DotBot

Searching for a positive white cane experience

Veronika Szabó

Dot Bot - *Searching for a positive white cane experience*

Master thesis by Veronika Szabó

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Faculty of Industrial Design Engineering, Delft University of Technology

The Netherlands

Supervisory team

Chair

Prof. dr. ir. Pieter Desmet

Delft Institute of Positive Design

Mentor

Dr. Maarten Wijntjes

Perceptual Intelligence Lab

In collaboration with

Koninklijke Visio

Margot Scheltema

Acknowledgements.

4

Summary.

The design of the white cane, the most used mobility aid for visually impaired, has not changed significantly since the mid-20th century. New concepts and technological solutions have failed to catch on. However, the cane seems unappealing and outdated to some potential users. Margot Scheltema, the initiator of tis graduation project, is a future cane user. She feels that the current cane design is alien from her identity and she feels reluctant to use it. She is not alone: due to the social stigma, many cane users feel self-conscious when using the device, some even decide not to use it, despite the mobility limitations resulting from such a decision.

Research

After the initial desk research phase, field research was conducted to explore questions of VIP mobility. The process contributed to a high level of empathy for VIPs. Autoethnographic studies were conducted in collaboration with Thijs te Velde, to build a base of self-experience concerning VIP mobility struggles. Through the collaboration with Visio Den Haag and Margot Scheltema, different perspectives were represented in the research data. The most important mobility struggles and attitudes concerning mobility aids were identified. Positive aspects of VIP life and the inherent dilemmas were also collected.

The design solution

The Dot Bot is a navigation aid consisting of a network of location-specific navigational and environmental information nodes (Dots) accessible to a specific user group. The information is stored in the form of audio descriptions created by the userbase. This way virtual DotBot community facilitates the sharing of commuting know-how. The information Dots make use of existing VIP relevant infrastructural elements in the tactile paving. It is aimed to enhance the perks of being part of the VIP community, cultivating feelings of connectedness and belonging. The semantic qualities of the cane are preserved, to keep it recognisable and ensure user safety in commute.

However, there are moments where the effects of impairment are preferred to keep private. For this reason, I aimed to limit the need to ask for directions and aid VIPs in cultivating pride and the feeling of competence through exercising their ability to navigate autonomously. The way the information is stored and accessed supports this: for the outsider eye accessing information from a road stud on the tactile paving is invisible.

During the evaluation phase, several aspects of the DotBot concept were tested with VIP participants. In the first validation session, insights on information needs during navigation were collected. In the second validation session the envisioned interaction was evaluated by the help of functional prototypes, and feedback types were also investigated. Further studies would be needed to establish the optimal Dot density in vibrotactile feedback pattern and intensity.

Contents.

Context.

1 | Introduction.

The modern white cane has been around since the mid-20th century, and it is still the number one choice of mobility tool for many of the visually impaired people (VIPs). There are new devices and concepts aimed at this audience, but these solutions have a low acceptance rate among both the VIPs and healthcare professionals working with them (Gori et al., 2016).

VIPs are a large group. Approximately 4 % of the total population lives with some kind of visual impairment (285 million VIP worldwide, 311000 in the Netherlands) and around 39 million of them are completely blind (770000 in the Netherlands). (WHO, 2012; Limburg & Keunen, 2009). VIPs are facing impairment related issues in several areas of their lives. Losing their eyesight can cause fear of losing control, fear of dependency and perceived loss of ability. (Teitelman & Copolillo, 2005). And some of these fears are based on very real phenomena. From a deteriorated functional vision unemployment and social isolation can result, leading to depression in some cases (Bartiméus sonneheerdt, 2014; Rees et al., 2010).

Being VIP can result from a spectrum of conditions, with different implications and different needs. However, the world of the VIPs can seem simplified from the outside. For the majority of the seeing world, a person with the cane and/or a guide dog is blind. The mobility aids signal the impairment of the user to bystanders, but also the vulnerability and the limitations resulting from the impairment. The stigma surrounding assistive devices is present in the case of the cane (Vaes, 2014). Using the currently available mobility aids, VIPs have very limited control over the image they create. It is one common image of "the blind". They are scarcely able to communicate competence and skill.

The aim of this project is to make it possible for VIPs to regain control over the image they create in the social setting. To make it possible for them to only show vulnerability when they mean to, for example when they need help, and show competence when that is their intention.

2 | The project.

Starting point

The current project was initiated by Margot Scheltema, who suffers from retinitis pigmentosa, a condition that is leading to a kind of tunnel vision. As her vision is deteriorating, she will need the cane for navigation soon. But she feels that the current cane design is alien from her identity, and she feels reluctant to use it. She is not alone with this feeling: due to the social stigma, many cane users feel self-conscious when using the device, some even decide even not to use it, despite the mobility limitations resulting from such a decision.

Visio, the Royal Dutch Visio Centre of Expertise for blind and partially sighted people helped the project by providing contact with rehabilitation and training experts, social workers and visually impaired people.

Initial goals

I started this project with the goal to design a mobility aid for visually impaired people that keeps them in control of the image they want to show in a social setting. This can be achieved for example by broadening the spectrum of messages the mobility aid can convey, or by taking away the overly functional and medical look of the device and making it desirable for other user groups as well.

My starting point of the new mobility aid was the current white cane. I was also exploring new, technological cane concepts, keeping in mind that the acceptance of these innovative designs is low. By the end of the project, I was aiming to deliver a tangible product or a product-service combination that will aid VIPs in everyday wayfinding.

14

Project process

Assignment   Liteature study

Stakeholder
meetings

Observation research

Initial project goals

Context &
Field research

Autoethnographic
studies

Design directions

Research results   Initial insights

Generative sessions

Ideation &
Conceptualisation

Ideation   Idea evaulation

Idea clusternig

The DotBot concept

Form giving   System architecture

Application

Localisation technologies Build-up

Elaboration &
Prototyping

Use scenario

Recommendations

Functional prototypes
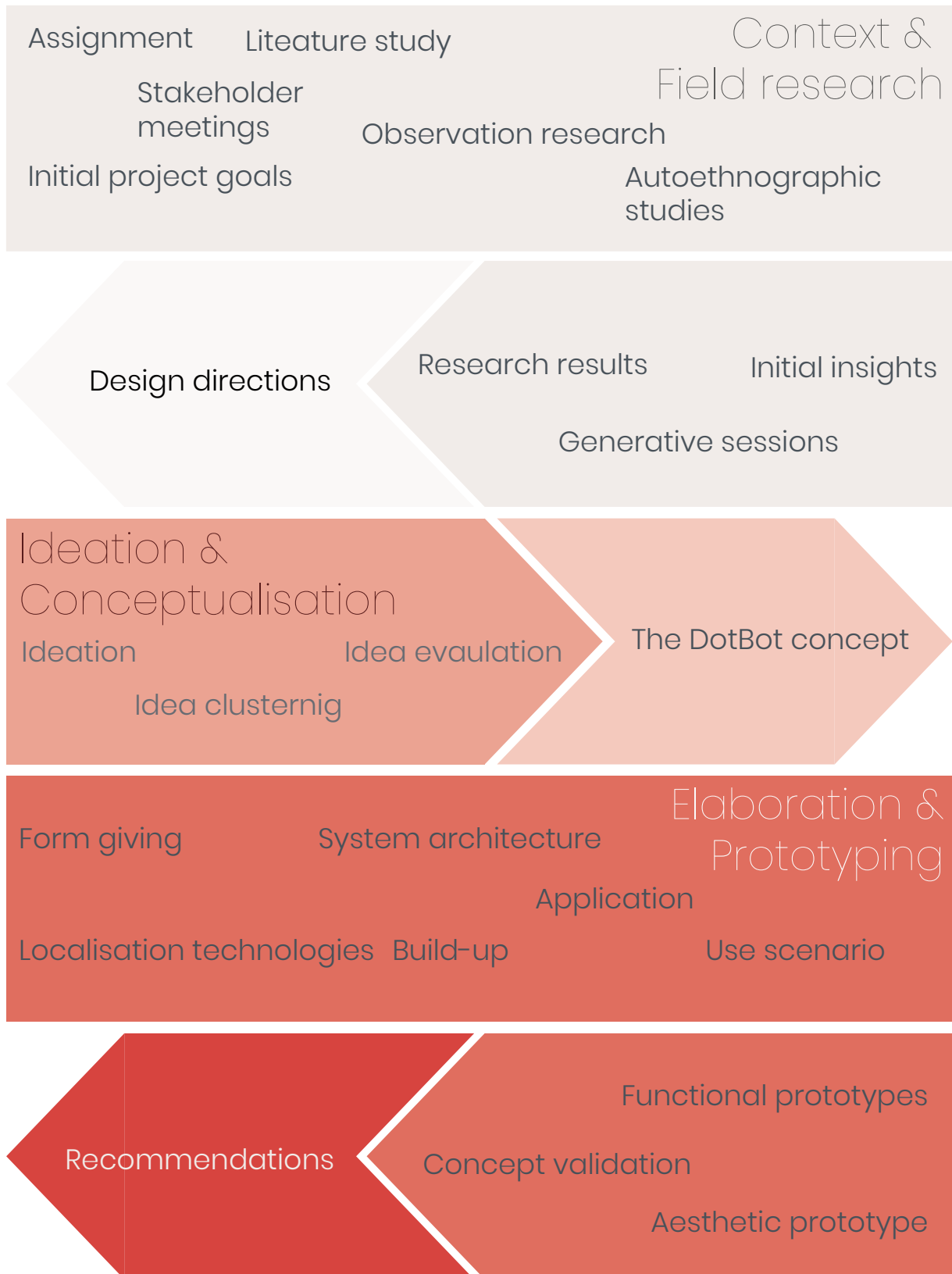
Concept validation

Aesthetic prototype

Figure 1: *The project process*

15

3 | About VIPs.

This section is focusing on visually impaired people (VIPs). To design for this specific user group, an understanding is required of what it means to be a VIP, what are the causes and the effects of visual impairments, and what their relation to the majority society is.

