicate in? Can you think of any other situations in which non-impaired people would have trouble hearing?

- Yes, a noisy restaurant would be difficult for anyone.
- Distance between speakers can create trouble hearing.
- Over the telephone or any other situation in which we do not have any visual cues, everyone lip reads to some extent.

What makes hearing aids so expensive?

- Unsure, the feeling is that the smaller size of the technology is a factor.

Interview with: Sarah Newstead
Title: Rehabilitation Specialist
Phone (Voice) 03 9522 0400
Conducted: March 24, 2006 at 12:00pm in Melbourne hearService
Interviewer: Kerri George
Notes: Jeremy Turner

What are the major problems that clients have come to you with respect to their hearing aids?

Background noise, management issues (dexterity problems), physical changes, maintenance, comfort

Do they feel closed off if they wear two aids?

Yes, solid models can cause "occlusion"

Any trouble with allergies?

Small irritations, sweat can cause issues

What, in your opinion, is the attitude towards the hearing impaired society?

Treated differently, as though they are stupid, not understanding, emotional (usually angry)

What are the most common misconceptions about hearing aids?

No follow-up is needed, get it and done, size problems, old problems continue

What are the best technologies available in hearing aids currently?

Feedback reduction, background noise reduction, programmability, automation could be better

If you were going to create an ideal hearing aid, what features would you include?

Waterproof, microphone link attachment for pubs, etc.

In what situations do hearing aids function poorly? Do you know why?

Trams, restaurants, background noise, clanky rooms, bad acoustics

Do you think those situations are also difficult for non-hearing impaired to communicate in? Can you think of any other situations to add? Do you think that some sort of hearing aid would alleviate these problems?

Yes, aids could possibly help, depends on the situation. Only 90% is heard in a one-on-one conversation, 75% in extreme situations, 40% if hearing problems are present. Cosmetic issues are also a large concern.

Do you think a universal design would help alleviate some of these issues?

Different moulds for different people would make a single design difficult. Feedback can cause issues, tinnitus is also something to consider.

Any other information you feel would be helpful?

Costs are high, mostly because of marketing costs.

Appendix D – Hearing Professional Interviews

Interview with: Gina Bertsch
Title: Manager – Rehabilitation and Information
Email gbertsch@vicdeaf.com.au
Phone (Voice) 03 9473 1127
Conducted: March 21, 2006 at 11:00 AM in 3rd floor Conference Room at Vicdeaf
Interviewer: Kerri George
Notes: Tim Buck

What are the major problems that clients have come to you with, with respect to their hearing aids?

They don't work
Clients' expectations are not met, but they rarely present their problems like this often times clients say it in other terms.

They don't help me
I can't hear my grandchild's voice
I can't hear birds sing, or other high frequency noises.

Clients are very specific about what sounds they want to hear, but aren't with their hearing aid.
Younger clients 30-40 report:

Telephone communication problems
Lots of distortion with mobiles phones
Loud speakers on trains clip frequencies causing further difficulties

Recruitment means that there is a very narrow comfort level between too quiet and too loud. This sometimes causes clients pain as the hearing aid amplifies an already very loud sound. Hearing aids are working to dampen loud noises.

Amplifying everything instead of being selective is a problem.

People feel closed off because there are two things over their ears

New hearing aids are letting air in.

What, in your opinion, is the attitude towards the hearing impaired society?

There's a general attitude of initial reaction

- they're stupid
- they haven't understood
- they're old
- fear
- anxiety
- depression.

People often put the problem all on the hearing impaired person. But it's a s social and communication problem involving multiple people, not just the one hearing aid user. Society puts it all on the one person

Discomfort from the listener not knowing how to communicate properly with the hearing impaired person

Do you believe a stigma exists? If so, what is the stigma?

Yes, you see people's faces when in noisy situations, people with hearing aids miss it, so "they're the last person laughing" or always the last to know. The only way to alleviate this is to have somebody there facilitating the conversation which immediately singles the hearing aid user our.

There's internal stigma as well where users know people perceive them as disabled.

Some people do very well with hearing aids. Some deal with it other ways:

Some users deal with their hearing aid by dominating the conversation. If there is never a chance for somebody to interrupt them then they'll never be in a situation where they don't understand, or miss a word. Others are passive, or very socially isolated. These users avoid social situations so they could never "build up for failure"

Hearing Impaired person will move into Personal spaces, to better get the message.

It's a common "Grief and loss" scenario. There's the initial denial, then anger and eventually moving towards acceptance. Some accept their hearing loss in 6 months, others it takes years. If there was better rehab and society support then some of this would not happen

Do you have any stories or anecdotes about these attitudes that your clients have told you about how they are treated?

Has 100's of stories

Attitudes towards deafness while working in UK.
Mother was told very blatantly that her child was deaf, and that set her whole perception of how the diagnosis was done.

Hearing Impaired users have a difficult time going to a store for simple things. Simple tasks like asking for a different clothing size. If the clerk's back is turned, and says something and the hearing impaired person doesn't hear it the clerk may often lash back saying "What are you deaf or something"

Ordering drinks food is often difficult

People are blatantly rude to the hearing loss people, the assumption is that the HI person is being rude by not answering right away so the shop keeper responds with rudeness.

There's a lack of compassion with hearing loss. Unlike, where as someone has a broken arm, a visible wound there's support compassion, but a hearing aid on the ear doesn't mean the same thing. .

Lots of people still think that a hearing aid is like glasses, but that's not it.

People think with a choc implant, they can hear perfectly. But it's just a device.

What, in your opinion, are the best technologies available in hearing aids today?

New mobile technologies are a big hit, like blackberries, and sidekicks.

Simple things like waiting for a train, big screen with waiting screens. Lots of visual aids, assisting hearing impaired.

Distance and background noise are the two biggest limitations of hearing aid technology. They are two large problems. Background noise, has applications to the non hearing impaired as well.

Because of distance and BG noise all people depend more on visual cues than what they hear. What they get from the visual is more accurate then what they get from their ears in crowded noisy situations

In what situations do hearing aids not function as well? Do you know why?

"Background noise is evil", Distance

Do you think that those situations are also hard for the non-impaired? Can you think of any other situations in which non-impaired people would have trouble hearing?

Yes, absolutely. For people who rely on their hearing, such as those who are visually impaired a hearing device could help them.

Do you think some sort of hearing aid would alleviate these problems?
3D hearing aids

Direction is a big issue. The ability to locate sound (sirens) is very important. That can be a dangerous issue. Very difficult for people with only one hear down, or a loss in one ear.

What percentage say "my hearing aid doesn't work"

No exact percentage.

Mild or moderate loss hearing aids on the market can compensate for that. It is difficult to give hearing to those who have extreme levels of hearing difficult. With hearing aids you're poorly amplifying a sound then shoving it down an already damaged system. The message gets horribly distorted.

Starting to implant choclear implants people with lower levels of deafness 45db

When you implant a choclaer you ruin all residual hearing.

Interview with: Di Attard
Title: Administration Officer for the Rehabilitation and Information Team
Email dattard@vicdeaf.com.au
Phone (Voice) 03 9473 1181
Conducted: 1:30pm on Tuesday, March 21, 2006 at the Victorian Deaf Society
Interviewer: Tim Buck
Note taker: Nick Verlinden

While working with ALD, what devices did you come across that worked specifically in conjunction with hearing aids?

"Transit Favourite" and "Echo Mini Tech"

Compatible with hearing aids, loops over the neck

A small hand-held microphone is pointed at the sound source to provide additional amplification.

Mobile phones, through the use of a T-switch, can be connected to the hearing aid

Cuts out background noise very well, resulting in a clearer call than for standard users.

Did you come across any devices that could be used by the non impaired as well?

Anyone could benefit from devices that are focused towards the hearing impaired

Shake Awake alarm clocks for those who do not want to disturb others when waking up (flight attendants on long flights, people who wake up earlier than their partners, etc…)

Portable amplifiers such as "Transit Favourite" and "Echo Mini Tech"

When working/chatting with clients, what were some of the reasons for getting a hearing aid?

The inability to hear family and friends was a very common reason.
When watching TV, often the volume had to be turned up so high it was disturbing to others.
Many times, hearing troubles occurred it noisy situations.

What were some of the reasons for not getting a hearing aid?

Many people, especially men, did not want others to see the hearing aid even despite the availability of smaller, in the canal type devices.

Some people have had friends who have had negative experiences with their hearing aids. As a result, that person is less likely to spend several thousand dollars for a device someone they know says doesn't help.

Wearing a hearing aid is associated with aging, and many people are unwilling to consider themselves as elderly and many others develop hearing loss at a younger age.

Do you think that hearing aid users are treated differently? Any examples?

"Yes, definitely."

People assume they need to yell and/or speak very slowly in order for the hearing impaired person to understand.

Since current hearing aids are available in smaller designs, this is decreasing a bit since it is harder to notice the hearing aid.

Do you believe that a negative stigma towards hearing aid users exists?

Hearing aids are often perceived as a sign of disability or old age.

What do you think would change these negative connotations?

Hearing aids that are unnoticeable.
More young people being seen wearing hearing aids.
More cosmetically appealing hearing aids.

What are the major situations in which hearing aids prove to be ineffective?

In the city due to trams, traffic, and other daily noises.
At parties where there is loud music and many people speaking at once.

Could this apply to the non hearing impaired?

Definitely

It is normal for anyone to have trouble hearing in environments with a large volume of background noise.
Some people are led to believe they have hearing loss based on difficulties in these kinds of situations, but in fact have normal (or close to normal) hearing.

Follow ups

Differences in gender

Among the older population women in general are not as concerned as men with hearing aid appearances.

Hearing aids are very small and difficult to manipulate during tasks such as changing the battery and placing the hearing aid in the ear.

This is especially difficult for the elderly or users with a visual impairment as well.
Some elderly people prefer to use a "Transit Favourite" type device with headphones to avoid having to maintain their hearing aids.

Interview with: Robert Cowan
Title: Director of Cochlear Research Centre
Email r.cowan@unimelb.edu.au
Phone (Voice) 03 9667 7539
Conducted: March 29, 2006 at 4:40pm in 4th Floor Translator Room at Vicdeaf
Interviewer: Kerri George
Notes: Jeremy Turner

What is a hearing aid?

A device that improves signal to noise ratio (SNR) we want HA for all people?

In what listening environments do you believe non hearing impaired have difficulty hearing?

Simple answer is in reverberant areas where there is poor SNR. You can have a poor SNR in a restaurant which is made worse by high ceilings, vaulted walls, close seating. In work environments there are problems as well and the issue here is that hearing protection is dumb. For example, airports security and max noise = 112dB -> class V ear muffs (46 dB attenuation). Australian rules say that you must be protected from loudest that would cause damage. Protection is removed so that people can hear conversation. Too much attenuation can cause problems because it makes it so people won't use protection. SNR is a huge problem. May want to look into work environments that cause problems with SNR because of hearing protection. We are currently working on coming up with voice recognition ear phones, different than BOSE.

Are there devices available on the market today that address these problems? If not, do you think some type of hearing device would be available to solve this problem?

No. There is a "hearing wand" with an extendable arm. RF devices are also a possibility. They are around, but they are add-on aids, not stand-alone devices. Recently there are devices like Senheiser Remote Controlled Headphones, RF headphones. This can help prevent social isolations.

We've learned that some manufactures are making a few devices that assist the non hearing impaired? But with virtually an untapped market, why are there so few manufacturers interested in developing hearing devices for non hearing impaired.

Resistance is the biggest reason with the main problem being the occlusion effect. Three things have happened, becoming more acceptable, good attempts at overcoming occlusion, and battery technology advances. One large problem area is batteries.

We have found that people's hearing loss is very unique to each individual. But is there one band of frequencies that would be more easily treated by a standardized hearing aid?

Variety of different ways that hearing loss occurs. Hearing aids work well as usually you just need amplification. When you go to sensory-neural loss there are lots of different problems. Neurons are not copper-wire, they are fluidic tubes, what happens with hearing loss because of a noise injury, it is sort like hitting your finger with a hammer, it swells and throbs (tinnitus). Soon after the

hair cells are damaged, the damage flows back through the entire system all the way to the synapses. Different etiologies of hearing loss have different effects and different losses effect different parts of the hearing system. To facilitate different types of loss you have to understand the problems. The universal hearing aid should be self training. We've developed a "trainable" hearing aid so they can select the gain and other factors to set different parameters. We need to get to a point where DSP can do this real-time and figure out the acoustic setting and adjust itself in real-time.

We've discovered that hearing aids are extremely expensive. What, specifically, do you believe drives up the cost?

R&D, marketing, supply chain add to cost. You have to balance cost against other options. You can get a $16 pair of glasses or a $300 pair. With the amount of R&D, they aren't that expensive. Cost of goods sold, most components come from Malaysia and China so the parts aren't that expensive. You have to figure in EVERYTHING in the cost, not just the parts. COGS of a hearing aid will usually be about 35-40% of the cost of the actual hearing aid. Different countries have different priorities as well, hearing aids for children or clean water? Take your pick.

What features do you believe should be included in every hearing aid?

Automatic adjusting, fully implanted, invisible (not feasible, but maybe in the future). Disposable contact lens revolutionized the market, invisible aids could do the same for hearing loss. I'm not sure if the HearWear concept will be embraced. The general public don't want to go to an audiologist for a device. I'm surprised I didn't get asked about the marketing strategy. Normal hearing people aren't going to go to an audiologist. Look into the market and what is the interface into the market. If your true market is normal hearing, you have a completely different look into marketing for the mild hearing loss. The companies are leery of this now because the HA is cornered as a medical device. A few years ago a company released "Songbird" and it failed. It failed because their marketing model was wrong, they tried to market through the standard hearing aid chain. It sold for $50 and the amount the audiologist made was $5. Audiologist would much rather fit a regular hearing aid. Innovation is having a good idea coupled with a good delivery model. You need to have a good technology but you also need to think about how you are going to interface with the end-user so they can buy it for the price you can sell it to them.

Interview with: Margaret Robertson
Title: Chairperson of the Deafness Forum
Email MFRobertson@bigpond.com
Conducted: Friday, March 31, 2006 at 1:00 pm in Vicdeaf Board Room
Interviewer: Tim Buck
Notes: Kerri George

What is your role as the chair of the Deafness Forum? What is your professional background?

- Chair of the Deafness Forum
  - Federally funded
- Provide systemic advocacy for
  - Hearing
  - Hearing impaired
  - Deaf
  - Service Providers
- Has retired from counseling

As a part time counselor, do your clients ever express feelings of negative stigma when wearing their haring aids?

- Diminished identity
- Hidden disability
- Not the sort of thing you tell people
- Jokes, that users are old or stupid
- Less assertive
- Clients seem snobby or shy because they don't respond

Do you believe people would purchase a device that would assist non hearing impaired in difficult listening situations, such as a restaurant, or a device that could double as a mobile headset or amplifier?

- FM technology would be excellent in noise
  - Brings specific speaker right to your ears
  - Manufacturers don't seem to like FM technology as much
- Probably would not work

If this was successful, you believe this would help reduce some of the negative attitudes towards those who wear hearing aids? Why?

- Hearing impaired users would still have difficulty hearing, so the stigma would persist.

How are hearing aids currently marketed?

- There are no safeguards to selling hearing aids, as there are with other medical devices
- Sales reps can do very well on commission by selling hearing aids.
- Audiologists sell most hearing aids, but none are registered, no control over Audiologists
- Prices are misleading, people don't know where to turn
- 70% of Australians are eligible for hearing aids.

    - Pensioners
    - Children < 20 years old
- Few organizations offer hearing aids for low income clients
- No price control for top up options

Would you suggest any different marketing techniques to sell a UD hearing aid, one that applies to all persons with hearing loss?

- This would be a different product
- Audiologist is still required in the hearing aid product
- Market directly to consumer, instead of though audiologist
- Possibly market with phones that have uses for non hearing impaired

We have found that the price of hearing aids is in the thousand's of dollars. To the average consumer, this is very high price. What specifically do you believe drives the cost of hearing aids?

- R & D
- Small market size
- Miniaturization also causes hearing aids to be expensive
- Hearing aids are dependable, and highly technical and need to be made that way
- Economies of scale would drive down cost

To your knowledge what are manufactures doing to address the non hearing impaired market? Why are they not doing more?

- Different colour hearing aids for BTE style.

What are some personal hearing aid problems?

- Battery changing is not a problem
- Feedback has improved a lot
- Tubing comes un stuck
- Equipment failure
- Can't get them wet.

Other suggestions:

- Manufacturers may be reluctant to UD, because they want to distinguish their product from another.
- Look into the marketing of cochlear implants, which have been very successful

Interview with: Professor Adrian Davis
Title: Director of the MRC Hearing and Communication Group
Email adrian.davis@mrchear.man.ac.uk
Phone (Voice) +44 (0) 161 275 8570
Conducted: Tuesday, April 4, 2006 at 10:00am at Royal Children's Hospital
Interviewer: Tim Buck and Nick Verlinden
Notes: Jeremy Turner

In what listening environments do you believe non hearing impaired have difficulty hearing?

Well, it depends on what you're trying to do. You have to think about function, the ability to hear and discriminate between time, frequency and amplitude. It depends on what you want to hear. Last night there was a lot of external noise that I didn't want to hear. Most people seem to build around function rather than activities people are using. There are two groups setting standards and they are trying to figure out how to make hearing better, distinguish between hearing speech and noise. So, what would I want a device to do? I would want to be able to hear clearly what someone is saying to me when there is other noise in the area. If I'm in a pub, it could be helpful to have two-directional microphones, where you could zoom in on a conversation to better hear it. You need things for environmental scenarios as well as speech. Directional microphones are nice, but they aren't the end-all save-all situation. One problem with hearing aids now is that the noise floor is rather high and most current aids aren't good enough for people with good hearing because the SNR will be worse that normal hearing. Is this still true? It used to be, I don't know if it still is. Hearwear didn't seem to me to step to change perceptions.

Are there devices available on the market today that address these problems?

Not that I really know of. There was a company in CA that was developing a device that would "link" all your audio devices to an aid that would change output depending on each individual specific hearing. Ear defenders are being worn more often now to prevent hearing loss, but you can't hear warning signals so they weren't worn. This caused profound hearing loss in those on many missions. If you don't hear something that is critical that can be a huge problem. You can still go and see people not wearing hearing protectors. The same is true in bars where late at night you can be exposed to 100 dB noises.

We've learned that some manufactures are making a few devices that assist the non hearing impaired? But with virtually an untapped market, why are there so few manufacturers interested in developing hearing devices for non hearing impaired.

Maybe there isn't really a market. To get these things through you need venture capitalists to fund as they are quite expensive. If you can't find them, you can't do anything. You also need the order of magnitude to produce it. As you miniaturize things they begin to cost more. In the UK we only pay $200 AUS, but we order 250,000. 80% of the cost of aids in Australia is R&D and marketing. Prototyping can be quite expensive. When you talk to Elaine you

can hear about the R&D for their new algorithm. They had to change their marketing strategy to be able to continue. If you could find a mainstream application you could have a 5 million order rather than a 250,000 order. Even the new aids you get occlusion. Bob makes "complitips" which are trying to make things more mainstream. These devices make it so you don't need an earmold which would help make things more mainstream. With a normal ear mould when you yawn/eat/etc, the shape of the ear changes and causes discomfort. With the complitip the mould can change shape with this. The problem with these is that they need to be replaced every month. It is very much about thinking laterally.

We have found that people's hearing loss is very unique to each individual, but is there one band of frequencies that would be more easily treated by a standardized hearing aid?

I think that the official answer is no, but...look at my toys. You could take these ends and add them to regular devices, like headphones. Having something like that that you could just plug in would be a good thing. With something like Bluetooth headsets you have the receiver on the ear that you could change between lots of different devices. I also have this hearing screener which you don't need occluding earmuffs. Hearing aids all have the problem that the noise floor is 15-20 dB so even in quiet you hear a lot of noise. The problem isn't particularly in conversation, but in quiet. The theory goes that if you have a moderate/severe/profound deafness there are three things to take care of: intensity (hearing level threshold, uncomfortable loudness level), discrimination, temporal patterns. The problem with a hearing aid that does everything for you (like the ear) disempowers the individual. What they might be looking for is a generic device that they'd have control over.

Shifting gears, we'd also like to ask you some questions about hearing aids. How have hearing aid design changed over the years? What, if any, is the current trend in hearing aid design with regards to function and cosmetics.

My interpretation is that there are two separate entities. However, if you go to Copenhagen and look at the headquarters they have made a design statement, it's a spectacular building with emphasis on hearing. The Phonak building has emphasis on design but Seimens has had more emphasis on being functional because they are much more focused on engineering. I think they are tackled separately.

What features do you believe should be included in every hearing aid?

"GM Resound" is the Ferrari of hearing aids. Simple and easy to use. It should work. Reliability. High quality components that do not distort the sound. The first lesson that Moe Bergman said to me is "Remember, what a hearing aid does is distorts sound, its not like hearing naturally." You need something that distorts sound minimally.

Others to get in contact with:

Richard Dahl

Elaine Saunders, Dynamic Hearing
Robert Oliveria, ex-3M (cochlear), Hearing Components

Interview with: John Donnon
Title: Service Coordinator
Email johnd@senswide.com.au
Phone (Voice) 03 9015 5155
(TTY) 03 9614 3062
Received: March 17th
Interviewer: Tim Buck

Employees of SensWide were asked to provide any anecdotal evidence of when their clients may have been treated differently. Below is what Mr. Donnon provided.

> A 20 year old Deaf man explained that despite having two behind-the-ear, hearing aids, he only ever wore one. He said that when he wore two, he perceived that hearing people thought he had a mental impairment. He used the words "retarded" and "stupid". He had made a conscious decision to wear only one hearing aid despite the benefits of wearing two.
>
> Furthermore, he said that this was common behaviour amongst his Deaf and hard of hearing peer group. They all felt embarrassed wearing two hearing aids.

Email correspondence from: Neil Thomas
Title: Head of Product Development at Royal National Institute for the Deaf
Co-Curator for "Hearwear" exhibition and Victoria and Albert Museum.
Email neil.thomas@rnid.org.uk
Received: April 6, 2006
Interviewer: Tim Buck

How was the Hearwear exhibit received? What was the reaction from the general public? Did people view the devices as "far out and very futuristic" or something that they could see their neighbors wearing in a few short years?

Very positively! The project is more about campaigning for change, than suggesting actual designs for the future – this has been very well received by everyone. If you do ask people what they think about the designs, you get a very positive response. If you ask people if they would actually wear them (the more futuristic ones)… most say no! This is not a surprise, the industry will not change with design alone, rather a combination of great products, great branding, and a new approach to marketing and distribution, are all needed.

It has been reported that a hearing devices market for the non hearing impaired would take in millions. Why aren't every day consumers seeing more devices similar to the Hearwear exhibition? Are typical hearing aid manufacturers working to creating these devices? If not, why?

As far as we can see the hearing aid industry is quite focused, and inward looking. This needs to change if we are to see hearing products become mainstream products. As to "if not, why?" - I suggest you ask them!

However, having said this, we are seeing a rapid expansion the hearing products market. As well as MP3 players and Bluetooth attachments, we are now seeing the start of products that combine these functions. Sunglasses with MP3 players built in, wireless headphones that let you switch between your mobile phone and your music player, headphones with built in protection from loud environmental noise – all these are available now.

We have identified background noise, and distance between two communicating parties as difficult situations to communicate in for both hearing and hearing impaired people. From your work at RNID, and the Hearwear exhibit could you comment on other difficult listening situations for the hearing and hearing impaired?

Your two broad definitions cover most situations, but also consider: Multiple speakers (such as a conversation around a table) and situations when the speaker can't be seen (most people lip-read a little), such as when people are behind a screen, or the other end of an intercom or phone line. Also when the quality of speech is poor, such as over mobile phone etc.

We have found there is a stigma attached to hearing aids. People treat hearing aid users as if they were elderly, or not as intelligent. Do you agree with this?

> Yes, although I think it's less that people treat hearing aid users as elderly (this is changing) and more that people will 'think' that they will be viewed this way if they have a hearing aid – this is the problem

Why do you think this stigma persists, even though society accepts a broken arm or person in a wheel chair? Do you believe that new fashion savvy hearing aids, could help alleviate this stigma?

> Attitudes to hearing loss go hand in hand with attitudes to hearing – when we start to take more care of our hearing, awareness and consideration for hearing loss will change. It's more than fashionable hearing aids will achieve – hearing products for hearing assistance, and hearing protection, being promoted as day to day items, available on the high street, will be key.

If everybody walked around with some sort of hearing device in their ear, do believe that this would encourage those who needed a hearing aid to be more apt to go out in purchase one?

> Very possibly, but only if hearing 'aids' were included in this revolution, not left as the 'disability' products they are now.

Appendix E – Designer Interviews

Interview with: Kathy Demos
Title: Director – National Design Centre
Email kd@nationaldesigncentre.com
Phone (Voice) 03 9654 6335
Conducted: March 30, 2006 at 11:00am in Mini's Coffee Shop
Interviewer: Tim Buck, Nick Verlinden
Notes: Jeremy Turner

Can you describe your role at the Nation Design Centre? How long have you been in the design industry?

> I'm an interior designer and I combined that with projects that i initiated. I founded the NDC 15 years ago and is meant to be a help in all aspects of design be it assistance, representation, etc. Its a private and unusual enterprise but is the only of its kind in AU. Something that hasn't been done before and is in constant contact around the world for lots of help with design in all aspects

How do you identify a trend in fashion? How are new trends started? Once you've identified a fashion trend how do you integrate that into your design work?

> First this you need to appreciate is that they usually emerge because of cultural and social issues. So when you consider trends you need to be aware of the factors that influence trends. You need to use that information to get things to the marketplace when they are going to want it. The point of trends is actually knowing how people are going to react ti a whole range of factors. A trend is something that becomes an invisible manifestation of what is intrinsically picked up. Cultural and societal changes are huge. Knowing what the trend is is meaningless, knowing what they are going to be is what is important.

Have you observed fashion trends in technology? Could any of these trends be applied to hearing aids?

> They are seen and they could absolutely be applied to HA. Telephone have developed from being a tool into an extension of personality. Whether its the new Motorola phone responding to what people what around them. We are very keen to expressing our individuality, "This is me, look at it" Its an extension of yourself, Its so linked in with how you are its hard to distinguish between the person and the technology.

Can you think of HA applications.

> The problem with HA is that they have a negative connotation. Glasses were like this once, but they are now individualized. You can express yourself with your glasses now though. There are a lot of people how have glasses as a fashion statement. They have ceased to be a negative connotation. There was the old statement that "Boys don't make passes at girls with glasses" that doesn't exist anymore. HA haven't gotten to this point yet. People used to get to a

certain point in their age when you were elderly, that doesn't exist anymore. These distinctions have broken down. People are no more young and old, they are people. As you get older there are aspects of your physical being that change, at this point people start to wear glasses because they think they are getting old. Even if I might present to the world that I am young, I might think that I'm getting old. HA fall into this category. People associate it with being old, both the user and the observer. There hasn't been enough of a breakthrough to fix that.

When you are designing something that is going to be worn what are some of the factors you take into consideration?

Its like any form of design. It has to fulfill its function. Fashion is, in some degree, just covering the body. You have to take your reference. If you just fulfill the brief, its not enough. It doesn't fulfill the desire/personal component. You need to make something wanted to be worn. "I want to wear this"" It must be functional and designed. When designing something for someone to wear it needs to reflect the way the person lives and the way they feel about themselves. It could be a hood with speakers into it. Just something integrated into their everyday life.

What are some of the specific concerns you would take into account when designing something that is to be worn on the ear?

People put things on their ears because they want to be noticed. Its an embellishment. Weather you put 16 earrings in or 1 big earring, its just an embellishment. HA are not embellishments at this point. Things with negative distinctions are all that way. There was this thing like a glove that younger kids would wear. The physical manifestation was a fashion item. Its something that would set you apart from your peers, its cool. It never went into production, but things have gotten to something similar to that. This was 10 years ago, but its changed peoples thinking. It brought smiles to people faces. That is a big thing for younger kids.

When designing a product that is to be worn by young adults, working professionals, and the elderly what are the different considerations that you would take into account for each age bracket?

The first thing to understand is that clients are different. Things need to be marketed as such. You must integrate the technology in a way that will market it as such. In every other aspect you have you realize that there won't be one thing that will suit everyone. People now choose their own groups rather than just being associated with their families. You need to diversify, make sure that things are individualized. The way that people see things changes, stigma is removed over time with some work.

Last Question about sketches.

If you make a distinction between the technology and the creative its pointless. You can't distinguish between the two. They need to work together and make

sure they are integrated. Design has been considered as something that comes along after and makes thing appealing, but they must be done hand in hand. Everything works together and it must be created so that it can. You can't make distinctions in your mind. If people don't want to buy things, you've missed the point completely. When integrated from the beginning you can save cost and time by not having things not mesh, work together from the beginning. Don't discard the fact that some people may like hearing aids as they are now. Consumers must be categorized.

The aid must not only fix your hearing, it must do it well and make you want to use it for other reasons.

Once you identify a trend, how do you popularize it?

You have to plan and make plans and remember that when it gets to the marketplace people will buy it because they want it, not because someone says that it is popular. It only becomes popular because you've identified it and brought it to the market at the right time, not because it got there. It works because they want it, not because they are told that they want it. Consumers are more sophisticated that you think, they may have a brand preference, but they guy what they want, not what they are told they want. No one can tell you what you have to do, you do what you want. One thing about the fashion industry, they can respond quickly, unlike the auto industry. The things that remain on the market are the things that work. Many different trends come out, but not all of them work and they disappear quickly.

Anything else?

Sketches might be tough to get because of the IP issues. Look into getting names for you that might work. Art is not design. Design works to a brief, art works to their own ideals. Industrial Design schools may be better than art schools.

Focus Group with: Professor Kevin Lewis, Professor of Product Design at RMIT TAFE
and Design Students Jess Pautting, Brad Ratajczek, Krista Lindetter, and Sarah Cole.

Email kevin.lewis@rmit.edu.au
Phone (Voice) 03 9925 4027

Conducted: Friday, April 7, 2006 at RMIT School of Design
Interviewer: Tim Buck
Notes: Nick Verlinden

Could each of you give us a brief background, what year you are, and your interests, why design school? How long have you been in the design industry?

Kevin Lewis graduated in 1988 from the Royal Melbourne Institute of Technology, school of industrial design. He spent time working with communication technology, such as radio phones before cellular technology was popularized, a battery company, and designed small toys, such as those that are given out to attract business from kids (i.e. McDonald's Happy Meals). He switched to teaching because he wanted to do something that he believed made a positive difference and was more dignified.

Jess Pautting is a 3rd year design student at RMIT and will be studying at Monash University in the school of industrial design next year. Brad Ratajczek is a second year student from San Fransisco. Krista Lindetter is very interested in graphics and fashion and is likewise a second year student. Sarah Cole used to work as an artist but decided she wanted her work to perform a function instead of just be decorative and enrolled in the school of design and is now a second year student. All of the students have a strong passion for design and have an interest in combining function and style.

How do you identify a trend in fashion? How are new trends started? Once you've identified a fashion trend how do you integrate that into your design work?