The spectrum of visual impairments

"Disabled people do not share a single experience"

(Pullin, 2011)

This is certainly true, even if we take only visually impaired people.

When thinking about VIPs, we commonly put them in one category, "the blind", symbolised by the white cane and the guide dog. This perception is reinforced by the common portrayal of VIPs as having no vision at all (see the section "VIP representation" on common stereotypes of VIP). But there is a whole spectrum of different conditions leading to visual impairment. This spectrum of conditions can lead to a variety of vision problems. Figure 2 illustrates how varied these vision problems can be. The implications of vision loss can be best described by considering the functional vision, the term describing how well can someone perform vision-related tasks. Functional vision has several aspects, for example, the ability to read or recognise someone over a distance.

The functional vision of VIPs shows a great variety. Moreover, functional vision is not constant over time. For most VIPs, sight loss is a series of challenges that requires constant adaptation to their ever-changing abilities (RNIB, 2015).

The level of functional vision is highly correlated to the degree a VIP can continue to live as before. If their level of functional vision it is not enough for safe commute, they became potential cane users. These potential cane users are a varied group, mostly they have only one thing in common: their impairment influences their mobility.

16

Normal vision.

Blurred vision, can be the effect of **uncorrected refractive errors**

Cloudy vision, can be the result of **cataract**

Central vision field loss, can be the result of **macular degeneration**
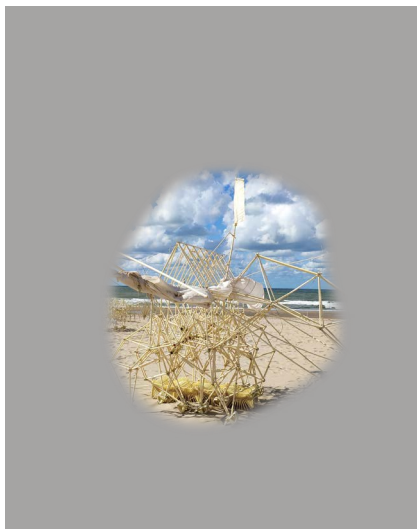
Peripherical vision loss, can be the effect of **glaucoma** or **retinitis pigmentosa**
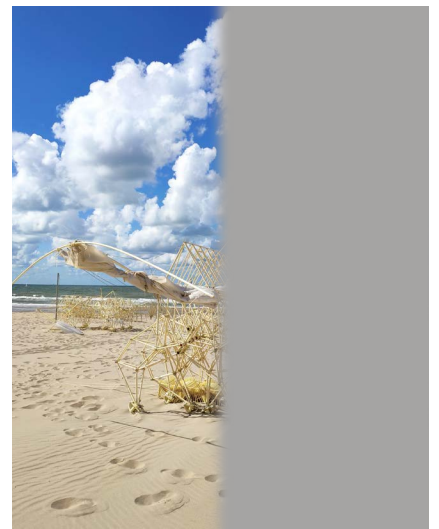
Hemianopia, loss of half of the vision field. The cause is brain damage from a **stroke** or **accident.**

Blind spots, possible cause is **diabetic rethinopaty**

Vision field loss and blurry vision
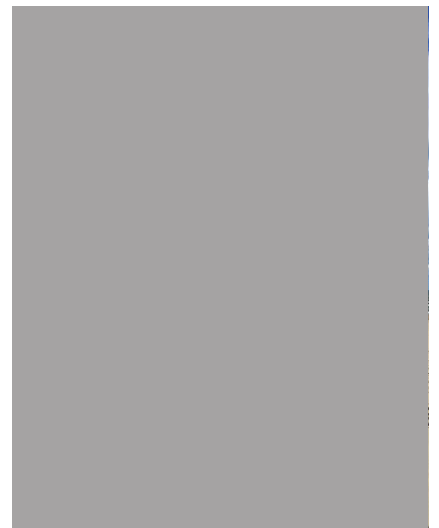
No vision.

Figure 2: *Effects of different conditoins on the field of vision*

Living with a visual impairment

Losing vision has effects in various life areas.

According to the 'My Voice' research carried out in the UK, sight loss is touching all areas of life. (RNIB, 2015). Visually impaired people are facing discrimination, loss of social contact and limited choices. A lower employment rate is linked to financial difficulties. Limited mobility and transportation possibilities contribute to feelings of being cut off, and limited choices in how they spend their free time. VIPs also reported negative attitudes from the general public towards their impairment. As a result of these factors, VIPs have lower levels of wellbeing, compared to the general population.

Vision loss is linked to a higher risk of depression. Garcia et al. found depression levels comparable to cancer patients about to start chemotherapy. They also identified a negative effect on career prospects and interpersonal relations, which can result in the deterioration in their financial situation. According to their model, sight loss has an effect on psychological wellbeing through changes in interpersonal relations, career goals, and mood (Garcia et al., 2017).

Studies carried out in the Netherlands also show that visual impairments have a negative effect on the quality of life, which is comparable to other chronic conditions. As Langelaan et al. (2007) shows , a large share of VIPs in the Netherlands see negative effects in their mobility and daily activities, are facing pain or discomfort, or suffer from anxiety or depression.

Surprisingly, the first piece of Dutch legislation to counter discrimination against disabled people came into effect only in 2003. The fact that this didn't happen earlier is showing how the rights of disabled people were (and somewhat still are) ignored by Dutch policymakers. Current policies to integrate disabled people in the 'normal' way of living still label them as 'second class citizens', and their goal is assimilation. (Van Houten & Jacobs, 2005).

Park et al. argues that the built environment is favouring able-bodied people, thus creating barriers to a disabled person, intrinsically 'disabling' them (Park, Radford, & Vickers, 1998). Hoven calls this effect the 'disabling city', which is the result of policymakers and urban designers prioritizing the needs of able-bodied, male, white, average aged, etc. users, creating an environment where minority groups are locked out from public spaces (van Hoven & Elzinga, 2009). VIPs are also confronted with discrimination, social exclusion at the same time as disabling environments and the vast majority have poverty in common (Shakespeare, 1993). For VIPs, these limitations amplify the effect of the impairment and contribute to the negative social effect and isolation.

Seeing how much of the perceived level of impairment or disability can result from the design of the built environment and the products surrounding us, a great opportunity space opens up. By design interventions, the "disabling city" can be transformed into an enabling city.

18

VIP representation

I DON'T REALLY CARE WHAT
YOU THINK A BLIND PERSON
IS SUPPOSED TO LOOK LIKE.

Figure 3: *Reflection on society's expectations by visually impaired cartoonist, Michael Sabine*
http://www.michaelsabine.com/

Media representation of VIPs strongly influences their perception in the majority society. Expectations on how VIPs look like, how they behave, what they do are not independent of the stereotypes present in their representation. The most commonly seen stereotype when it comes to visually impaired is that all VIPs are blind.

If we look at how cinema depicts visually impaired, we can get a general picture of what the typical stereotypes are. As Corbella and Acevedo finds, this image is not constant in time (Corbella & Acevedo, 2010). The VIP characters appearing in cinema have evolved over the years. Although their image evolved, their impairment is always represented as complete blindness. In the silent film era, they were victims of tragic events or just comic relief. Around the middle of the XX. century we see visually impaired (mostly blind) characters battling with their fate and overcoming limitations. From the seventies on, their roles are more normalized, but their representation is still scarce, and oftentimes defined by their impairment. Nelson (cited in Corbella & Acevedo, 2010) that VIPs are often depicted in the media as either pitiful and pathetic; heroic; sinister, evil, and criminal; "better dead"; a misfit; a burden for the family and unable to lead a successful life. Corbella and Acevedo found that there is a prevailing stereotype missing from the previous list, the visually impaired character with extraordinary auditory and olfactory (relates to smell) senses.

This way of representation is perceived by VIPs in different ways, for some, it can be a source of constant frustration, some find the humour in the situation.

Orientation and mobility

Being a VIP has a serious effect on mobility. While moving around independently, sighted people strongly rely on visual information. Visual cues provide information on the space surrounding us, as well as help in orienting oneself in the space. Without visual cues, this orientation process is much more difficult (Espinosa, Ungar, Ochaíta, Blades, & Spencer, 1998). Petrie (cited in Bradley & Dunlop, 2005) distinguished two aspects of wayfinding: micro and macro navigation. Micro navigation is related to the immediate environment (for example detecting obstacles or keeping a direction), while macro navigation is related to the distant environment (for example wayfinding in a city, navigation to a location). VIPs can have difficulties with only one or both aspects, and the nature of the impairment plays a role too. People with a limited field of vision can still be confident in macro navigation, as their remaining vision makes them capable to read signs or maps while having difficulties with detecting obstacles and perceiving traffic situations (micro navigation).

According to a study by RNIB, transport and mobility is one of the biggest issues VIPs face in their daily life, with more than half of VIPs needing assistance to leave the house (RNIB, 2015). VIPs with a low level of functional vision have difficulties with getting out and about, being it by the means of walking, driving or using public transport. This leads to fewer journeys taken, limited independence, but also accidents while out and about.

20

Figure 4: *Tactile paving at the train station of Schipol Airport*

Mobility solutions

Figure 5: *Guide dog*

Figure 6: *Eyedog*
Galatas, G., Mcmurrough, C., Mariottini, G. L., & Makedon, F. (2011). iDog : An Assistive-Guide Robot for the Visually Impaired.

Most mobility solutions are designed to give back the lost independence to VIPs. This usually is done by addressing one or more of the sub-issues of mobility VIPs face: the problems of orienting, obstacle detection or building cognitive maps to navigate. In this section, several solutions are collected and categorised by the goal and working principle. Some of these solutions are commercially available, others are in a concept phase.

A (virtual) buddy

These solutions try to lift some of the cognitive burdens of living everyday life with a visual impairment by introducing a physical or virtual buddy. In the case of the guide dog or the running buddy from the Running Blind Association, the decisions concerning micro navigation are lifted form the VIP, and they can be more relaxed. In the case of the Be My Eyes app, the guidance or help is given by a virtual community through a video call.

There have been numerous efforts to translate the functionalities the guide dog or a helper fulfils to robotic systems. There are robotic guide dog concepts dating back to the 80s. A number of different solutions can be found in table on the next page. The technologies used both for feedback and environment scanning are varied and none of them is commercially available so far.

22

Figure 8: *Be my eyes app*
https://play.google.com/store/apps/
details?id=com.bemyeyes.bemyeyes

Figure 7: *Running blind association*
https://vechtloop.nl/nieuws/running-blind-
doet-mee-aan-vechtloop/

Guiding robots and the technology involved

table after Cuturi et al. (2016)

Name	Sensors	Feedback
MELDOG MARK (Tachi et al., 1981)	Ultrasound	Verbal audio, Electrocutaneous
HITOMI (Mori et al., 1994)/HARONO-BU (Mori and Sano, 1991)	Vision system, Ultrasonic, Global Positioning System (GPS), Geographical Information System (GIS)	Braille key, Verbal audio
PAM-AID (MacNamara and Lacey, 2000)/VA-PAMAID (Rentschler et al., 2003)	Ultrasound, Laser	Verbal audio
Care-O-bot (Graf, 2001)	Laser	Kinesthetic
Robotic Guide/Robocart (Kulyukin et al., 2004)	Ultrasound, Laser, Radio Frequency Identification (RFID)	Verbal audio
Guide-Dog Robot (Saegusa et al., 2011)	Laser	Kinesthetic
ROVI (Melvin et al., 2009)	Ultrasound, Infrared	Kinesthetic
Robotic System to Assist Visually Impaired People (Capi and Toda, 2011)	Laser, Vision system	Verbal and non-verbal audio
EyeDog (Galatas et al., 2011)	Laser	Kinesthetic
Omnidirectional-type cane robot (Wakita et al., 2013)	Laser, Tilt angle sensors	Kinesthetic

23

Canes

As a navigation aid, the white cane is mainly a tool for micro navigation. It aids its users in avoiding obstacles, getting information on the terrain (textures, curbs, slopes) as well as to 'read' tactile pavement elements like guidelines. During cane use, vibration from the cane is transmitted to the skin of the hand and the whole hand-arm system is an essential source of information, as this activity is a form of indirect haptic perception (Lederman & Klatzky, 2009).

The second functionality of the cane is its signal functionality: it notifies bystanders about the impairment of its user so that they can adjust their behaviour accordingly.

There are several canes and cane-like solutions to aid VIP mobility. Some of them are "analogue", while others try to introduce technological advancements for better obstacle detection.

The most common "analogue" cane type is the long cane. The long canes are often made from aluminium, fibreglass or graphite. The handle is made of rubber in most cases and contains an elastic cord at the end. However, the handle can also be made of cork or wood. The canes can be telescopic, foldable or they are one long stick. The tips of the cane can differ on your own likings. You can have a roller tip, pencil tip, marshmallow tip or metal glide ("Canes – Ambutech," n.d.).

The first technological cane concepts emerged in the '60s, and now there is a plethora of technological cane concepts, using different sensor-feedback combinations to translate the visual information to stimuli accessible to other senses. These technologies are called sensory substitution technologies (Gori et al., 2016). Most of these solutions are technology-focused and can be considerably bulky, invasive and overwhelm the user's cognitive abilities. This results in low acceptance rates.

Cuturi et al (2016) compared a number of technological canes by and feedback technology used. Based on their research the most common feedback is either audio or vibrotactile while the most common sensors used in technological cane designs are infrared or ultrasound. Ultrasound sensors are used in, for example, the We Walk, the Eye stick, the Smart cane and the Icane concepts, visible on the next page. But there are concepts with different technological solutions. The mySmartcane and the Xplor use a camera as the main information source, and the Navi concept uses the sensor combination of the Kinect.

Figure 9: *Long cane*
https://shop.rnib.org.uk/mobility/canes/canes-bestsellers/120cm-long-cane-roller-tip.html

24

Figure 17: *We Walk*
https://wewalk.io/

Figure 11: *Eye stick*
https://www.yankodesign.com/2009/09/08/
blind-stick-with-eyes/

Figure 18: *Navi*
https://www.engadget.com/2011/03/17/
navi-hack-uses-a-kinect-to-let-
the-blind-see-wear-awesome-

Figure 12: *Safe stick*
https://www.yankodesign.com/2015/06/29/
the-infrared-walking-cane/

Figure 13: *I cane*
https://i-cane.nl/nl/home/

Figure 14: *Smart Cane*
http://assistech.iitd.ernet.in/smartcane.php

Figure 15: *mySmartCane*
https://www.manchester.ac.uk/discover/
news/prototype-smart-cane

Figure 16: *Xplor*
https://www.bcu.ac.uk/news-events/news/a-
pioneering-facial-recognition-cane-for-the-
blind

Figure 10: *White cane with led and
siren*
https://lathatarbolt.hu/termek/feherbot-be007-
135cm-4-reszes-alu-led-szirena/

Context

Figure 19: *Supersonic stick*
https://www.gadgetreview.com/supersonic-stick-sonar-for-blind-people

Hidden mobility aids

Several concepts try to hide the mobility aid, or the impairment itself. The Supersonic cane concept is similar to the ultrasound enhanced smart canes, but it is replacing the cane itself with the handheld sensory substitution device (SSD). Smart glasses like the SlimmeBrill use sensors and cameras to help in navigation. There are solutions that are embedded in clothing like the Eyeronman vest, Maptic jewellery, and the Feelspace navibelt, or use another common object to house the SSD. These solutions can fulfil some of the traditional cane functionalities, like obstacle detection, and they might add new functionalities, but none of them carries the signalling functionality of the white cane.

Figure 20: *Eyeronman vest*
https://inhabitat.com/ecouterre/vibrating-eyeronman-vest-could-help-the-visually-impaired-avoid-obstacles/eyeronman-

Figure 21: *MAptic sensor jewelry*
https://www.dezeen.com/2017/08/02/maptic-wearable-guidance-system-visually-impaired-design-products-wearable-
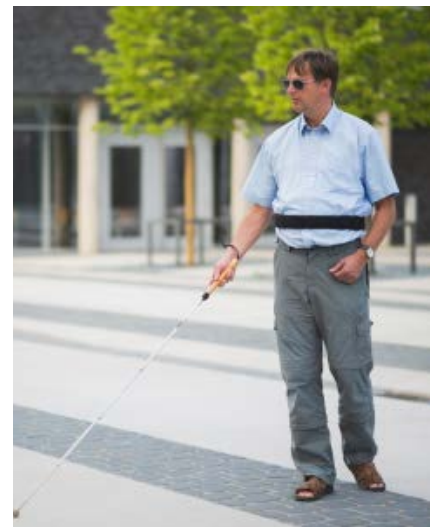
Figure 22: *Feelspace navibelt*
https://www.feelspace.de/644-2?lang=en

Figure 23: *Collison detecting suitcase*
https://www.nsf.gov/discoveries/disc_summ.jsp?cntn_id=298599&org=NSF&from=news

Figure 24: *Slimme bril smart glasses*
https://www.bartimeus.nl/nieuws/slimme-bril-ontwikkeling-voor-herkennen-gezichtsuitdrukking

Figure 25: *Lechal smart shoes*
https://www.sciencealert.com/an-indian-startup-has-developed-smart-shoes-that-could-help-the-visually-impaired

26

Figure 26: *Blind maps*
http://www.rubenvandervleuten.com/
blindmaps.html

Tactile maps

With the aid of tactile maps, it is possible to give a better understanding of the routes and the structure of the built environment. These tools are suitable for aiding macro navigation but have no use in real-time or micro navigation.

Figure 27: *Brainovi*
https://www.yankodesign.com/2010/09/20/3-d-braille-map-that-talks/

Figure 28: *Drop*
http://leege.blogspot.com/2010/04/gps-braille-system.html

Figure 29: *Touch mapper*
https://touch-mapper.org/en/

27
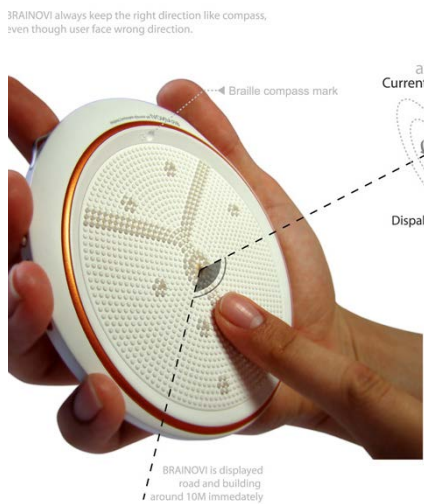
Positioning technologies

Positioning technology can aid VIPs to orientate themselves while navigating. Some solutions, for example, the Global Positioning System (GPS) can help in macro navigation outdoors, while some positioning technologies, like the augmented reality-based navigation solution, VPR, or the iBeacon technology are more suited to indoor positioning.

These solutions are working using the capabilities of the smartphones, either by utilising the phone's camera (VPS), the GPS sensor or the Bluetooth antenna (iBeacon).

Figure 30: *VPS - indoor navigation with AR*
https://uploadvr.com/google-reveals-vps/

Figure 31: *iBeacon*
https://spin.atomicobject.com/2017/01/31/ibeacon-in-swift/

Figure 32: *GPS*
https://redpinemapping.com/collections/frontpage/gps

28

Built environment

There are several solutions implemented in our surroundings that have the goal of aiding VIP mobility. These solutions are aimed at making the solely visual nature of the navigational information accessible to other senses. Tactile paving informs cane users about direction and orientation, translating it to tactile information. The visual information from the traffic light is translated to auditory stimuli. Information concerning navigating in a building is also given with braille signs. But the braille sign is not accessible for all VIPs, as not all of them can read braille. The second limitation of this solution is that a braille sign is read in a rather different way to a visual sign as each sign must be approached and touched by hand. This interaction with braille script in public places can be somewhat off-putting for VIPs.