Brad mentioned that when he is creating a design, often times he will just write down random ideas to search for inspiration and when a design is made, you can never predict the level of success it will achieve.

Jess talked about how he looks at culture to try and spot emerging trends before they become mainstream or watching people's attitudes towards new ideas.

Krista likes to look at trends in clothing; if people are wearing 80's style clothes, perhaps they will accept other products remind them of the same period.

Kevin mentioned batteries and how small they have become since he worked in communications. The current size of cell phones was something they could only dream of, and therefore as industrial designers they try not to limit themselves to what is currently available because as technology advances new designs must be available.

"If there's enough incentive to do it, you can design anything" – Brad

It was brought up that hearing aids should be made waterproof, and Jess had the idea that instead of making smaller and smaller hearing aids, continue using the current size and add battery power to extend life. This would probably cost less as well.

Have you observed fashion trends in technology? Could any of these trends be applied to hearing aids?

Mobile phones are a good example, some that play Mp3's and there is the finger-in-the-ear mobile phone idea. However, just because a design is unique and high tech doesn't mean people will want to buy it.

A feature that was suggested was using Bluetooth to connect the hearing aid to a computer hard drive so it record sound, such as in a lecture or meeting. The noise canceling option, such as what is available in Bose headphones, was mentioned as a ear protection device maybe for tank drivers or others exposed to excessive noise.

When you are designing something that is going to be worn what are some of the factors you take into consideration?

Comfort and balance are key considerations, ideally the hearing aid user will forget that they are wearing the device. Similar to glasses, originally it is a inconvenience but eventually the wearer gets used to it and forgets about it. Due to sweat and earwax sanitation must be considered also as well as potential damage to the device.

People would not want to feel self-conscious about wearing a hearing aid, there is a certain stigma attached to them. Some users might like to have it be hard to notice and blend with their hair colour, others might want a more modern looking silver. It's also a possibility that a user might want a flashy hearing aid for nightclubs, maybe even something that had a number of LED lights that flash with the music. Other ideas included hearing aids with cartoon characters for kids or make hearing aids look more like jewellery for adults following the piercing trend.

Depending on the feasibility of bone transmission, maybe even a device that doesn't have to be in the ear and can be fixed behind it might be appealing.

If you believe you've created a successful design trend, how do you popularize it?

Giving hearing aids away to celebrities who are deaf or who have partial hearing loss, like musicians perhaps, would really help. Also, distributing a few at trade fairs is in general a good idea for new products.

Many hospitals and clinics have support groups for people who have to deal with any kind of medical condition. Displaying hearing aids at groups for the hearing impaired would help get the consumers' attention.

In order to both reduce the stigma associated with hearing aids and to make them more desirable for the user, add an additional feature such as being able to listen

to music. This will make non-hearing impaired people at least slightly jealous of the person with the hearing aid, and they will no longer see it in a negative light.

Appendix F – Manufacturer Interviews

Interview with: Anthony Shilton and Christi Wise
Title: Chief Operations Officer and Audiologist
Email ashilton@dynamichearing.com.au
Phone (Voice) 03 8420 8525
Conducted: Wednesday, April 5, 2006 at 2:00pm at Dynamic Hearing Offices
Interviewer: Tim Buck
Notes: Jeremy Turner

Could you tell us a little bit about Dynamic Hearing. What does it do, specifically when was it founded?

There are 20 people working here. We sell software that runs on the open source DSP chips that are available. Two companies run this software, AMIS, formerly the DSP factory, and Gennum, a company that has been making analogue parts for a long time. We don't only work in hearing aids, we also work in headsets, low-power portable communication devices. We work completely with the acoustic side, not implants and things of that nature.

Could you tell us about your current products?

There is a company in German called Interton AHS that are distributing in both Europe and the US called the Bionic. This Bionic contains the ADRO, our product. What we started out as was a spin off of a research center, CRC Hear. A project there created a new amplification technique that is an alternative to compression, something that fixed the reduced dynamic range. ADRO is Adaptive Dynamic Range Optimization, check the website for more information. We also have a directional mic algorithm, feedback canceling algorithm. Bionic has been on the market for about 2.5 years. Gennum offers a bundled solution with their chip and our software together which is then marketed to larger companies. Reon, *Japan*, was recently launched a product with ADRO as well and there are some other licenses that are currently confidential.

What does your software do for Bluetooth?

ADRO improves the signal coming in. The signal coming in could be from any source and what ADRO does is correct and optimize frequency impairments that occur depending on the transmission. It can also monitor environmental noise and change the amplification depending on surroundings.

What are the limitations of your current projects? How are you planning on improving them?

The ultimate hearing aid would be one that you can't see and makes hearing perfect. If you ask someone with a hearing impairment what they ultimately wanted it would be perfect hearing, something acoustically transparent.

We've talked with some users and they say no matter how good the current hearing aids are they distort speech, would you agree with this? Why?

No. The reason it distorts speech is because its being compressed. If you don't compress you don't distort. People have different profiles though and everything needs to be customized. The best sound quality comes from a linear device but the problem is that when it becomes noisy it has a problem. They tried to fix this originally by putting a limiter on the devices, but that distorts sound. What ADRO does is adaptive linear.

iPods and other music players have equalization settings built into them that do very well at manipulating frequencies. Why can't hearing aids use the same technology?

There's a couple things going on there. One is that the level coming out of the player is predictable whereas a hearing aid is sitting on someones ear so the input could range from 0 to 140 dB. An iPod just runs a HiFi amplifier whereas a hearing aid has to do a much higher range of amplification. Hearing aids must be able to have 50-60 dB differences between different frequencies. Has are also trying to be low-power and small. Telephony is 4 kHz, HA is 6-8 kHz, iPod is 44.1 kHz. HA also have very small components, small mics that are also susceptible to thermal noise so they have to have smarts to reduce that as well. There are physical design limits in hearing aids because of the size. MAMS tech (micro and mechanical systems) is one thing that I would suggest look into.

What's next for hearing aid sound processing. First there was simple analogue amplification, now there is advanced DSP, what do you think will come next?

DSP, hopefully ADRO will be the next big thing. What DSP has done is made the hearing aid more like a computer. Previously everything was custom made and what can happen now is that you can get one mic and one speaker from different people and figure out the best was to get the best features. DSP is just like a computer so if it has an operating system on it you can run any type of program that the hardware can handle. Hearing Aids aren't developing as fast as computers because the market is smaller. New DSP platforms come out every 2 years or so.

How do economies of scale affect the end user price?

The latest Bluetooth headsets are getting as small as hearing aids and there are companies that can provide cross-over funding which is affecting things. Bluetooth headsets are also using DSP which is helping with the HA market. Because they are converging a little there is more money that is coming into DSP which can move over into Hearing Aids.

Could your products be placed into a device that would assist non hearing impaired in difficult listening situations?

We've had a whole range of companies coming to us. One thing is emergency phones in subways. Wall clocks transcribing court rooms. We have 4 people at AAA, American Academy of Audiology, talking about problems that may come up in the future. Hearing protection is a big thing.

What are the costs associated with developing a prototype?

The key costs in a Hearing Aid is the processor, the microphone and receiver, and the labor. It doesn't cost much to stamp plastics out, volume controls, battery terminals, etc. Almost all the big companies are doing their manufacturing in China. Knowles have a large consumer base so they can sell cheap, but they still sell at a premium. The cost of the processor is probably 10x that of the DSP. The big hearing aid companies have teams of 30 or 40 engineers working on algorithms to put into their aids and researchers working on what is next. Siemens don't but processors, they make their own so they are putting millions into developing new processors. The choice between buying of the shelf vs. building your own is all dependent on how many you are selling. It costs very little to get them off the shelf, but it costs much less to build them however, that start-up costs for building your own are large. Ultimately, they will get to the point where it doesn't make sense for them to build their own.

Difference between analogue and digital hearing aids being sold?

We don't even give the option. You can get a low end digital hearing aid for the same price as an analogue hearing aid. Its about 95% digital from the last report.

Anything else?

The CIC have a lot of problems. The ear is hot and damp and waxy and its hard to make them comfortable. They are also not very flexible. The delta is an interesting product that solves a lot of problems. Having the open ear makes it work a lot better. Australians are less vain than Americans.

The biggest thing that is going to change hearing aids is that they are becoming more like a computer so the companies can focus more on design. If it comes like a computer everyone can be writing software to create the best end-product. This way the hearing aid won't be a closed device, but something open. If the client can fit it themselves that would help also. Five years ago every hearing aid was the same and innovation has really started to take off. Gennum has a Bluetooth/HA compilation.

It's difficult to discern, as an Audiologist, what the user wants. " They say things like it sounds furry or it sounds sharp and crackly" What does that mean?

The bionic ear tests how the sound is perceived, not how the hear it.

"Lots of people would like to be more involved in the process. They don't want to be administered to."

Egger, custom moulds. www.egger-labor.com

Interview with: Patrice Lockwood and Craig Curtis
Title: Audiological Training Representative for Widex Australia
Email p.lockwood@widex.com.au ; c.curtis@widex.com.au
Phone (Voice) 1800 999 659
Conducted: April 13th, at 1:00 PM at Widex.
Interviewer: Tim Buck
Notes: Nick Verlinden

** Note, this interview was originally scheduled with Ms. Lockwood. During the course of the interview Mr. Curtis was also able to join, and answered some hearing aid sales questions, and also provided us with some feedback on the sketches.*

Could you tell us about your background briefly, please?

Patrice has been with Widex for approximately 4 years working predominantly as a training representative showing other representatives the features of Widex hearing aids. Before coming to Widex she worked for 9 years as a audiological clinician.

Could you tell us about some of your most current hearing aids on the market?

Inteo is Widex's most recent hearing aid.
It has an open fitting, with a integrated core processor. Instead of many different programs processing the sound separately, with each filter or processing technique not communicating with the other, Inteo works to have all processes working together. This creates less audio artifacts. It also has the ability to transpose frequencies.

Does Widex produce any devices that could assist the non hearing impaired in difficult listening situations? If not, is Widex exploring uses for devices for the non hearing impaired?

No, Widex does provide devices such as FM systems, but they are not manufactured by Widex.

What challenges does Widex face in manufacturing a hearing aid shell that could be waterproof.

In order to prevent water from getting into the hearing aid you have to seal the hearing aid. Sealing the hearing aid prevents sound from getting into the hearing aid. There are "Hearing aid condoms" that cover the hearing aid except for the microphone for BTE style hearing aids. These add protection for clients who are very active in sports.

Do you know if other companies are conducting such research? Why or why not?

Investigate the Dolphin, made by a US company.

If you can answer, what specifically drives the cost of hearing aids up?

Both stressed that the Research and Development were what drives the cost.

How do economies of scale affect the end user price? What is the break point of production?

Widex Denmark would be the organization to ask.

Could you please describe your design process, with respect to how product designers and engineers work together? Do they work together?

Yes they do work together, one of the strengths Widex has is that it's a family owned company which makes the Designers and Engineers work together better.

What are some design guidelines that Widex follows with respect to the appearance of the hearing aid?

No Official ones, receiver and microphone must be distant to reduce feedback. Hearing aids should be as un-occlusive as possible. 30% of hearing aid users choose not to wear them because they dislike the occlusion effects so much. FM systems are looking more like Ipods, seldomly are hearing aids built to stick far out of the ear.

Follow up: Why are the FM systems built like Ipods, and hearing aids rarely sticking up

Hearing Loss is still a very "invisible disorder." People don't like to advertising that they have a hearing loss. Hearing aid glasses use to be sold, during the JFK era when big framed glasses were in style a hearing aid was integrated into the frames. But this causes problems, because to change the battery it is necessary to take off your glasses. For older users who have vision impairments as well this can be a problem.

Does Widex produce any hearing aids that are cosmetically designed for kids?

Widex reaches to the younger market by providing colored hearing aids, and a kit "dexy" the Widex wale, that teaches younger kids how to care for their hearing aid.

Do you currently produce any shells that have applications for hearing devices for the no hearing impaired?

Mobile Phones, Bluetooth makes it so many applications can now be wireless. Jewellery, musician plugs are all possibilities. Creating a device that could dampen loud sounds by let in soft sounds would be a good idea.

We have heard that hearing aids are traditionally seen as "The beige banana behind the ear." What is Widex doing to change the appearance of a hearing aid?

The Elan is focused at the babyboomers generation of hearing aid users. It's purposely marketed towards more active clients. Improved feedback management is allowing more open fittings. The technology is finally catching up, giving hearing aid companies more flexibility in hearing aid functions.

Approximately how many hearing aids are sold world wide? We've heard about 6 million, do you agree with this?

Mr. Collins agreed saying that figure sounded correct, He said that about of 1/3 of hearing aids are sold in the US, and another third in Germany.

We asked for feedback on RMIT drawings. Below is a summary of comments.

Overall Patrice and Curtis were very impressed with the drawings. They commented that the drawings were very cool, and that they could have applications for a future hearing aid market such as the up and coming baby boomers market, but not to the generation of clients they currently service.

- Many of the designs drawn could work with the advances in feedback cancellation.
- Placing a microphone close to the mouth would be bad, because one's own voice would sound louder.
- Widex spends about 100 million developing a hearing aid, but the design and shape of the shell hasn't changed much.
- The Kinetic charging hearing aid was well received.
- The Piercing hearing aids would lose directionality of the sound.
- In Japan people were purchasing mock hearing aids as a fashion statement
- Commenting on the USB hearing aid, good idea sort of like the program selection by remote that is provided. People do like to have a personalized touch to their hearing aid, but you also have to cater to clients who want no work involved at all, and "just want to stick it in my ear and be done with it"
- Some of the designs seemed to cover the ear, and the current market trend is open fit.

Ms. Lockwood suggested that for hearing impaired, microphones on the rims of the glasses would help with directionality.

Mr. Curtis suggested that a hearing aid that could translate (similar to "babble fish") would be a HUGE seller.

Both agreed with the "glasses model" that clients need personalization, and that devices such as these could help reduce the stigma. Mr. Curtis commented, "As time progresses it becomes more acceptable" People are now shifting back to BTE hearing aids because of the new open fit hearing aids, which hide well behind the ear, and blend into hair.

Email correspondence from: Michael Gordon
Title: National Audiological and Sales Manager
Chief Audiologist for Oticon Australia Wholesale Team
Email MGO@oticon.com.au
Phone (Voice) 02 9857 8201
Received : April 11th, 2006
Interviewer: Tim Buck

What is your position at Oticon, and how long have you been there?

I am the National Audiological and Sales Manager, and chief audiologist for Oticon Australia Wholesale Team. I have been with the company since 2000.

The Delta is a very interesting new product, and we've actually had a chance to hold one at a clinic in Melbourne. Where did its design come from? What prompted this very new style of a hearing device?

Delta adheres to all the rules of form and function. That is to say the form follows the function seamlessly. The function of delta is to remove the stigma of the "big beige banana" hearing aid commonly perceived by many people, while providing the best sound quality and speech intelligibility in noise for people suffering from a high frequency hearing loss.

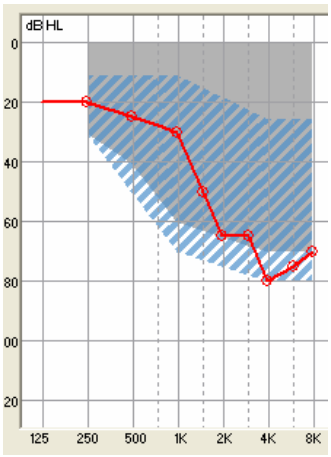
As the name indicates, Delta is based on a triangular shape. Aesthetically this sits very cosmetically behind the ear, but more importantly it ensures the directional microphones are on a horizontal plane. The horizontal plane provides the best front-back ratio for directional microphones.