Figure 33: *Tactile paving*
https://upload.wikimedia.org/wikipedia/commons/d/d9/Truncated_domes.jpg

Figure 34: *Acoustic traffic signal*
http://its-traffic.com/category/product/pedsaf/aps/

Figure 35: *Braille signs*
https://nos.nl/artikel/2200593-alle-treinstations-zijn-nu-toegankelijk-voor-blinden.html

29

Field research.

Figure 36: *During the autoethnographic study*

4 | Research goals.

There is only a limited understanding that can be gained by doing only desk research. By using field research methods, gathering first-hand experiences and personal contact with the user group a better level of understanding and empathy is reachable, which are serious assets in the design phase.

While designing the research strategy, the principle of triangulation was used (Berg, 2001). With the combination of different data collection methods, research subjects and researchers, it is possible to have more robust results, capture more rich data, and avoid a one-sided narrative.

The goal of the field research was to explore the effects sight loss has on the everyday life of VIPs, with a special focus on mobility in some of the activities. The questions to answer through the research activities were the following:

What are the struggles of visually impaired people when it comes to mobility? What are the different ways to overcome them?

What are their attitudes towards assistive devices (especially the white cane)?

The secondary goal of the research was to create empathy in the researchers, by providing first-hand experiences from the user perspective. During the research activities, a network of stakeholders for the graduation projects was also built.

Most research activities featured in this section were conducted by Veronika Szabó and Thijs te Velde. The research activities in Autoethnographic studies, Observation studies, and the two Starting points were conducted as part of the research elective

32

33

5 | Starting points.

Two research activities were carried out as starting points to the field research part of the design project. They served as orientation points as well as inspiration to the design of the research activities.

Expert meeting

To start the collaboration with Visio Den Haag, an expertise center for VIP rehabilitation and training, an initial meeting was held with the manager of the Visio Den Haag facility and two occupational therapists. Firstly, expectations were discussed along with opportunities to collaborate. During the meeting, one of the occupational therapists offered the opportunity to experience what it's like to be visually impaired, which was gladly accepted. Several modified ski masks were tried on, starting from completely blind, which simulate various visual impairments. This first experience was meant to be a starting point for subsequent autoethnographic studies. Personal narratives of the experience can be found in Appendix A.

The expert meeting at Visio allowed us to structure our collaboration with the people at Visio, as well as get a first glimpse into what it is like to be visually impaired. This set the stage for subsequent autoethnographic research and started a relationship with the people at Visio Den Haag, which would prove instrumental in the further development of the project.

To illustrate the experience during this study, we provide a few relevant quotes from the autobiographical narratives.

"Walking towards the elevator, we met another of her co-workers, with whom it was hard to get a normal interaction. I felt a little bit awkward and just waved in all directions, making jokes to alleviate my own distress."

"After arriving back to the Visio facility, I was relieved and exhausted. Being tense all the time needed a lot of effort."

34

Visiting the ZieZo Beurs

In order to explore what is currently available for visually impaired users in the domain of mobility tools, the ZieZo Beurs was visited. The secondary goal of this activity was to build connections with possible stakeholders of the project.

Firstly, the researchers explored the selection of exhibits. The offering was assessed visually, to have an overview of the technology and visual style. The exhibitors of interest were selected, favouring the topics related to mobility and the booths who sported an original approach.

During the course of the visit, several discussions were held to acquire more information on the projects and products exhibited. After the fair, the researchers completed personal narratives on the visit, which can be seen in Appendix A.

Visiting this trade fair gave the researchers insights into the current state of assistive technology for the visually impaired. The researchers also met employees from Bartiméus and got insights into how VIPs prefer to present themselves to the outside world. We also got to see visually impaired people interact with each other for the first time. This was very interesting to see and can be illustrated with the following quote from one of the reflections both researchers wrote:

We saw that VIPs who attend were in a positive mood, greeting each other. I don't suppose they meet so many fellow sufferers very often, and at this fair they were the "normal people", the sighted were the ones out of place.

The second striking observation is that there are, next to technological advances, quite some efforts that help visually impaired people to integrate into society, as evidenced by the following quotes:

Another highlight was a voting booth, adapted for the visually impaired. I thought it was wonderful to see that there are efforts to give these people the means to participate in and put their mark on society.

We encountered a booth from Bartiméus with an interestingly unusual approach: at the Oogverblindend Mooi workshops, they help VIPs regain control over how they present themselves to the seeing society. This includes style and colour advising, makeup, but also self-presentation and body language. I did find it inspiring that they leapt over offering purely functional help and are giving tools of self-expression to their clients.

Figure 37: *Ambiance at the Ziezo Beurs*

Figure 38: *Reading aids*

35

6 | Autoethnographic studies.

Figure 39: *Glasses to simulate the effects of retinitis pigmentosa.*

Figure 40: *Long cane.*

As Wall (2006) puts it, autoethnography "allows the author to write in a highly personalized style, drawing on his or her experience to extend understanding about a societal phenomenon". As the subject of the study is highly personal and related to emotions and struggles, a similarly personal and sensitive method is needed, alongside the more traditional qualitative research technique of participant observation.

Autoethnography can take several different forms. In the course of this study, autoethnographic texts were the product of the researchers' reflections on fieldwork activities. In the creation of autoethnographic texts, researchers tell about their experiences, in most cases using the first person. Aesthetic qualities of the text are also important to convey the experience to the readers (Ellis, Adams, & Bochner, 2011).

During this study, the two researchers experienced navigation with limited vision, and analysed this experience, creating their personal narratives. As the autoethnographies were created by two researchers, the differences between voices and narratives could be subjects of analysis as well. Using this kind of self-observation as a research tool had two main goals. Next to obtaining knowledge on the main research question, the secondary goal was to develop empathy towards the user group, to aid the design phase and the communication with users. Having this experience and looking at it analytically can be a powerful tool in bridging the communication gap resulting from experiencing the world in a different way.

During the activity, an audio recording was taken, and the researchers' observations were stated out loud for ease of further processing. After each session, the researchers took quick notes on their most important observations and impressions. After each research activity was completed, both researchers expanded their notes with the help of the audio recording and created a text containing their personal narrative of the activity.

This method was used in three sessions. To obtain diverse observations, a variety of locations, times and activities were used. This way the researchers could also compare the experiences between cities and times of day to see if there is a lot of difference between, for example, a familiar or unfamiliar neighbourhood or between rush hour and a quiet morning hour.
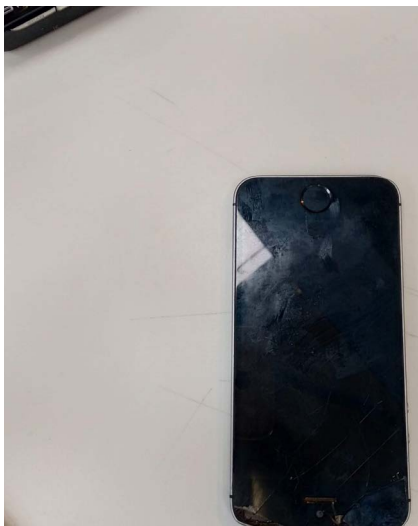
36

Figure 41: *Field notebook and pen.*

Figure 42: *Mobile phone for audio recording and taking pictures.*

The tools used to perform these autoethnographic studies are the following:

Glasses to simulate the effects of retinitis pigmentosa.

We took a pair of sunglasses and neatly cut out blinds out of thick black paper. We then used a pin to create two small holes in the middle of these blinds to see out of. This simulates the effects of retinitis pigmentosa. We chose to simulate this specific type of visual impairment because one of the main stakeholders in the project suffers from this condition.

Long cane.

The kind people at Visio allowed us to borrow a used long cane. This particular cane is quite worn as it has been used in many a training but still functions and serves our purposes perfectly.

Field notebook and pen.

We carried around a notebook to note down particularly noteworthy observations.

Mobile phone for audio recording and taking pictures.

Because we knew that we wouldn't be able to record everything in a written form while walking around town, we decided to use a mobile phone to record most of the information.

The autoethnographic studies yielded results pertaining to the daily experience of visually impaired people, as well as reactions of bystanders. These results were instrumental in gaining a better understanding of the effects of using assistive products and the stigma surrounding impairment in the public domain.

37

Figure 43: *Entering Leiden Central Station*

Figure 44: *Navigating in Delft*

Pilot study in Delft (06-03-2019).

To get familiar with the methods of participant observation and autoethnography, a pilot study was conducted in the city centre of Delft. The secondary goal of this study was to uncover problems that can emerge during the execution of the methods, and improvement possibilities of the equipment used. The third and last goal was to get insights into the reaction surrounding visually impaired people and to gain empathy for this target group.

A detailed plan of the session can be found in Appendix B.

Study in Leiden (19-03-2019).

The second instance of this research activity was conducted in Leiden, near the central station. The area around the central station was chosen because one goal of this activity was to find out how people would react to the presence of a visually impaired person in a busy environment. The presence of shops also provided an interesting opportunity to get more data on behaviour and feelings during daily interactions between bystanders and visually impaired people.

This session, similarly to the session in Delft, consisted of two parts, so that both researchers could experience both roles. The detailed plan of this activity can be found in Appendix B.

Study in Den Haag (20-03-2019).

The third instance of this research activity was conducted in Den Haag, in the city centre. This session was substantially longer than previous sessions and was designed to be as diverse as possible. Den Haag was familiar territory for one of the participants, but not for the other. Various activities were chosen to get insights into multiple aspects of daily life for visually impaired people.

This extensive study yielded all kinds of results in visually impaired experience and bystander reactions. This study also helped the researchers empathise with the experiences described by clients at Visio Den Haag, who also must move throughout Den Haag daily.

38

Figure 46: *Navigation inside of a shop*

Figure 45: *Thijs in the Hague*

Figure 47: *Selecting notebooks with limited vision*

Field research

7 | Observation studies.

Participant observation is one of the most common methods of qualitative research, that can be used to compare their reported and actual behaviours. This method can also serve the purpose of building a positive relationship with the important stakeholders of the project. (Mack, Woodsong, M. MacQueen, Guest, & Namey, 2005). It is important to note that participant observation is subjective in nature, therefore researchers need to be conscious of the difference between the observed phenomena and the interpretations made based on it.

While preparing the research strategy, shadowing was also considered as a method for data collection. As described by Quinlan (2008), the method is suitable to capture behaviours and opinions and can provide answers to the why questions, and not only descriptive data. The downside of shadowing is that both the data collection and analysis require considerable time and effort, and to reach the depth and richness of data the shadowing periods are typically longer (several weeks). Due to time constraints present in the graduation projects, the method of participant observation was used instead.

Figure 48:   *Margot Scheltema in the Netherlandse Fotomuseum*

Observation of Margot Scheltema.

In the course of these observations, we accompanied Margot Scheltema throughout her daily activities. Two observation days were conducted. In both studies, the goal was to both uncover difficulties in her day-to-day interactions with the outside world, as well as get a sense of her lifestyle. While observing her, we noted down observations and interpretations and asked questions to Margot to validate the assumptions made. These initial notes were expanded after the observations.

In the first study, the participant was observed during several activities. First, she gave a tour in the Nederlands Fotomuseum in Rotterdam. After the tour, we accompanied her to her home in Den Haag, and to a reception in the Tropenmuseum in Amsterdam by public transport. In addition to the goals previously described, it was a great opportunity to get to know her personally and to build a professional and friendly relationship. A detailed research plan can be found in Appendix C.

In the second observation, the participant was observed during an hour-long drive to Baarn, where she was to give a presentation. After the presentation, she was observed during the car drive back to her house. A detailed research plan can be found in Appendix C.

During these observations, Margot Scheltema was observed in different contexts, including a board room, museum, public transport, and large-scale event. The results from this study were enlightening and told a lot about her daily trials and tribulations and underlying concerns. Some key insights about her environment, the people in it and the role it plays in the experience of her newfound visual impairment can be found in the following observations:

The room is very dynamic, with people moving about, meeting and mingling. It's hard for her to recognise faces in this dim environment.

Margot remarks: "When I have to look for the button to call the elevator, I'm always happy when no-one's around".

Trying to still be a part of this dynamic scene takes extra effort on the part of visually impaired people. A lot of tricks and adjustments are necessary in order to still be able to participate. These often go unseen, but a few can be found in the following observations:

She only goes to stores where they already know her and her condition, as it is a hassle to explain it, and what kind of help she needs.

"I'll just bluff if I don't recognise someone, it takes too long to explain." she said about the event later on.

A lot of insights were also gained in role-specific environments can play in the experience of visually impaired people. Due to them experiencing their surroundings in a very different way than sighted people, certain behaviour can seem out of place, as well.

At the reception overwhelmed by the crowd "There are a few people I want to meet, but I don't see where they are. I will just walk around, and someone will recognise me."

Margot bumps into a door and the bystanders get startled. One of the bystanders asks Margot if she's okay.

A gentleman coming down the stairs did not know what to do when Margot -

who was going up the stairs - suddenly stopped walking up. He kept standing, waiting for Margot to pass.

Our observations yielded a lot of insights into the behaviour of visually impaired persons when in the spotlight, and the reaction of an audience on that. It is interesting to see that Margot can be very open about her impairment when necessary and reserved about it otherwise.

Margot has trouble sitting down on her chair after the talk and almost falls. Some people in the audience gasp or talk amongst each other after this.

Margot tells the technicians that she is visually impaired. She is not ashamed to talk about her impairment and mainly wants the talk to go well.

It showed us what is necessary for visually impaired people to succeed in life and be a leader. It also gives insights into how bystanders react to these needs.

Upon arrival, Margot is received by someone that guides her to the room downstairs carefully. The event's organisation is expecting her and does know of her visual impairment.

The first thing Margot does as part of her talk is announcing her visual impairment.

Apart from these findings, some additional specific struggles in the daily life of visually impaired people were found that provide a richer picture of the visually impaired experience:

Margot: "I hate not knowing what the room will look like and what I will encounter."

Margot asks us to describe where a hot air balloon is, instead of pointing at it. People tend to point things out to Margot. This obviously doesn't work, and she tells us so in a deliberate but slightly annoyed tone.

43

Field research

The activities described in this section were executed over the course of a day at the Visio Den Haag location. The most valuable aspect of these studies was that they provided insights into the great lengths visually impaired people go to in order to be able to live a fulfilling life. These observations allowed us to better understand pain points with current (digital) products for visually impaired people, the great effort it takes to learn how to use assistive products effectively and the social implications of impairment.

Observation of the training of a cane walker.

In this session, the researchers observed the training of a completely blind cane-walker learning a specific route from the Visio location to the nearby station. He has been learning how to use a cane for years, so he was moderately skilled in using it. The goal of this session was to uncover common problems visually impaired people have when learning how to use a cane, both practical problems related to navigation as well as emotional problems relating to the social implications of using a cane. The observation notes can be found in Appendix D.

This observation gave us insight into the elements that make navigation hard for the visually impaired. It also showed us just how much effort goes into learning to navigate a specific route. We also learned about how bystanders and the environment play a role in either discouraging or enabling mobility for the visually impaired. Some quotes are provided to illustrate these findings:

The bumpy road is hard for Jaap to walk on. He sometimes trips.

When asked whether people are more careful with him now: "Not all of them. Some people don't. Central Station sucks."

While walking, Michelle tells Jaap what is on the square, and which of these things make a noise. Michelle notes that the fountain in the square is probably only working in the summer. Small differences in height can be very invasive when trying to walk straight.

Jaap tells us that learning this route to the bus really opens up options. He is going through this hardship in order to still be able to live a rich life in possibilities.

"Well, well." sighs Jaap after the first practice lap. Navigation with the cane is exhausting for him.

Observation of an ICT-related training

During this activity, the researchers observed an ICT training at the Visio facility. During the lesson, the researchers were sitting near the client and the instructor and were noting down observations. At times short questions were asked to the participant. After the lesson, a short interview was conducted with the instructor about the training observed and her experiences with ICT trainings in the past. The goal of this research was to find specific problems relating to visually impaired users and their interactions with (digital) products. The observation notes of both researchers can be found in Appendix D.

This observation exposed problems visually impaired users have with certain assistive technologies. Its results lay out the flaws inherent in speech- and gesture-based controls and the social difference between walking with a cane and a guide dog. Some quotes are provided to illustrate these findings:

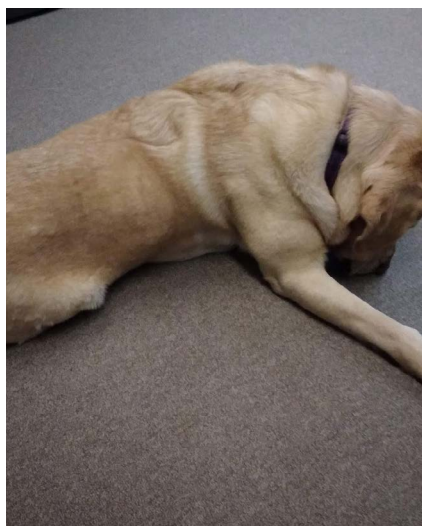**Figure 50:** *The cane walker during training*

Figure 49: *Irene was acconpanied by her guide dog*

44

Irene remarks that lists can take very long to go through. She is bored or annoyed by the entire process.

"It sometimes doesn't work, so most people do it the old way. There is some level of distrust towards newer technologies."

The keyboard consists of little keys that all feel the same. It is not designed for visually impaired, but for sighted users. However, many people use the keyboard because "typing things is better than dictating them, especially for emotional content."

"The cane seems very confronting, pointing people to facts they don't want to accept. When walking with a dog, people offer you help a lot quicker."

Observation of a talk with a social worker

During this activity, we observed as a newly visually impaired person and their spouse were having a meeting with a social worker. The main topics of the conversation, as well as the reactions and behaviour of the parties, were noted down. No recording was made of the conversation out of respect to the personal nature of the topic. The observation notes of both researchers can be found in Appendix D.

Attending this conversation gave us great insight into the reactions of people close to a recently visually impaired person. It gave the researchers a lot of insight into misunderstandings that occur and the hard dilemmas that visually impaired people are facing. Some quotes are provided to illustrate these findings:

Menno is working hard to get his old life back. He has used a viewing strategy training to get his driver's license back.

People in his surroundings have a hard time understanding the implications of his condition, in what way can it cause problems. "You have a bad vision? You just have to put on glasses."

Menno: "You can't see anything about the impairment so that's the problem, really."

Ria is tired of explaining her husband's behaviour all the time. "People keep asking me, why isn't he joining this time?"

Ria: "We still try to do everything, but then a little bit adjusted." Menno: "While in fact, we can't."

Menno has the dilemma of going to a dance performance of her granddaughter. Menno: "These are dilemmas that people just don't get.

45

8 | Initial insights.

After the observation notes and autoethnographic texts were completed for the first research activities, both researchers selected the most important insights and observations on a subjective basis keeping in mind how much do they reveal about the main research question. These valuable insights and observations, the gems found in the research data, were turned into GEM cards (see Appendix E). An example can be seen on figure 51.

The GEM cards were clustered by the researchers to create a shared understanding of what is present in the data. The clustering of the GEM cards was completed in two manners: first by spontaneous clustering to identify the main themes appearing in the data. The second clustering was completed by predefined categories: the GEMs were categorized by the underlying concern.

46

> **VIPs have to work hard to be able to live a full life.**
> Observation at Visio Den Haag 02-04-2019
>
> Jaap tells us that learning this route to the bus really opens up options. He is going through this hardship in order to still be able to live a rich life in possibilities.

Figure 51: *An example of a GEM card*

Themes

1.   Product stigma

VIPs experience stigmatisation as an effect of using certain products.

2.   Product problems

Problems with products can be an effect of the fact that they were designed with only sighted users in mind. This creates scepticism and reluctance to use new innovations.

3.   VIP community

VIP community can be a source of reassurance, giving VIPs the positive push to carry on.