Placing the receiver in the ear not only provides a smooth and broad high frequency response, it also makes Delta one of the easiest hearing aids to fit and maintain by the user.

What is the Delta's largest hurdle in terms of getting in the ears of eligible consumers? In other words, what is keeping Oticon from selling a Delta to every user with a mild hearing loss?

The biggest hurdle is public awareness - that their hearing loss can be helped.

The Delta is only able to assist those with a mild, high frequency loss. Can its application be spread to those with more severe hearing losses? Why?



Firstly I must correct you on the Delta fitting range. Delta can be prescribed down to severe (80dB) high frequency hearing losses above 1.5 kHz. Please refer to the fitting chart. However Delta is designed for people with normal LF hearing, as is the case for most noise induced hearing losses and many presbyacusis hearing losses.

The Low Hertz are not amplified for two main reasons:
1. In quiet situations people can rely on the LF redundancy in speech to hear as well as normal hearing. This is why people with HF losses often say they only have difficulty hearing in noise. Furthermore these people are often the people who are told nothing can be done for their hearing loss.
2. Sound quality issue- mixing HF amplified sound with direct sound (vent transmitted sound), provides natural sound quality.

Winning the Red Dot award must have been very exciting for Oticon. Has this recent praise effected the way future Oticon hearing devices will be designed?

Very good question! Yes Oticon feels very proud that Delta has been recognized by the Design Community. Breaking down the stigma associated with hearing aids is very important as it will encourage more people to address their hearing loss and not putting up with what is a very isolating disability. Oticon will continue to focus on the form and function of its products.

The Delta is very fashion forward, but why design it to be discrete? Why not let others see it and admire it?

Part of Delta's appeal is that the user has a little something that helps them that no one is aware of. We all tend to have some thing that we keep secret that makes us feel unique. For example some people may have a tattoo no one knows about. These little things remain hidden but are part of our identity.

In the last few pages of the pdf on the Delta you provided me with, there is a very interesting marketing slogan, "To wear a delta means keeping your edge." This is very different from most hearing aid marketing techniques. Most products market to "Improving your hearing," "Letting you hear your grandchildren." Is there a particular reason for this much more modern slogan?

Another very good question! People with hearing loss don't want other people to know they have a hearing loss. Hearing loss is associated with age and being old. However in reality every second person over 50 has a hearing loss to some degree. If you ask some one who is 52yrs old how they feel they will tell you they feel young. As such Delta is about keeping them young. People are healthy for longer and we should no longer assume their lifestyle only revolves around their grandchildren. They live active, social lifestyles thus Delta aims to ensure they continue to do so, and this is the message conveyed in the product slogan.

What has been the consumer response to the Delta? Is it Selling well? Do users like it?

The consumer response has been excellent. Australia and New Zealand were among the first markets to launch Delta. Since its launch (12 days ago) the consumer awareness has been incredible. We are now receiving feedback from Audiologists fitting Delta and their reports are extremely positive

Is Oticon working towards more devices for the non hearing impaired, or those with very minimal losses? Does Oticon see any future in developing hearing devices with new technology synergies (*i.e.* The Delta with a Bluetooth link to your phone).

As with many industries we too are experiencing convergences in technologies. These convergences are aimed to make it easier for people to use hearing aids. This will continue over the foreseeable future with all players introducing new convergent technologies.

Does Oticon see any value in hearing devices for the non hearing impaired? How do they plan on penetrating this market?

There will be more development into products for people who don't see themselves as hearing impaired but are looking for something that provides help in certain areas (e.g. at a board meeting, socializing, going to the opera…etc). We are at a very exciting stage in Audiology.

Up until about a few years ago it was often reported our "Audiological Knowledge" exceeded the technology available. However, with recent changes to digital technology that now sees artificial intelligence using parallel processing streams inside hearing aids, we are now in a world where our technology far exceeds our Audiological Knowledge. What does this mean? – Well it means we can be more creative in how we approach solutions to hearing loss and we have better tools in helping us understand and treat hearing loss.

Appendix G - Oticon's Delta

Oticon • Delta

We all have a little something that gives us an edge

Delta
1:1

www.my-delta.com

oticon
PEOPLE FIRST

As individual as you are

Keep your edge with Delta

Typically, you don't see yourself as a person with a hearing loss – you just have difficulty with understanding what people say in noisy situations. But you have most likely been in situations where missing out on important conversation made a big impact on your ability to stay connected with the world around you.

Conscious of both body and mind, you've probably been setting the pace and adopting new things ever since you can remember – things that spice up

your life, boost your well being or enhance your career.
But, there's one thing you won't have encountered yet – a device that will enhance your hearing and ability to stay connected with your world:

Introducing Delta – a brand new hearing device specifically designed for people who plan to continue to lead an active life.

Delta
1:1

Delta
Chocolate Brown

Delta
Diamond Black

Delta
Champagne Beige

Delta
Cabernet Red

Be who you want to be

Enjoy your freedom with Delta

Never before has a hearing device looked so good and had so much power to improve your world of understanding. With Delta, the most advanced technology available today is seamlessly orchestrated by Artificial Intelligence, leaving you totally free to enjoy your new world of speech understanding.

Delta's "high-tech", triangular design and virtually invisible sound wire make the whole device as discreet as you want it to be.

Delta is all about helping you get on with your active life without noticing you are wearing it – except when you miss being without it, in the situations that matter the most! Simply put it on, turn it on and enjoy.

Delta's unique, triangular shape is designed to fit perfectly and totally discreetly behind the ear.

Simplicity, sophistication and style

Delta
Green Chameleon

21st century design

Dramatically different from any previous design concept, Delta propels hearing care into the 21st century and sets a new standard for aesthetics. Delta's beautiful form and broad range of finishes inspire so much confidence that it may well inspire others to follow your lead! Pleasing to the eye and smooth to the touch, Delta is the epitome of simplicity - so cleverly conceived that it seems rather a shame to have to wear it behind your ear! Revolutionary concepts deserve to be shown off - at least once in a while...

Discreet - when you want it to be

Specifically designed to hide comfortably behind your ear, Delta blends in beautifully with your skin and hair, but demands attention and admiration when in the palm of your hand.

You can explore the technologies and the benefits of Delta's design in more detail on Oticon's website: www.my-delta.com.

Make it uniquely yours

Express yourself with Delta

Owning a Delta lets you make as much of a statement about yourself as the clothes that you wear, the hobbies that you have or the kind of work that you do. Just like a tailor made suit, your favorite tennis racket, or any other thing that says "this is uniquely me", no other hearing device looks like Delta or performs for you like Delta.

Delta offers maximum flexibility – even in colors. The range of finishes spans everything from hair, skin tone and metallic colors to smart and sporty patterns.

With Delta, you look good. But you also feel great all day long – not just on the outside, but inside, where it really counts.

Delta
Deep Purple

Delta
Cabernet Red

Delta
Racing Green

Delta
Wildlife

Delta
Check

Delta
High-tech Silver

Delta
Charcoal Grey

Delta
Diamond Black

Delta
Chocolate Brown

Delta
Champagne Beige

Delta
Mother of Pearl

Delta
Green Chameleon

Delta
Shy Violet

Delta
Samoa Blue

Delta
Midnight Blue

Delta
Sunset Orange

Delta
Wall Street

Give yourself every advantage












Take pride in wearing Delta

Taking good care of your hearing is one of the most important things you can do to keep on feeling good about yourself. Delta is the latest in a long line of tried-and-tested hearing solutions designed to support not only the way you hear, but also the way you live.

Keep your edge with Delta

- Improve your interpersonal relationships
- Take part in the conversation - also in noisy situations
- Feel more energetic
- Enhance your emotional stability
- Maintain your desired social activity level
- Perform better in your career

To wear a Delta means keeping your edge. If you have any questions, just ask your hearing care professional; like us, they can't wait to show you what Delta can do for you.

Welcome to the world of Delta.

People first

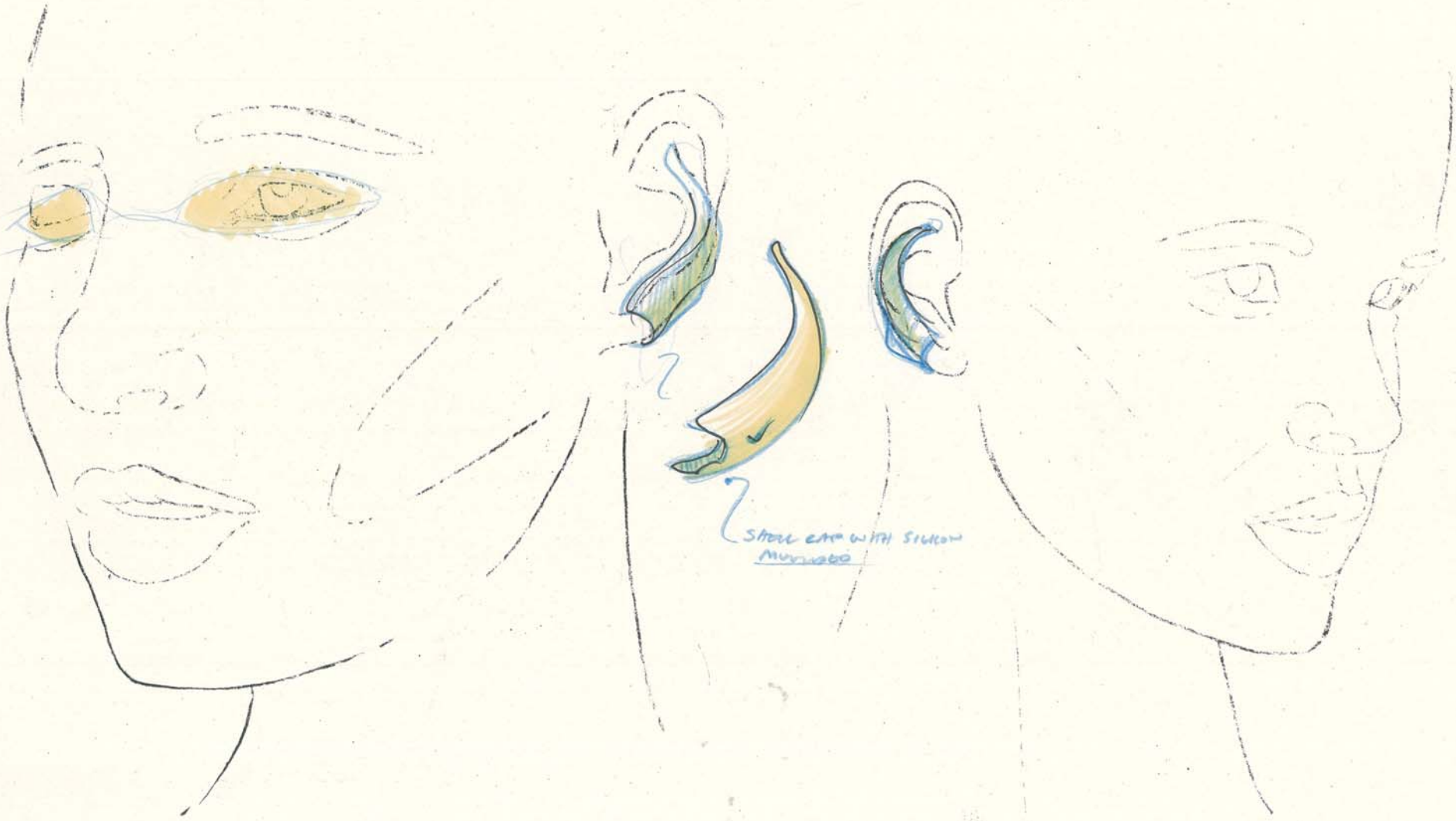
We believe that it takes more than technology and audiology to create the best hearing instruments. That's why we put the individual needs and wishes of people with hearing loss first in our development of new hearing care solutions.

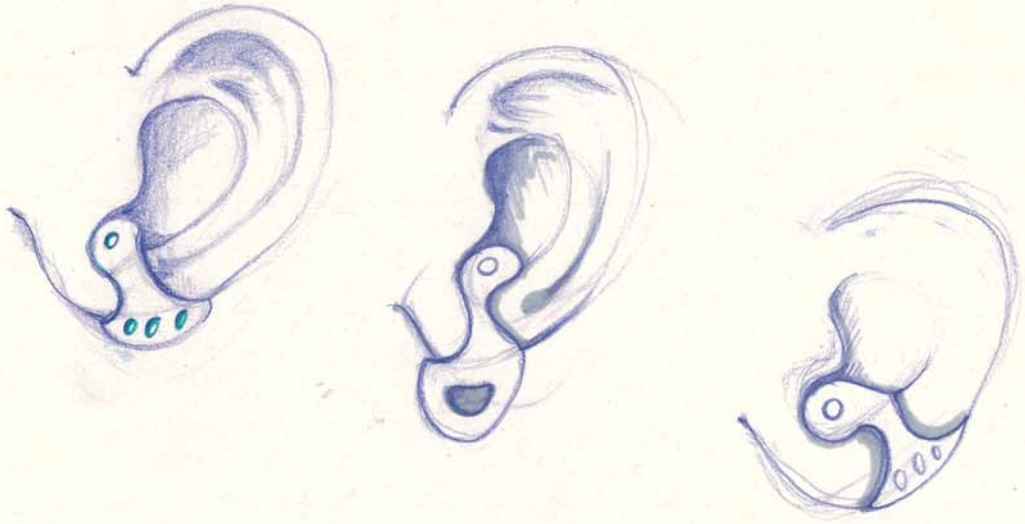
www.my-delta.com

oticon
PEOPLE FIRST

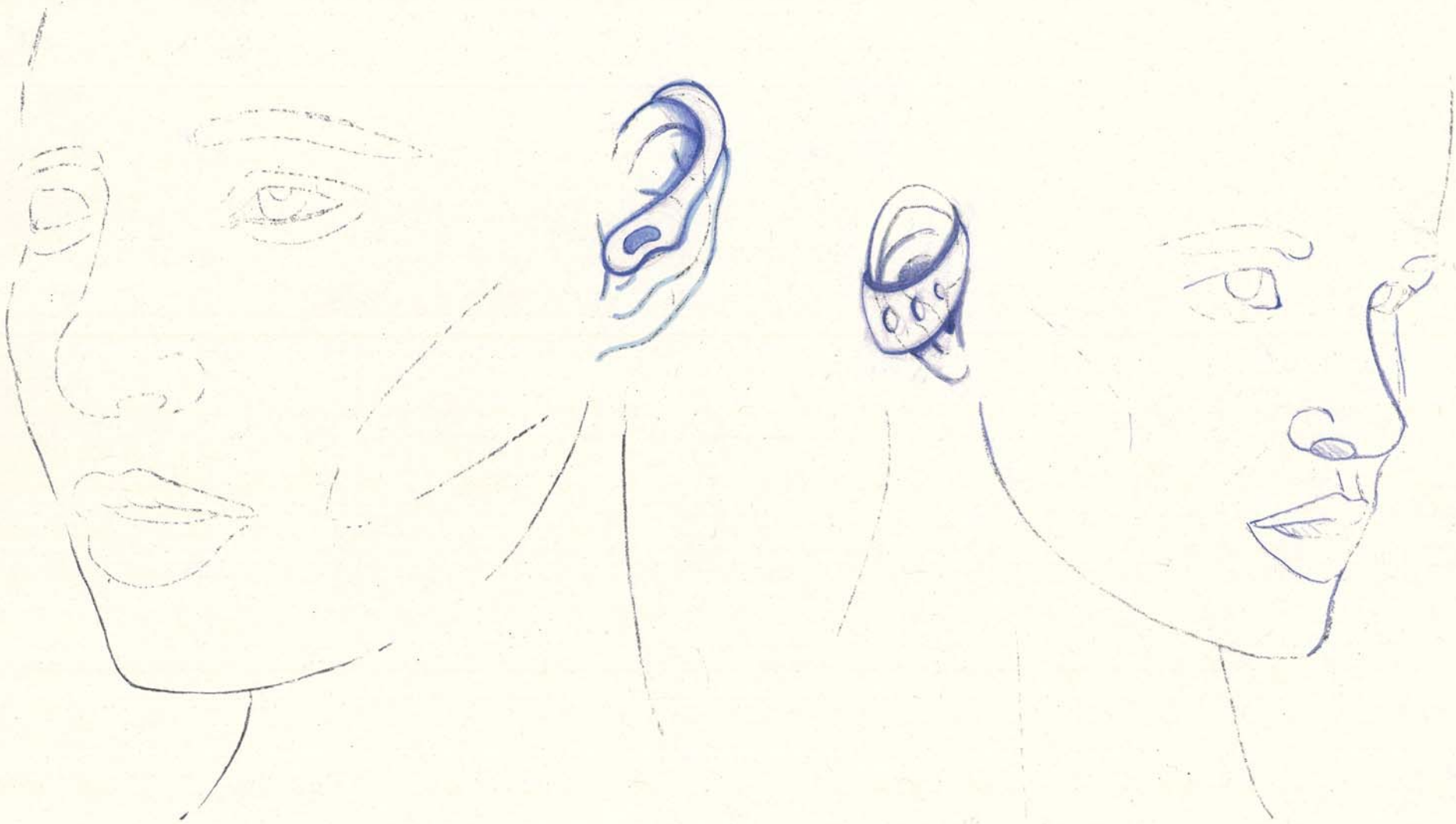
906 51 511 00 / 02.06 Printed in Denmark