4.   EX/INclusion

Several GEMs showed examples where the exclusion or inclusion if VIPs was visibly present.

5.   More effort

There are many, small and big, aspects in the life of a VIP that requires more effort compared to the sighted people

6.   Caring about aesthetics

Part of the stigma VIPs carry is the belief they don't care about aesthetics anymore.

7.   Impact on friends and family

The impacts of a condition causing visual impairments don't stop at the VIPs themselves, their environment is also affected.

8.   Overstimulation

Frequently stimuli levels are optimised for sighted users, while for the more sensitive senses of VIPs are not considered. This can happen from public spaces to app interfaces anywhere.

9.   Misunderstanding

Lack of information on what an impairment implies can lead to misunderstandings. This can have a negative effect on the quality of everyday life.

10.   Problems in face-to-face communication

In the sighted world, face-to-face communication relies strongly on visual cues, facial expression, body language, movement patterns. This makes it harder for VIPs to partake in it.

11.   (Over)reaction of environment

Overreaction of the environment to their condition can feel patronising to VIPs. In the long run, it can erode their self-esteem.

12.   Standing out

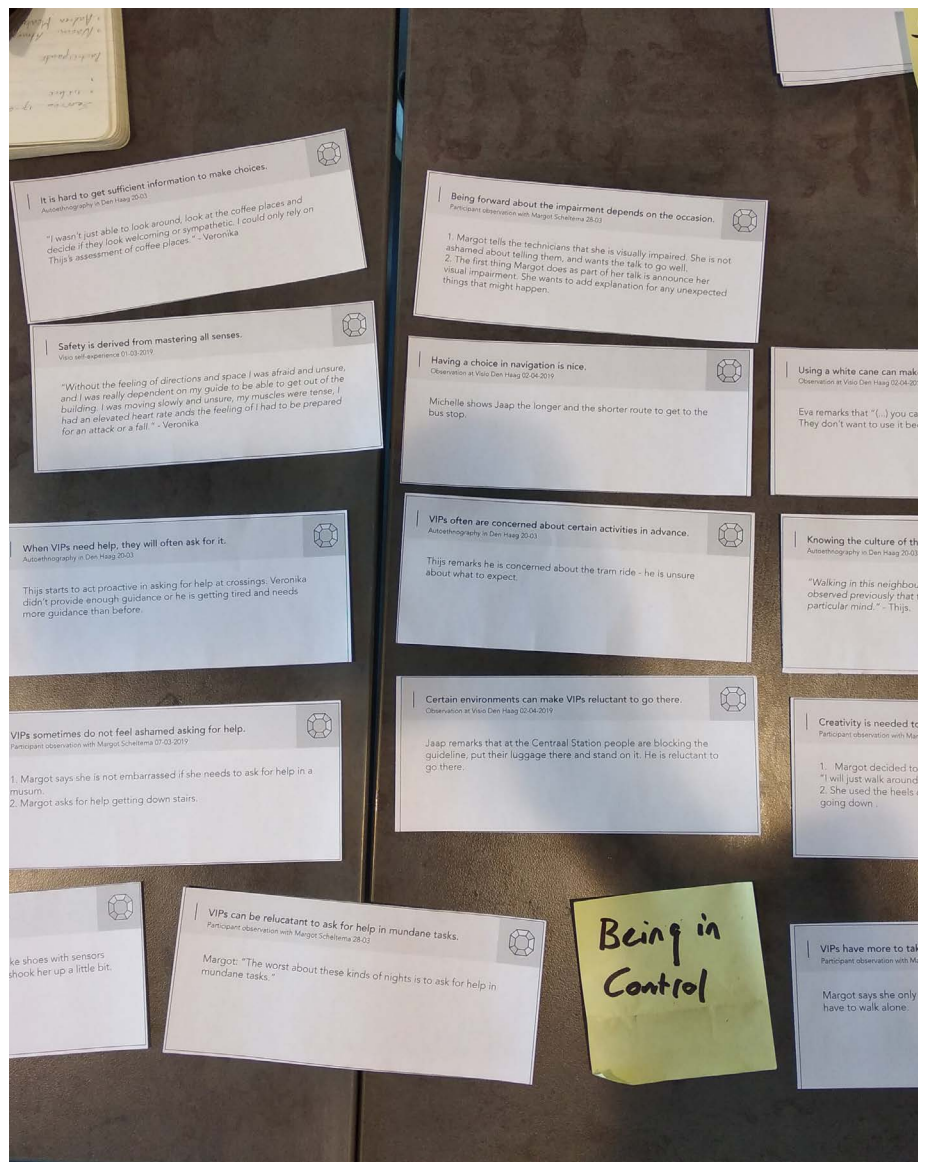Living with a visual impairment can result in standing out in certain situations.

48

Figure 52: *The cluster "Being in control"*

13.   Being/staying in control

Fear about the loss of control is a widespread sensation while developing a visual impairment. Therefore numerous ways are used to stay in control of their lives and the situations they are in.

14.   Different impact

Everyday phenomena have different impact when you have a visual impairment.

15.   Confidence

Confidence has an effect on how competent you seem. This is also true for how the limiting power of visual impairment is perceived by the environment.

16.   Negativity

Living with an impairment can lead to negativity.

9 | Generative session.

To further explore the chosen directions, a generative session was carried out with visually impaired participants. When planning a generative session with visually impaired participants, a slightly modified approach is necessary as the majority of the commonly used creativity techniques build strongly on visuals stimuli and cues. However, examples of how to overcome this difficulty exist in literature.

Metatla, Bryan-Kinns, Stockman, and Martin (2015) describe an iterative method consisting of several workshops with the same participants. The workshops are carried out using audio-haptic mock-ups, audio diaries, and highly malleable prototypes. But, counterintuitively, the use of mock-ups and prototypes hindered the communication in the workshops, suggesting that replacing the focus of the prototyping methods from visual to haptic is not the appropriate solution.

Sahib, Stockman, Tombros, & Metatla (2013) provided a participatory design approach that is built on using scenarios to simulate the user interaction, to engage visually impaired users at different points of the design process. This approach was used as a basis of the ideation in the generative session planned. Brock et al. (2016) included a locomotion trainer in the session to ease the communication and a researcher to note down the ideas and group them in categories. They suggest limiting the number of participants to 5-8, in order to make it possible for the participants to identify the speakers based on voices. These guidelines were also considered when preparing the session plan. The detailed session planning can be found in Appendix F.

Generative session at Visio Den Haag

The generative session at Visio Den Haag was carried out with five visually impaired participants, as well as two Visio employees: a secretary and a general advice employee. The presence of the general advice employee was particularly helpful because she was able to steer the conversation and filter out irrelevant directions in the group discussions.

50

In the first part of the session, participants introduced themselves and an open discussion was started within the topic of assistive products for visually impaired. The topic was steered towards specific problems daily users face. These problems were to be used as primers in the second part of the sessions, which focused on solving specific problems in specific scenarios. Three scenarios were chosen: "at home", "having a drink with friends" and "taking a walk in town". Audio recordings were selected and played to aid in imagination. Participants were split up in three groups of two and were asked to come up with specific solutions to problems in these contexts. To aid creativity, no constraints were placed on the ideas by placing the context in the year 2050, where the government funds all assistive products for the visually impaired.

The issues raised during the session can be illustrated with the following quotes:

"One of the cons is that people see there's something wrong with your eyes, so you feel that you're being treated differently. I could always see, I became blind in 2016, and you do notice a definite difference coming from your environment."

"You do lose a lot of friends."

Joris (when the subject gets changed to going out in a busy bar): "Avoid." People agree.

"Sometimes I'm using my phone in public and that also makes people curious: "You're blind right? But you still have an iPhone!" Especially when the voice speed is fast, people are amazed you can use it. And then there's already a loss of a social barrier. "

"I once had dinner in a themed restaurant, and a magician got mad at me for not responding to his tricks. You experience things that are quite weird."

"You choose visibility, and the degree of visibility would be nice to be able to control."

Their relations with the cane can be illustrated with the quotes below:

"When someone walks with a cane, people won't talk to you that often, but a dog gives people a lead to make small talk with you. And that gives life a different colour."

"The cane is empty. It doesn't have any qualities that attract people."

"I don't often use my cane, because I see just enough to see the world around me react to my cane. And I don't have the need to be seen as dependent and pathetic."

"If there's a genuine interest in for example a guide dog or an iPhone, that breaks barriers. But you don't accomplish that with a white cane."

"I know I can carry a larger cane and the solution is there, but my emotions say that I'm not up for that yet."

"If you don't walk around using a white cane, the world will judge you as a sighted person. And that's what you'll have to deal with."

Figure 53: *Participants ideationg during the session*

51

10 | Conclusions of the field reserach.

Everyday struggles

Attitudes

Positive aspects

Dilemmas

52

This section contains the answers to the initial research questions. To complement these results, the positive aspects of VIP life identified during the research process are also described. The research activities showed that there these aspects are a crucial part of experiencing VIP life. Next to the perks of being a VIP, many dilemmas of the VIP life also surfaced. The most notable ones are described in this chapter, including the key dilemma of navigating as a VIP.

The research activities and their results were used in the context of a design graduation project. The positive aspects and dilemmas outlined in this chapter were used as the starting points of the ideation phase of the project.

The research activities helped the researchers to form a solid network of stakeholders. This network consists of visually impaired people in various stages of their impairment, offering a rich dataset that touches multiple facets of the visually impaired experience. It also consists of trained professionals that help these visually impaired people reach their full potential, including professional mobility trainers and social workers.

This research phase also allowed us to empathise with the visually impaired target group more deeply. Experiencing both practical and social difficulties through autoethnography and talking to and observing actual visually impaired people in their daily routines allowed for more empathic design solutions and ultimately more added value.

53

Everyday struggles

VIPs face many struggles in their daily lives. We have found issues such as sensory overload, having a tough time avoiding obstacles and people offering unnecessary help. Apart from the issue of mobility, we have found many social struggles, such as having trouble explaining their impairment to bystanders and perceiving social stigma due to their impairment and its signifiers.