Appendix H - Hearing Aid Sketches

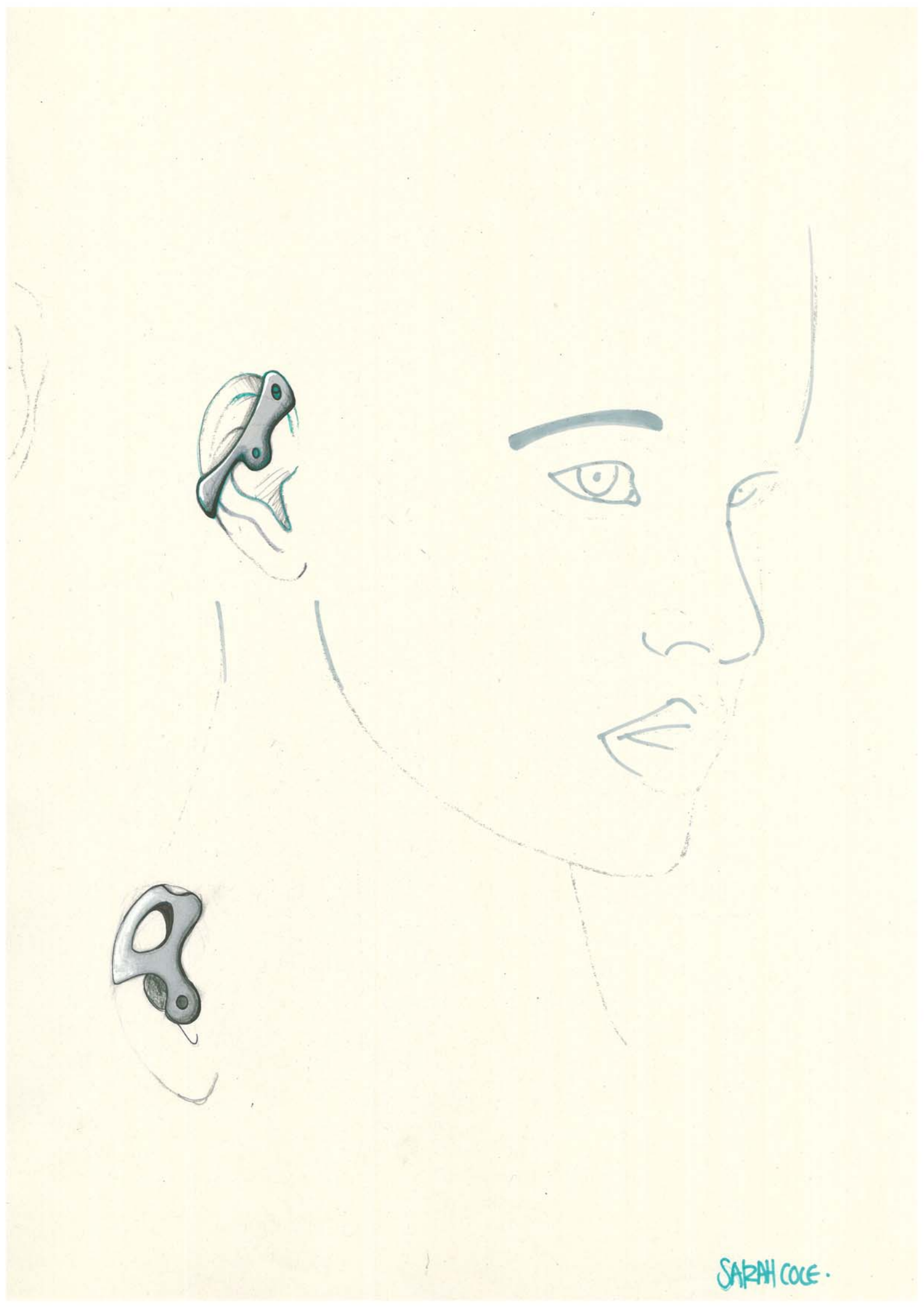

STEEL EAR WITH SILICON
MUSCLES

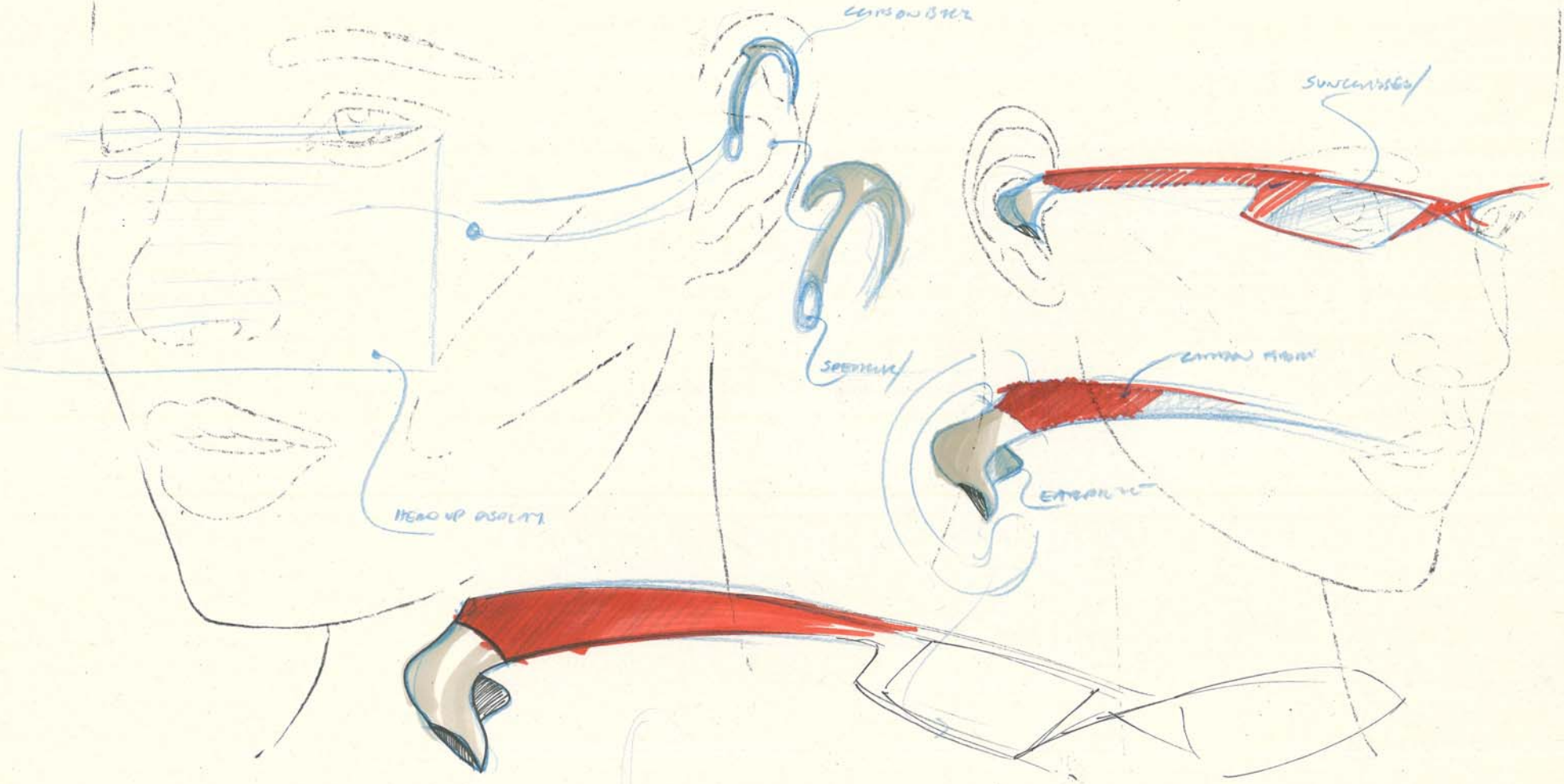


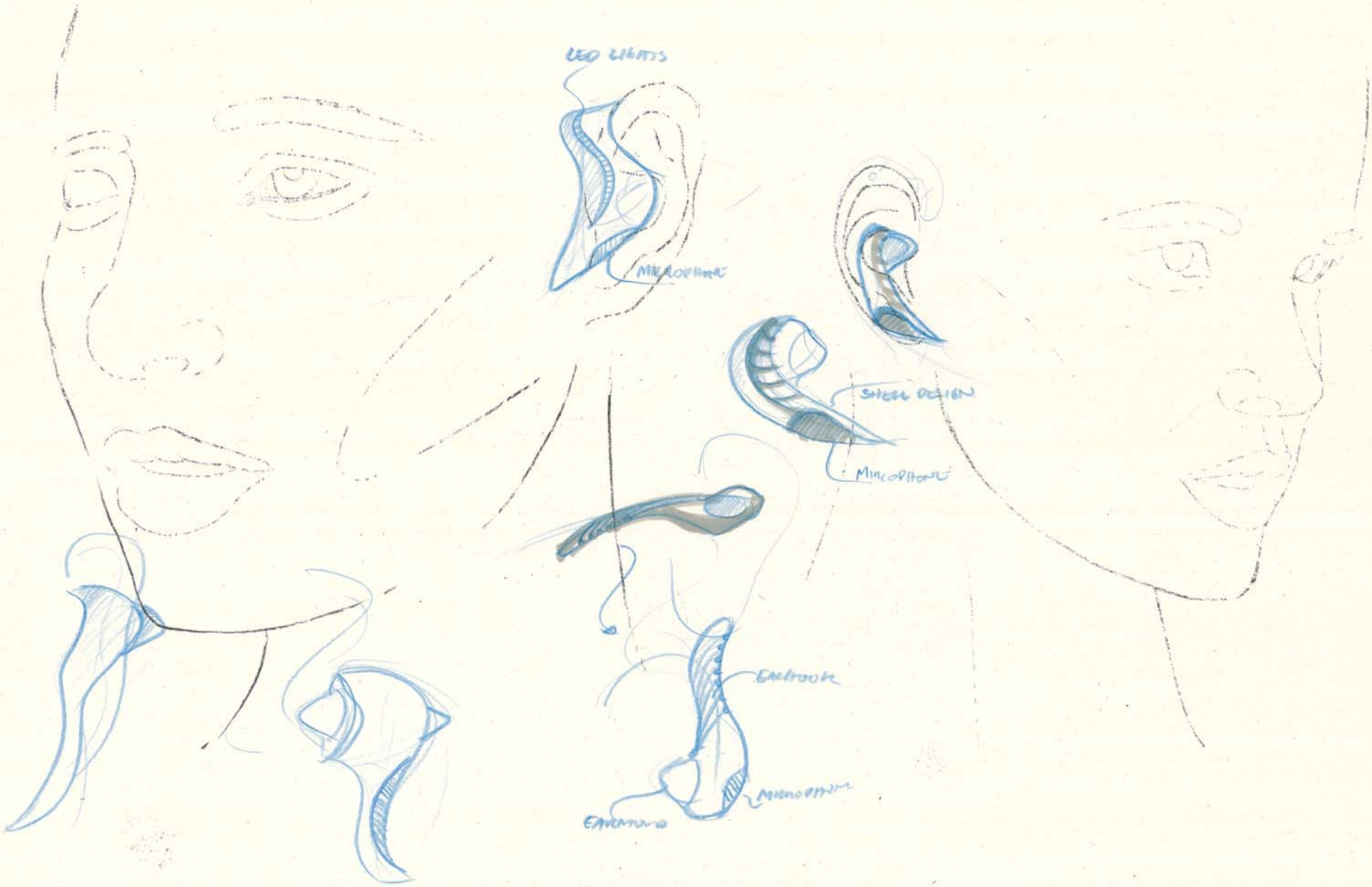
SARAH COLE ·

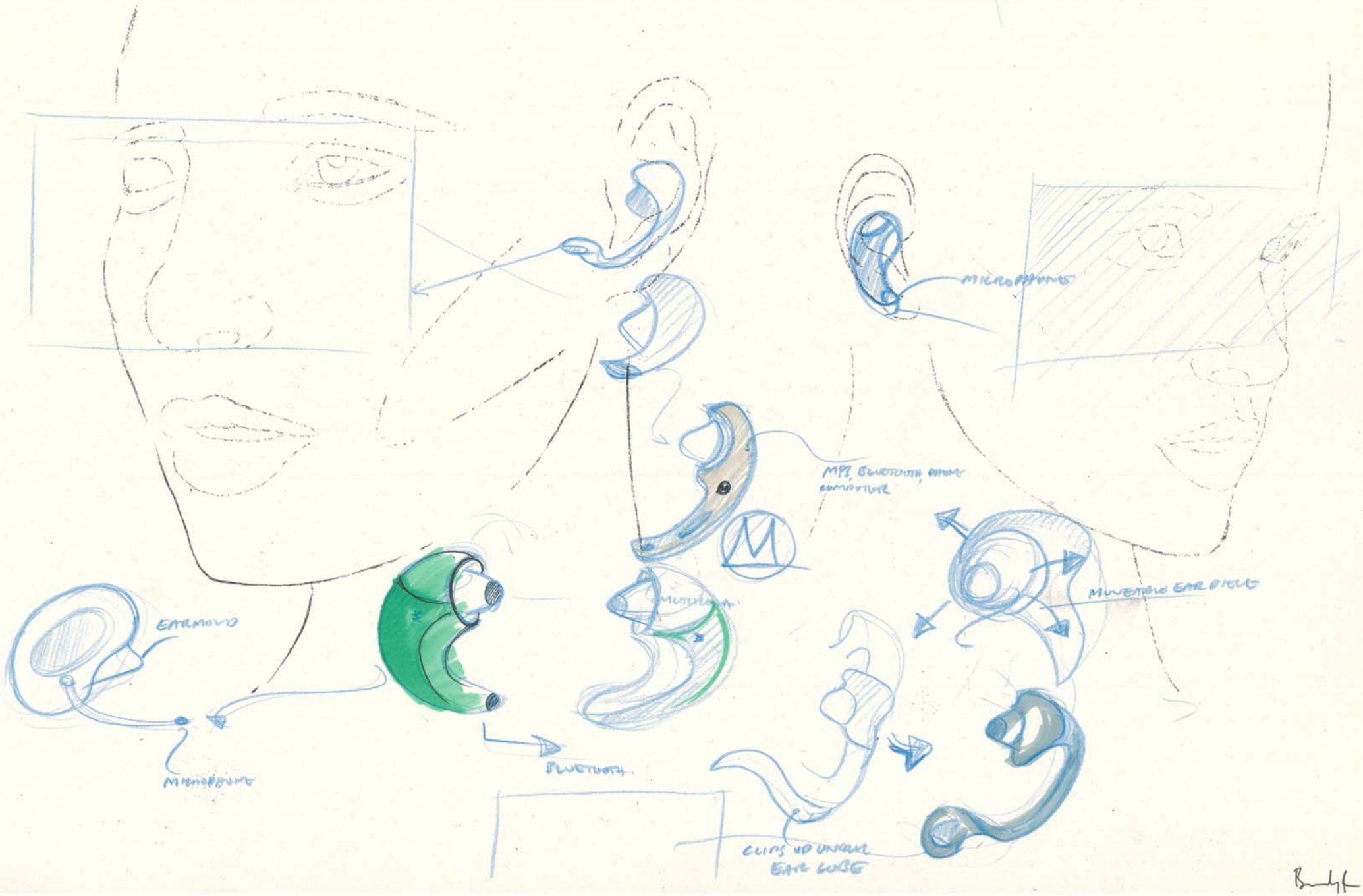


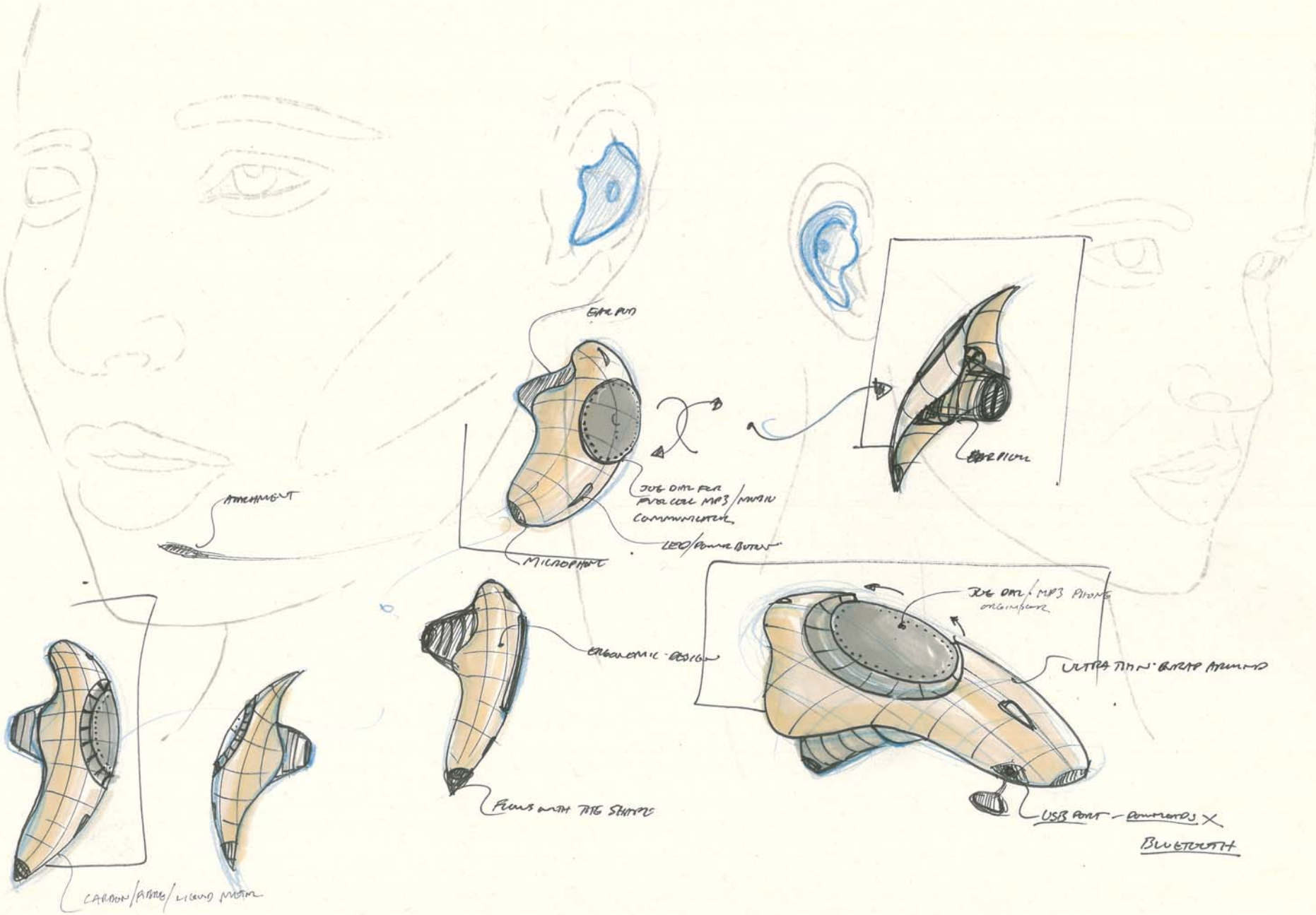
SARAH COLE.

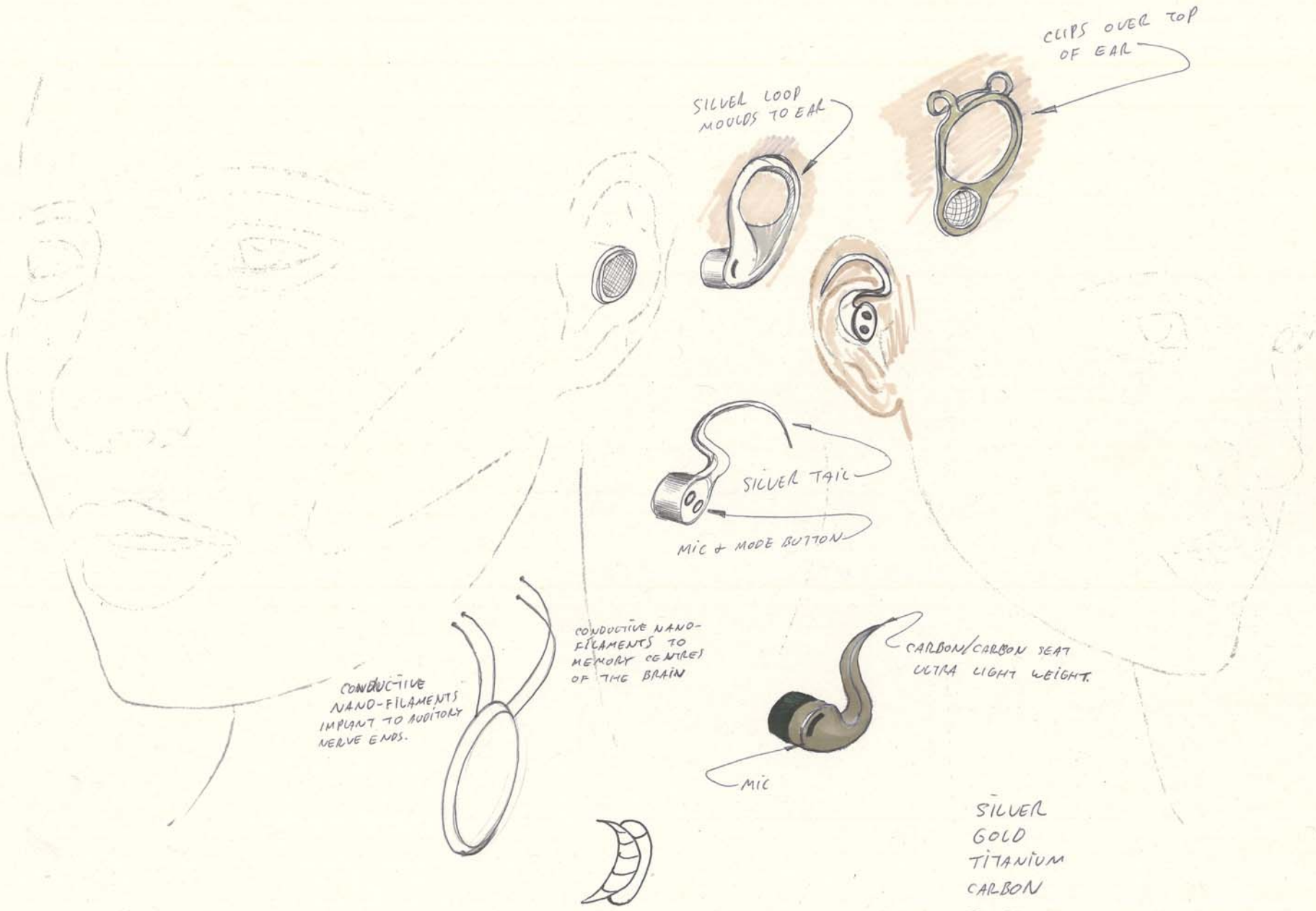

SARAH COLE.

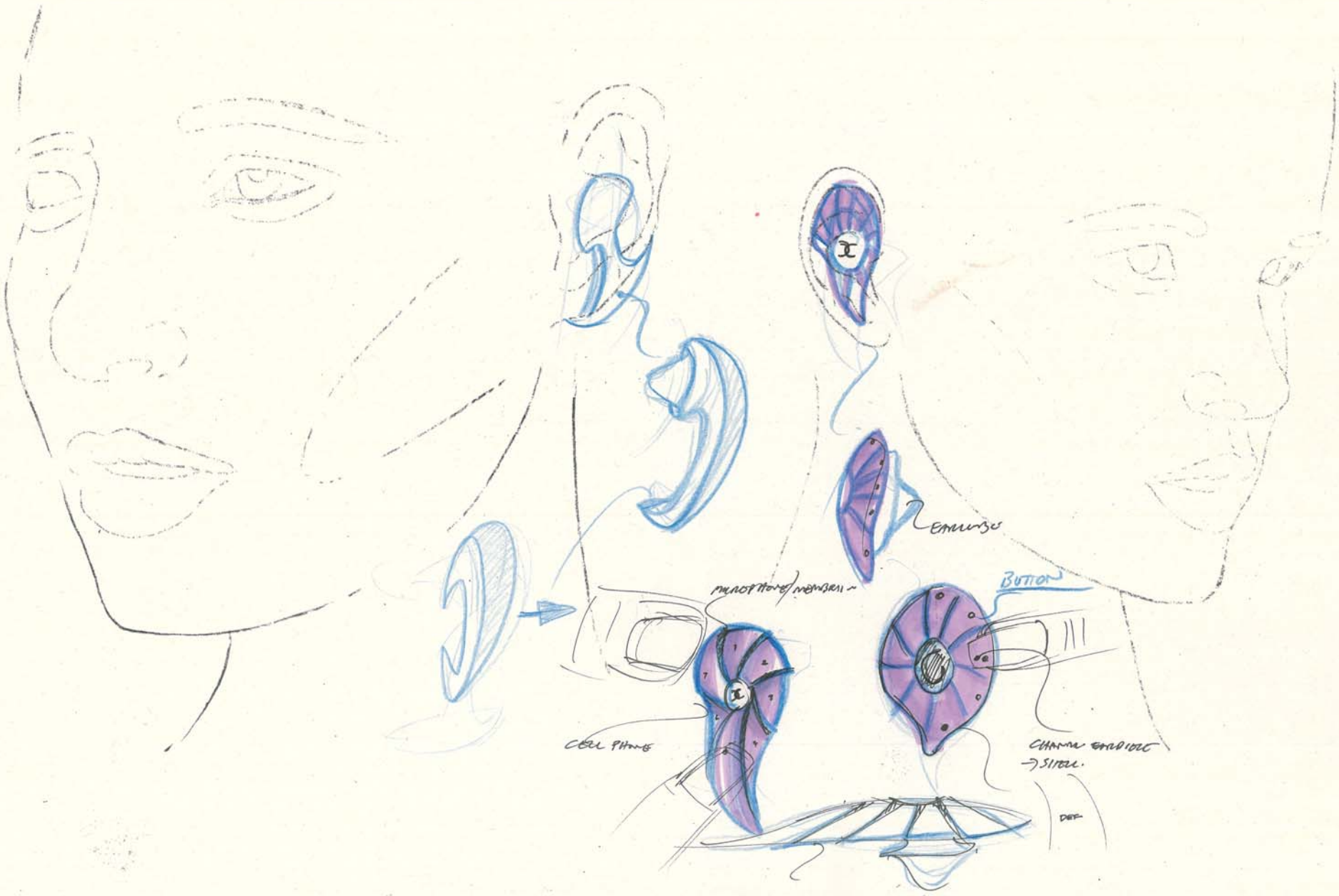

SUNGLASSES/
HEAD UP DISPLAY

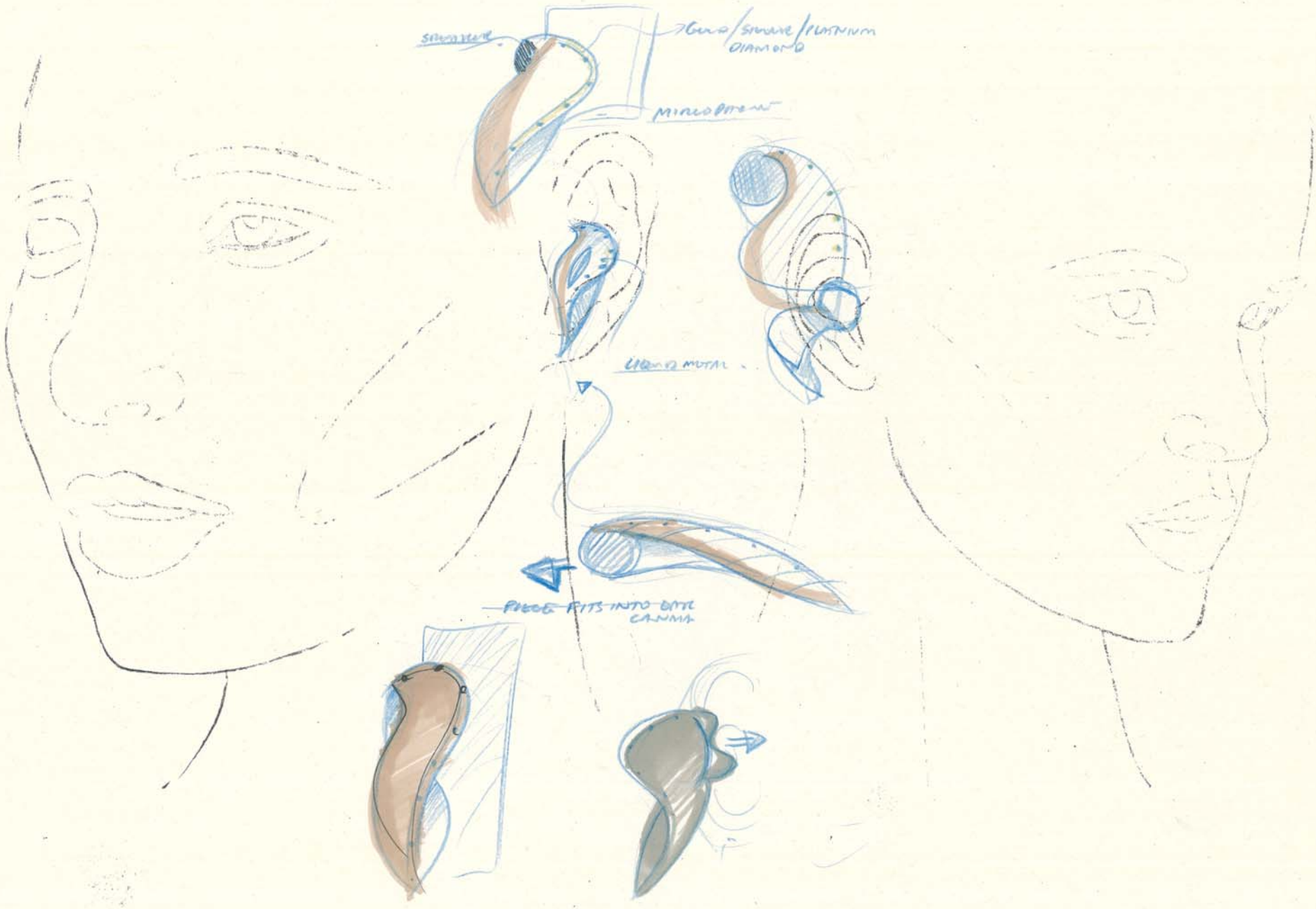

LED LIGHTS
MICROPHONE
SHELL DESIGN
MICROPHONE
EARHOOK
MICROPHONE
EARPHONE

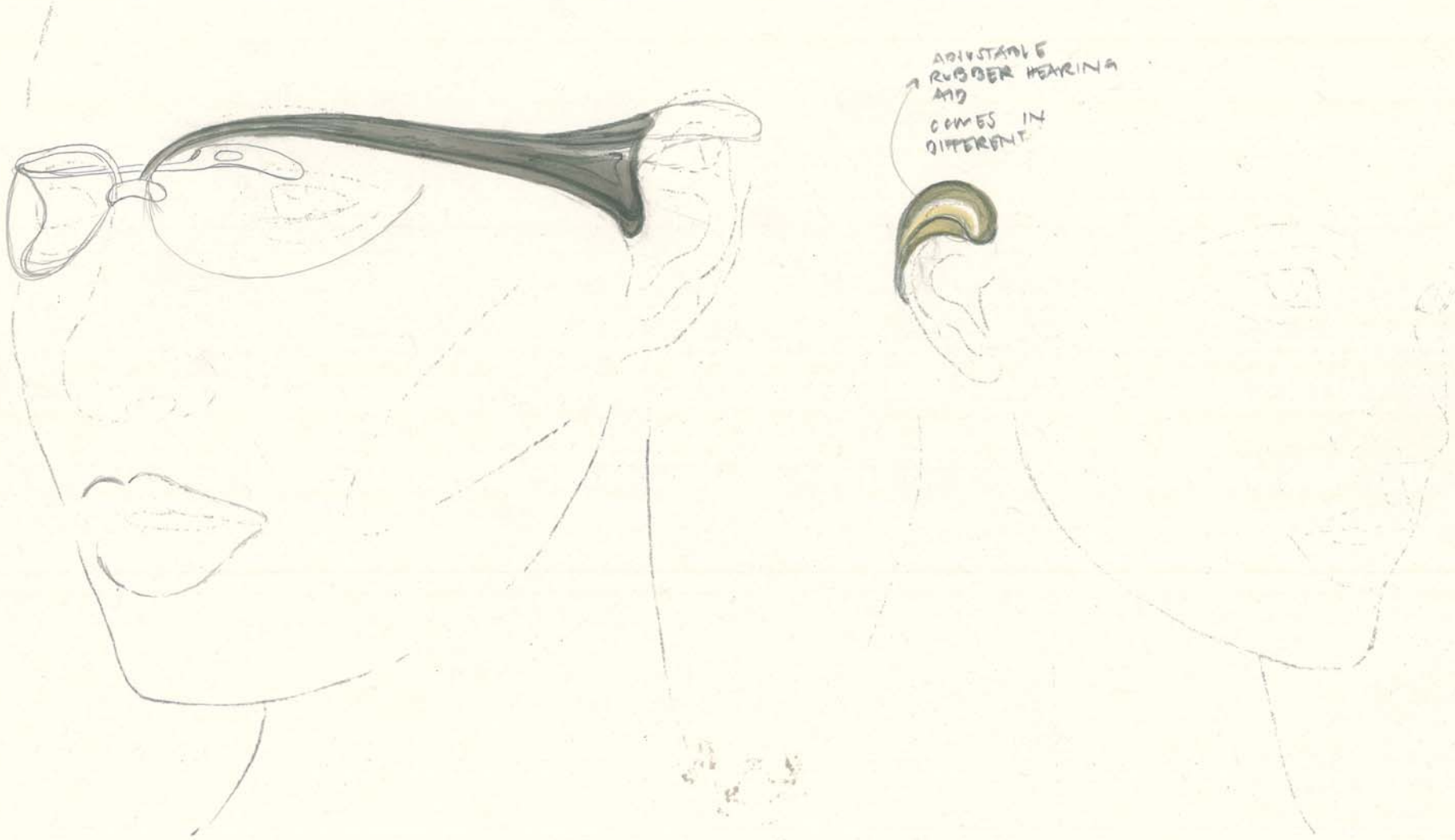

MICROPHONE
MP3, BLUETOOTH, BATTERY
EARMOULD
MICROPHONE
BLUETOOTH
MOVEABLE EAR PIECE
CLIPS UP UNDER EAR LOBE


EAR PIN
ATTACHMENT
MICROPHONE
LED/POWER BUTTON
ERGONOMIC DESIGN
FLEXES WITH TATE STRUCTURE
CARBON/FIBRE/LIQUID METAL
USB PORT - CONNECTS X
BLUETOOTH


CLIPS OVER TOP OF EAR
SILVER LOOP MOULDS TO EAR
SILVER TAIL
MIC & MODE BUTTON
CONDUCTIVE NANO-FILAMENTS TO MEMORY CENTRES OF THE BRAIN
CONDUCTIVE NANO-FILAMENTS IMPLANT TO AUDITORY NERVE ENDS.
CARBON/CARBON SEAT ULTRA LIGHT WEIGHT.
MIC
SILVER
GOLD
TITANIUM
CARBON
CLEAR GEL – GLOSS.