Increased visibility due to (effects of) impairment.

Visually impaired people face a lot of issues executing mundane visually-oriented tasks. This can have great effects on both the enjoyment of life and the way visually impaired people present themselves to the outside world. This problem is illustrated by this quote:

Ines has a small amount of mascara in her hair. We assume she has a hard time maintaining her appearance. When asked about this, she confirmed that choosing the right clothes became harder and shopping is not as much fun as it used to be.

These problems can cause visually impaired people to stand out from the general populace, drawing even more unwanted attention to themselves. The researchers regard this as a strong design direction, possibly offering great amounts of value. This extra level of visibility is supported by the following quote from one of the autoethnographic studies:

A man was looking at Veronika, noticed he caught my eye and then looked away, all the way behind him. He proceeded to pretend that he was looking around at his surroundings with great interest.

VIPs can are oftentimes reminded of their increased visibility in public spaces:

One time, she walked outside with a cane and a child yelled she saw a blind woman. "That was very rude and confronting."

On a deeper level, this increased standing out leads to a reduced sense of belonging in many visually impaired people, causing them to lose their bonds with communities they were once tied to:

Rachid: "I think that when you finally do walk with a cane, people will drop out." Bruce: "You don't fit in their image of you anymore." Bert: "It's also the fact that people don't know how to behave, themselves. So they might avoid you for that reason. Rachid: "It's new for them, as well."

54

Loss of agency.

Visually impaired people experience a loss of agency in almost all facets of life. The most obvious example is their inability to, in most cases, go out in public by themselves. This is a mobility issue, as illustrated with the following quote.

She uses public transport as much as she can, but in the evening, she is not able anymore. She travels a lot less than she used to.

But the loss of agency runs a lot deeper than that and can be way more subtle and, in some ways, more impactful than just mobility issues. Visual impairment can cause people to not only limit their mobility but also avoid entire environments altogether. This can be illustrated with the following quotes and observations:

Jaap remarks that at the central station people are blocking the guideline, put their luggage there or stand on it. He is reluctant to go there.

When asked how he would deal with going to a crowded bar, Nick answers he would always "avoid it". The others in the room agree.

Another aspect of this loss of agency is the difficulty to ask for or receive assistance when a visually impaired person needs it. On the one hand, many visually impaired people experience intrusive behaviour from bystanders that offer them help. Oftentimes, this is coupled by touching, tugging or other unwanted actions. On the other hand, asking for help can be embarrassing. This is a recurring problem that can be illustrated with the following data from the research:

Ines: "The worst thing about this kind of night is asking for help in mundane tasks."

Difficulty communicating the (effects of) impairment.

Some visually impaired people have a hard time communicating their impairments to the people close to them, causing all kinds of misunderstandings. This may be due to ignorance in the general population about the various kinds of visual impairment, or the impaired person's own inability to talk about their struggled. This can be nicely illustrated by the following interaction, taken during the observation of a discussion between a newly visually impaired person and a social worker.

Menno has had a stroke and lost a part of his vision. This is called hemianopsia. His newfound visual impairment costs him a lot of energy and the company doctor doesn't recognise this. Neither does his brother. He is not very good at sharing concerns with friends.

Alma: "When people see the words "visually impaired", they think it can be solved with glasses."

Menno: "You can't see anything about the impairment so that's the problem, really." Ria agreed, saying she is tired of explaining her husband's behaviour all the time. "People keep asking me, why isn't he joining this time?"

55

Face-to-face communication can also become a challenge, as it is, for the sighted, heavily reliant on visual cues and nonverbal communication elements.

When ordering, I was completely incompetent in reading the situation. It wasn't a pleasant experience; I was extremely self-conscious. I felt I was missing out on the reactions, the facial expressions. It was exhausting.

Having a negative or changed self-image because of the impairment.

The impairment, the assistive products used to mediate it and the message they send to the outside world can change the self-image of visually impaired people. Most visually impaired people get confronted with that on a regular basis. We would like to share this quote as an example:

One time, she walked outside with a cane and a child yelled she saw a blind woman. "That was very rude and confronting."

As was established in the section "VIP representation", there are plenty of misconceptions about visual impairments in the general populace. These misconceptions can often have a large impact on visually impaired people. There are various coping strategies, the foremost being the use of humour to ease the tension:

Lars: "You're not seen as being full. I have a button that says: "visually impaired". One day someone walked up to me and said "I don't believe it. You don't look retarded." Literally."

Although it has affected him very much, Menno is very humorous about it all: "The bus (that disabled people use in Holland to go to work) has arrived and here I am!"

56

Attitudes towards assistive devices

Through multiple observational studies and a generative session, many different attitudes towards the use and stigma surrounding assistive technology have been uncovered. These particular attitudes will form the base of personas to design for in the next steps of this project. Some attitudes here will be discussed and illustrated using quotes.

Connecting assistive products to self-image.

As already discussed in the section above, impairment can greatly change one's self-image. Assistive products, often used by impaired people, play a big part in this change. Numerous points of evidence were found that indicate this is one of the main psychological aspects of using assistive products. Users often feel like they are seen by others as less capable, or on some occasions even less human. This sentiment is illustrated by the following quote:

Lars: "I don't often use my cane, because I see just enough to see the world around me react to my cane. And I don't have the need to be seen as dependent and pathetic."

This often causes visually impaired people to postpone the public use of assistive products such as white canes. Because the cane is a signifier that its user is visually impaired, making the step to using a cane is often seen as admitting to oneself that one is indeed visually impaired:

Lars: "I know I can carry a larger cane and the solution is there, but my emotions say that I'm not up for that yet." Ines remarks that "the white cane is stigmatising".

Peter: "As long as I can go without a cane, I won't use it. Reason one is that I see it as a step backward in independence. That to me weighs more than the extra effort needed to get around."

As time goes by, some visually impaired do get over this dilemma:

Irene became visually impaired slowly and took twenty years to admit it to herself. "Walking with a cane is admitting. Eventually, you have to, and you get over the fact that people see you differently."

57

Facing the reality of the situation.

Some visually impaired people take the assistive products for what they are and use them regardless of the negative effect they might have. Most of these people became visually impaired due to an accident of rapidly progressing illness, causing them to not deal with the transition other visually impaired people might face. They use their assistive products because they must and often indicate that they were left with no other choice. This sentiment is echoed in the following quotes:

Jaap (when asked whether the pros outweigh the cons in using a cane): "I don't have a choice; I don't see anything."

Jaap: "For my self-image, I would not like everyone to see I am blind. But I am, I am someone with a double impairment. This is the way it'll have to be. If I don't use the cane, I won't be able to go outside."

Some assistive products for visually impaired people are designed with sighted people in mind and have a layer of added functionality that makes them usable. Some people still use these products because they offer a lot of benefits and put up with the discomfort of use. This is what we observed during the ICT training for the visually impaired:

Even the teacher doesn't know the answer when confusion arises whether they are in "rotor mode" or not. The teacher suggests rebooting the iPad.

A lot of people use the keyboard because the gestures don't always work as intended. The gestures are finicky.

The teacher and Irene complain about updates changing shortcuts.

Not letting the opinions of bystanders affect you.

Some visually impaired people are not affected by the reactions of bystanders to their impairment, and thus don't feel the stigma. Others have felt that stigma in the past but are now so acclimatized to it that that they don't let it

58

bother themselves any longer. Oftentimes, these are either individuals that were born visually impaired or have been so for a long amount of time. See the quotes for examples:

Bert (when asked about whether he feels eyes on him when walking in public): "No, I'm over that. I don't feel it and I don't care." Lars: "Do you still register that people look at your more?" Bert: "No, I'm preoccupied with my own route and my own thing."

Jaap: "If I try to hide it, I'm only kidding myself and spend unnecessary energy on other people's opinions."

Being concerned about the social effects of using specific assistive products.

While some visually impaired people are concerned with their self-image due to using assistive products, this participant group is mainly concerned with their changing social roles due to their impairments. They worry that their use of certain assistive products limits their social interaction when out and about and base their choices of and attitudes towards assistive products on that. We provide some quotes to provide some perspective on this attitude:

Bert: "If there's a genuine interest in for example a guide dog or an iPhone, that breaks barriers. But you don't accomplish that with a white cane. It's a dead object that signifies your impairment. They should have made the bands black instead because it's a black-and-white object."

"I walked into a restaurant with a cane a few times, and it instantly became quiet."

"When walking with a dog, people offer you help a lot quicker. They don't do that when you're using a cane."

Lars: "If you don't walk around using a white cane, the world will judge you as a sighted person. And that's what you'll have to deal with."

59

Positive aspects

During the research activities, several aspects of the VIP life surfaced that are clearly positive. These positive aspects served as a strong source of inspiration, therefore worth collecting. In the following section, each aspect is illustrated with quotes from the research data.

The kindness of strangers

VIPs receive smiles of encouragement and positive attitude from bystanders.

A lady walking with a bike first looked at, then smiled at Veronika. This lady was checking Veronika's safety and then felt happy to see she was doing well on her own.

People, in general, were curious about how Veronika navigated or wanted to make sure she was okay.

An older lady smiles at Thijs while passing. She was encouraging us.

The right of way

Being visibly visually impaired can grant safe passage.

I was walking knowing that passers-by will look out for me a bit more, this gave me a sense of safety.

People standing on the guideline move out of their way. The guideline was opening like the sea to Moses. It was quite touching.

Seeing the people moving away from my way, opening the guideline gave a satisfying feeling. I felt that the cane has the power to grant me passage on the train platform. People who were looking at their phones heard the noise of the cane swiping on the guideline and moved away as well.

Liberating limitations

There is more space for imagination if your vision is limited.

Because I could only discern shapes and the buildings around were columnated white, it felt like walking around ancient Rome.

60

Margot remarks: "I feel like I am living in some kind of parallel world".

The blurriness made it feel as if I was underwater. The face of the office building next to the station looked like the Coliseum. The low definition and high contrast inherent in my vision turned the world around me into simplified shapes and icons. This made my brain fire rapid associations in an attempt to make sense of it all.