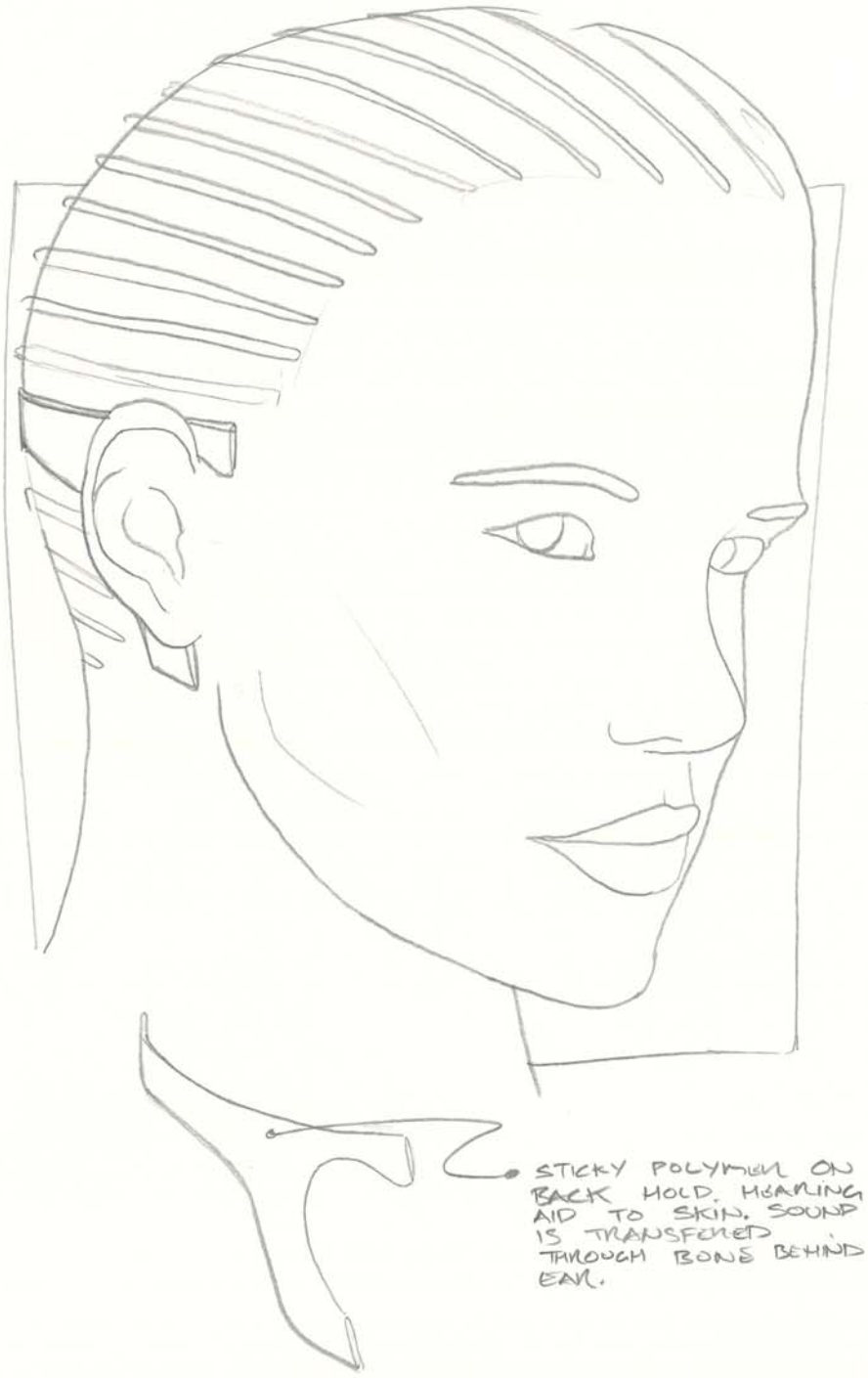

BUTTON
CELL PHONE
DEF

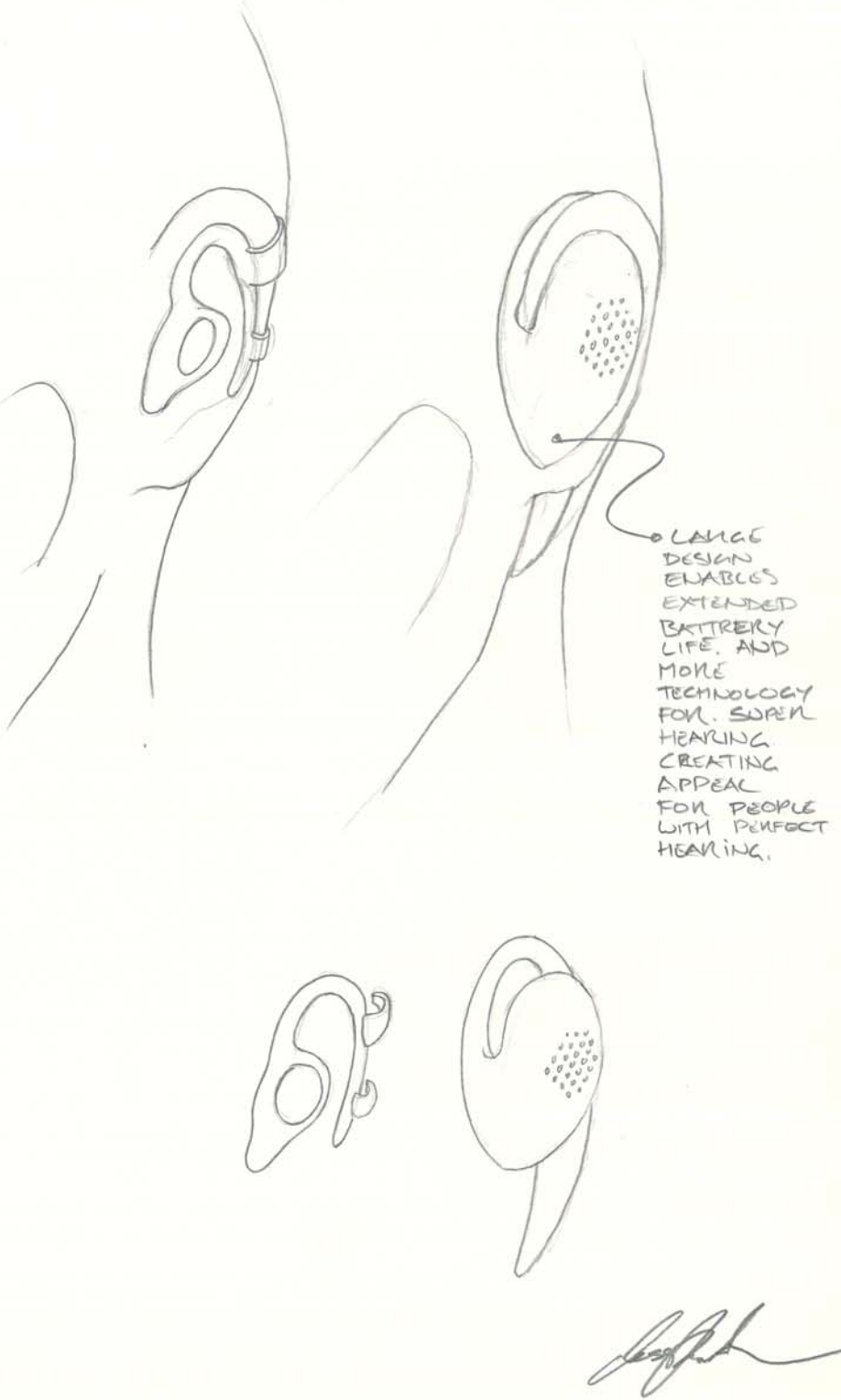

PIECE FITS INTO BITE CANNA

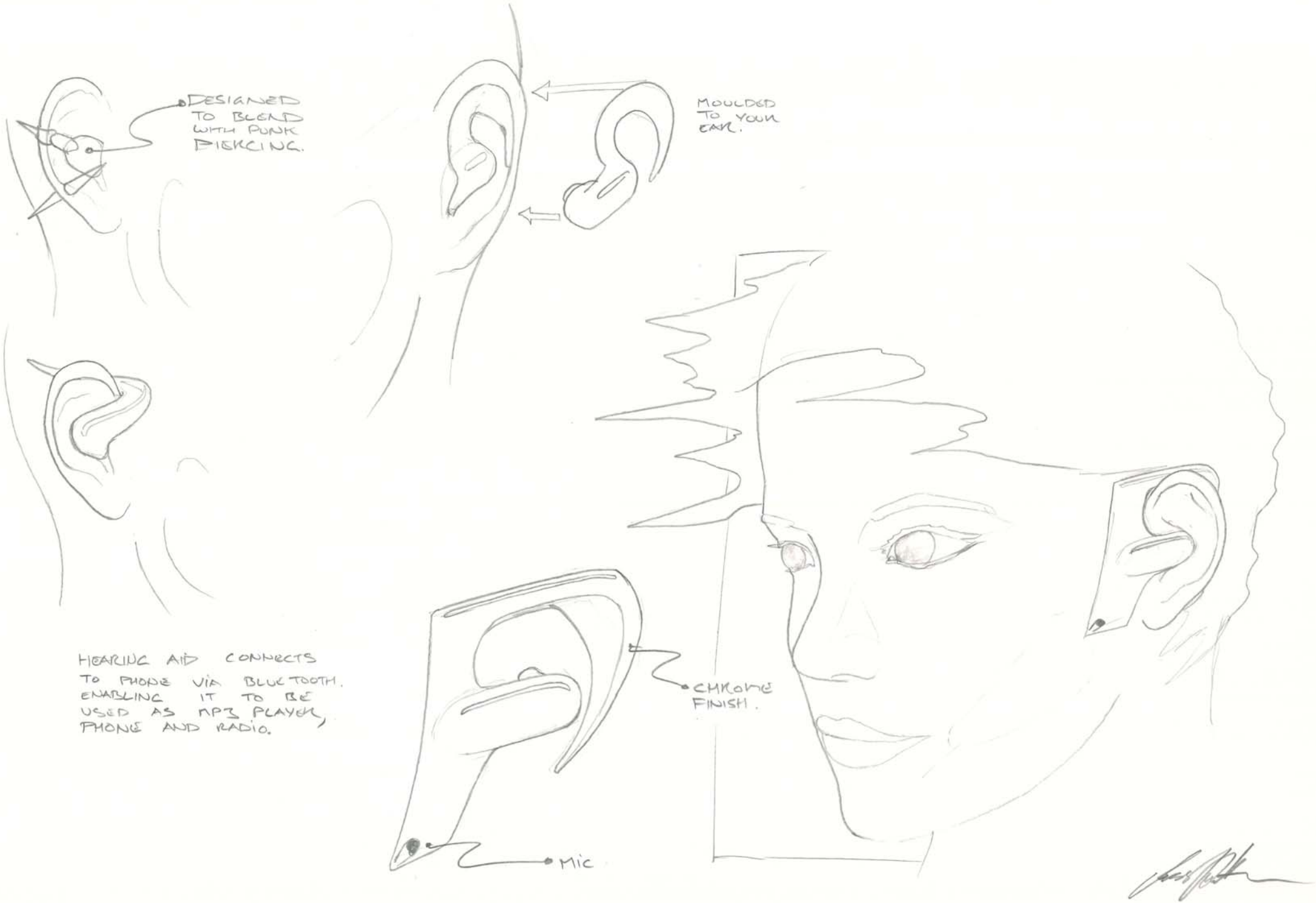

ADJUSTABLE
RUBBER HEARING
AID
COMES IN
DIFFERENT

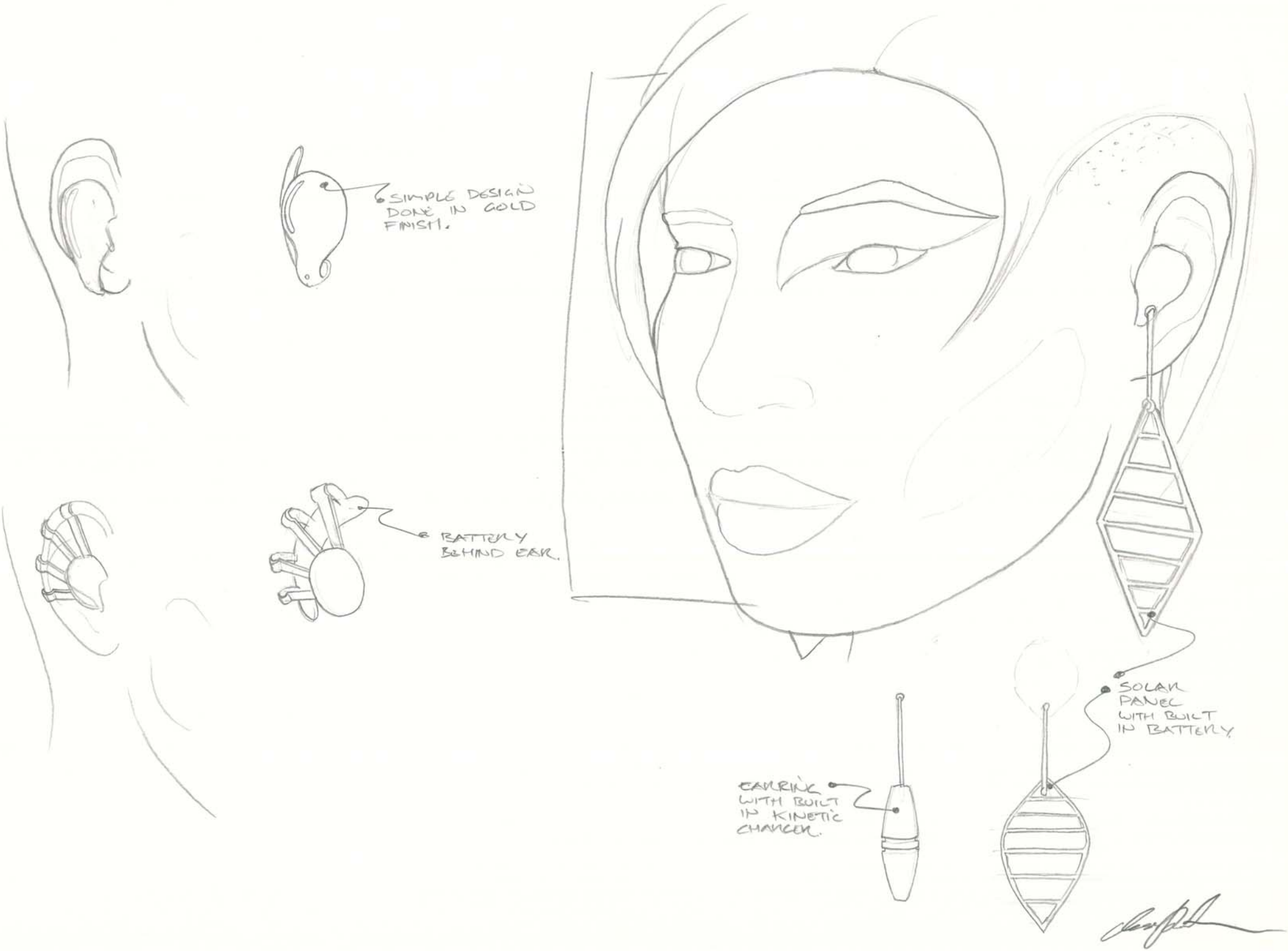
Kriota Lindegger

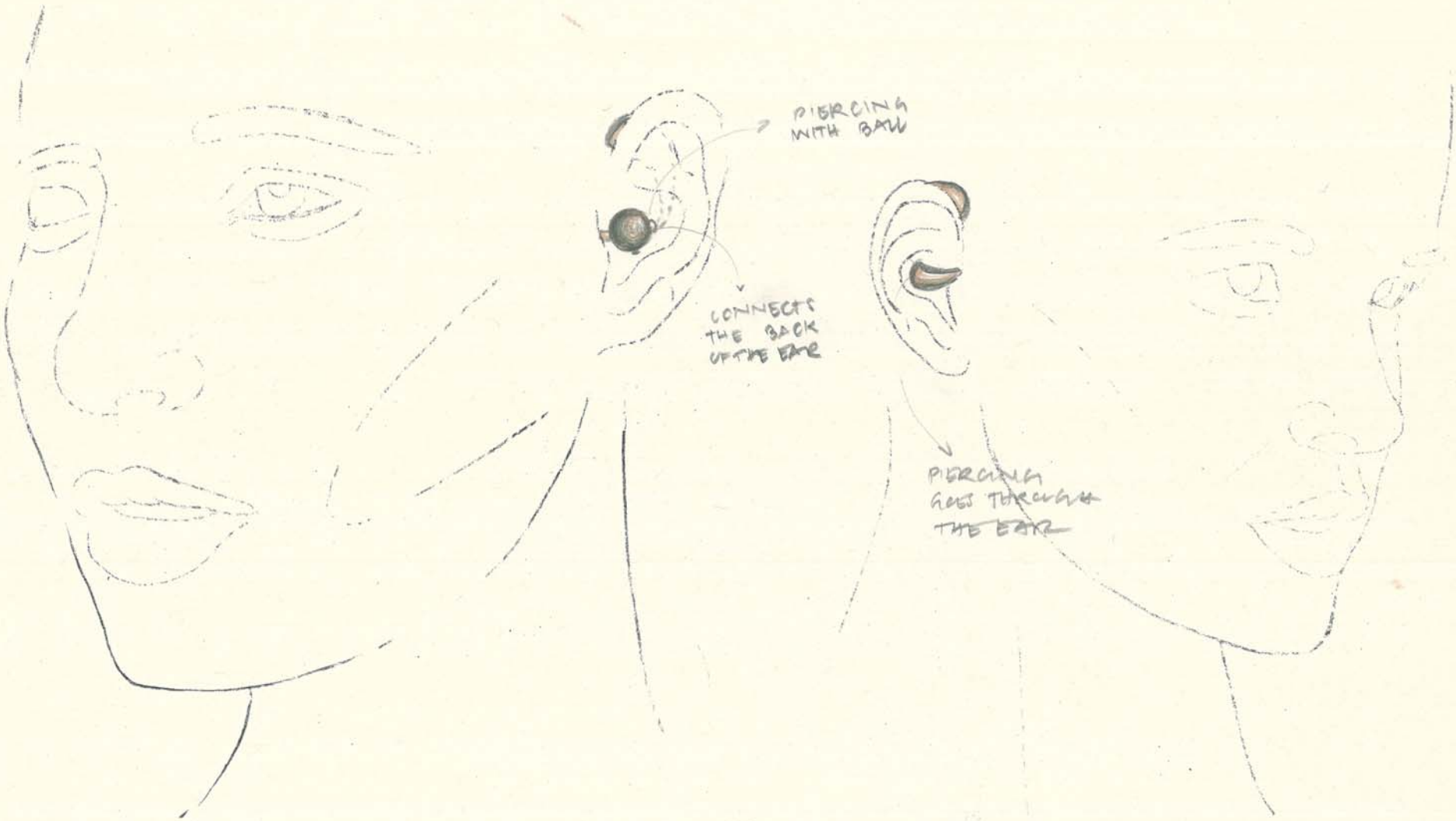
Kristin Lindgren


STICKY POLYMER ON BACK HOLD. HEARING AID TO SKIN. SOUND IS TRANSFERED THROUGH BONE BEHIND EAR.


LARGE DESIGN ENABLES EXTENDED BATTRERY LIFE. AND MORE TECHNOLOGY FOR. SUPER HEARING CREATING APPEAL FOR PEOPLE WITH PERFECT HEARING.


DESIGNED TO BLEND WITH PUNK PIERCING.
MOULDED TO YOUR EAR.
HEARING AID CONNECTS TO PHONE VIA BLUETOOTH. ENABLING IT TO BE USED AS MP3 PLAYER, PHONE AND RADIO.
CHROME FINISH.
MIC


SIMPLE DESIGN DONE IN GOLD FINISH.
BATTERY BEHIND EAR.
SOLAR PANEL WITH BUILT IN BATTERY.
EARRING WITH BUILT IN KINETIC CHARGER.



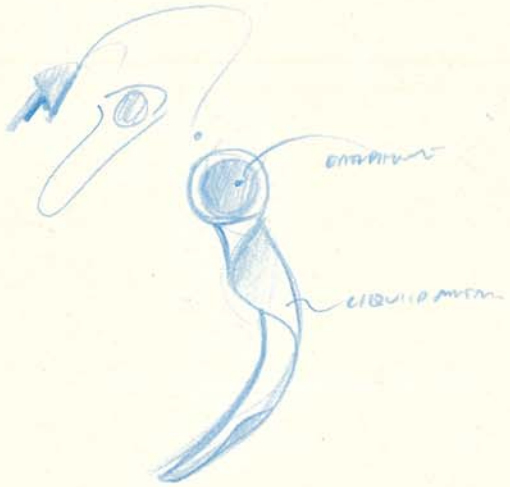
Kristen Lindegger

LEANNE BENNETT

LEANNE BENNETT

BATTERY
MICROPHONE
BUTTON

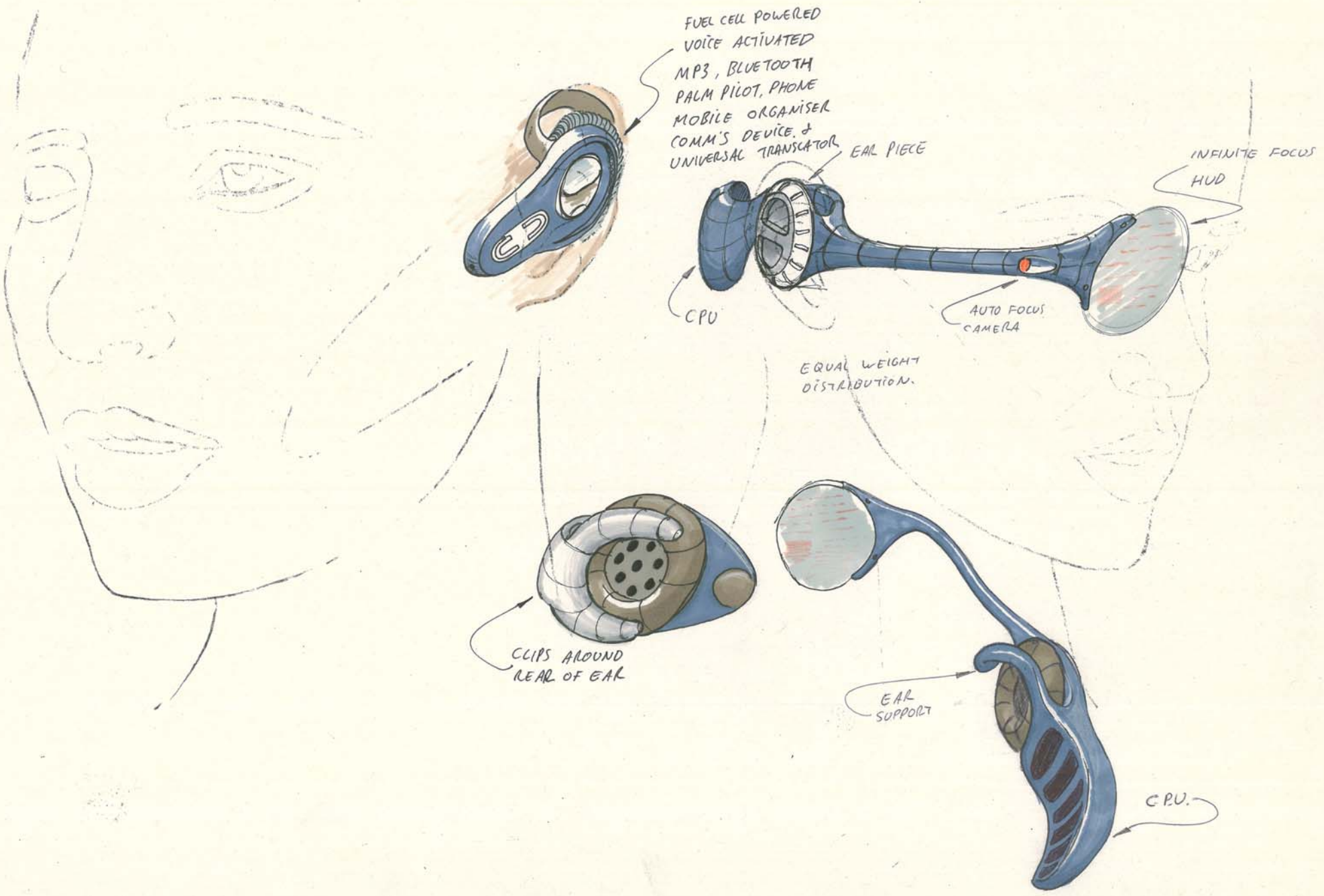
LEANNE BENNETT



LEANNE BENNETT

LAMAR BENNETT


LEANNE BENNETT


FUEL CELL POWERED
VOICE ACTIVATED
MP3, BLUETOOTH
PALM PILOT, PHONE
MOBILE ORGANISER
COMM'S DEVICE &
UNIVERSAL TRANSLATOR
EAR PIECE
INFINITE FOCUS
HUD
CPU
AUTO FOCUS
CAMERA
EQUAL WEIGHT
DISTRIBUTION.
CLIPS AROUND
REAR OF EAR
EAR
SUPPORT
C.P.U.


SARAH COLE

SARAH COLE.

SARAH COE.