Camaraderie

There is a strong sense of camaraderie in the VIP world, which can serve as a source of consolation.

Jaap meets Seb, a visually impaired man approaching. They recognise each other, make jokes and are friendly. The two men already know each other, maybe from Visio. They are friendly because they might be going through the same.

Jaap meets another man walking with the cane. They know each other. The man cheers him on with the training. Jaap seems happy about the support of his peer.

We saw that VIPs who attended were in a positive mood, greeting each other. I don't suppose they meet so many fellow sufferers very often, and at this fair, they were the "normal people", the sighted were the ones out of place.

Mundane magic

Performing normal activities or using products without vision seems like magic to the outside world.

The client (Irene) is already skilled in using voiceover on her iPhone. Irene uses her iPhone with a black screen, she is navigating in her emails quickly and confidently.

"A few times a year I have people coming up to me that don't believe my button. For example when I was playing football in the schoolyard. It's all about public perception."

"Especially when they hear you can still use Facebook and Instagram."

"Especially when the voice speed is fast, people are amazed you can use it. And then there's already a loss of a social barrier."

61

Dilemmas

When conversing with VIPs, it soon became evident that their emotions towards the cane and cane use are conflicting, sometimes strongly turbulent. Cane users were having a love-hate relationship with it:

Jaap doesn't know whether he liked being more visible with the white cane: "It's a little bit of a double-edged sword, isn't it?"

and the ones putting off the cane use were themselves considering it a slightly irrational behaviour, and were critical about it:

"I know I can carry a cane and the solution is there, but my emotions say that I'm not up for that yet."

To better understand the emotions involved, the dilemmas inherent in the research data were identified. When referring to dilemmas, a holistic perspective was used, considering cognitive, behavioural and emotional aspects (as outlined by Ozkaramanli (2017)). In the case of each dilemma, a mutually exclusive choice has to be made. This choice on the behavioural level results in conflicting concerns on the cognitive level, and mixed emotions on the affective level (Desmet, Ozkaramanli, & Özcan, 2013).

The resulting dilemmas are described in the following section, illustrated with quotes from the research.

62

I want to navigate with ease ↔ *I want to be honest about my abilities*

I also felt like I was tricking bystanders as if me pretending to be blind was somehow unfair to them.

The cane was still very useful as I could still feel the ground in front of me and thus did not have to think that much about navigating curbs and slopes. Otherwise, this would have been very exhausting navigation.

I had an awkward feeling. I was anxious about looking around as I had the assumption that people generally don't distinguish between the different visual impairments and suppose everyone with a cane is totally blind, so they will notice me looking around and will think I am just acting as I was blind.

I want to receive navigational information to make up for my impairment ↔ *I want to walk undisturbed*

Thijs gives a lot of information about the surroundings while crossing. He wants to involve Veronika in the navigation as much as possible. It is questionable how much Veronika can actually do with all of this information.

Veronika tries to give Thijs cues in the navigation by naming the buildings but it doesn't really help him. As Thijs is not really familiar with the city it only adds to the information overload already created by all the audio, so he is not happy about this.

"Using this technology with voice application can cause audio overload." Listening to the voice on her phone and the sounds around her is auditory overstimulation.

I want to use new tools and technology ↔ *I want to stay with the well-established ways of doing things*

"It sometimes doesn't work, so most people do it the old way." There is some level of distrust towards newer technologies.

Irene remarks that "(...) it is true that you have to remember a lot, but you can do it by ear if you know the basic commands." She is optimistic about the capabilities of the system or isn't able to imagine any other way that might be smoother.

"I was walking down the street a while ago and saw a man walking with a cane using sonar to determine where a pole was. I was in awe."

63

I want commute safely ↔ *I want be accepted*

"The cane seems very confronting, pointing people to facts they don't want to accept."

"When using a cane, people don't dare to talk to you anymore. I walked into a restaurant with a cane a few times, and it instantly became quiet." This is a stigma at its most immediate.

"As long as I can go without a cane, I will. Reason one is that I see it as a step backward in independence. That to me weighs more than the extra effort needed to get around."

"For my self-image, I would not like everyone to see I am blind. But I am, I am someone with a double impairment. This is the way it'll have to be. If I don't use the cane, I won't be able to go outside."

I want to live a full life ↔ *I want to have an easy life*

She only goes to stores where they already know her and her condition, as it is a hassle to explain it, and what kind of help she needs. It is hard to get it through to people what her condition implies, and what can she do herself, what is hard and what is not really possible

Jaap tells us that learning this route to the bus really opens up options. He is going through this hardship in order to still be able to live a rich life in possibilities. "Walking or navigating when visually impaired takes way more cognitive energy and power of memory."

Menno has the dilemma of going to a dance performance of her granddaughter. He wants to go, but it is a tiring thing for him to have a whole evening in the city. Menno: "These are dilemmas that people just don't get."

64

I want to manage on my own ⟷ I want to receive help in navigation

Veronika is uncomfortable asking directions. She does not want to randomly approach people on the street.

He is not very good at sharing concerns with friends. He seems to be very down-to-earth about his condition and finds it unnecessary to bother others with it.

I want to indulge my curiosity ⟷ I want to conform to social norms

Some people in the station glance at Veronika from the corner of their eyes. A man was looking at Veronika, caught my eyes and then looked away completely. This man was ashamed to be caught looking, so pretended like he was looking around very interestedly.

I want to show my impairment to stay safe ⟷ I want to fit in while in commute

A gentleman coming down the stairs did not know what to do when Margot - who was going up the stairs - suddenly stopped walking up. He kept standing, waiting for Margot to pass. It is not visible that Margot is visually impaired. As such, she showed weird behaviour for a "sighted" person.

Jaap is sceptical of a way for him to be as visible to the outside world in a nicer way: "What, with lights, a horn or electrocution?"

Jaap doesn't know whether he liked being more visible with the white cane: "It's a little bit of a double-edged sword, isn't it?"

Menno: "You can't see anything about the impairment so that's the problem, really."

The "cane dilemma"

This dilemma arises when deciding whether to start to use the cane or continue to commute without the cane. This choice is present with deteriorating eyesight, in the transitional period.

Using the cane will fulfil the concern for autonomy ("I want to be able to commute on my own") but it also results in a more visible impairment. On the other hand, not using the cane fulfils the need for belonging ("I want to be accepted"), but will make commuting more challenging, or even impossible. This results in mixed emotions about cane use. Using it will evoke feelings of confidence, safety but also feelings of being judged and rejected, while not using the cane will make you feel in control, accepted but also dependent, overwhelmed and vulnerable see table below.

	I want to commute on my own	I want to be accepted
Mutually exclusive choices [Behavioural level]	Use the cane	Go without the cane
Conflicting concerns [Cognitive level]	Autonomy	Belonging
Mixed emotions [Affective level]	Confident Safe Being judged Rejected Stigmatised	Dependent Vulnerable In control Overwhelmed Accepted

66

350

Plastics Inc.

Ideation and conceptualisation.
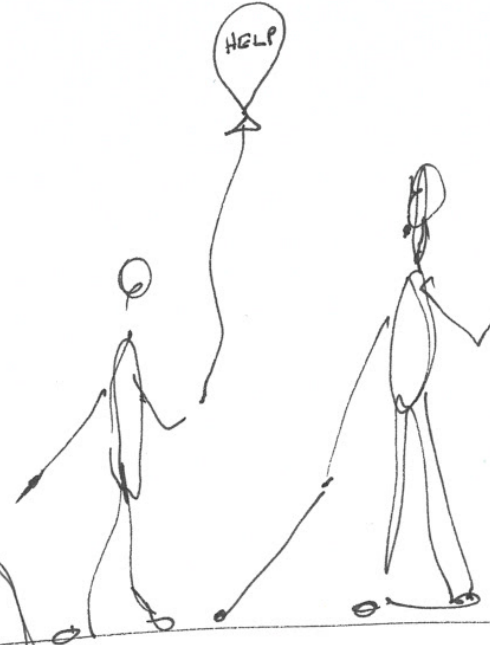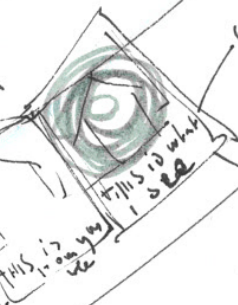
11 | **Design directions.**

*The insights, experiences, and knowledge gained from
the first project phase were translated into design goals.
To preserve the richness of the field research results, the
goals presented in this section are not requirements, but
parallel visions towards a more positive VIP experience.*

Creating a mobility solution that aids VIPs in the transition period.

Creating a mobility solution that transforms a disabling environment into an enabling environment.

Creating a mobility solution that helps dealing with the social aspects of impairment.

Creating the feeling of being in control.

12 | Ideation.

During the idea generation phase, the results of the field research were used as starting points. In the case of the positive aspects of being a VIP, I was looking for ways to enhance them. In the case of the dilemmas, opportunities to resolve, moderate or trigger dilemmas were explored (Desmet et al., 2013).

The idea generation phase resulted in a high number of ideas. These ideas were collected and clustered based on the product intervention model for stigma framework (PIMS) developed by Vaes (Vaes, 2014). This framework contains 17 intervention types to combat product-related stigma, the three main categories of interventions being product, user, or culture focused. The intervention categories are visible on figure 54.

The idea clusters are visible on the following idea heatmap (figure 55) where each idea is represented by a dot. As it is visible, some categories contained a high number of ideas, while other categories remained empty. The full list of ideas can be found in Appendix G.

Product interventions

|			
De-identify	**1. Camouflage or disguise** stigma-sensitive product features	**2. Diversion of attention** divert the bystander's attention away from stigma-sensitive product features		
Identify	**3. Strengthen the product's individual identity** in such a way that users wish to associate themselves with that product, and value it as an extension of or addition	**4. Strengthen the product's institutional identity** Reinforce the link between products, their institutional context and roles people play in those institutions	**5. Strengthen the product's group identity** in such a way that it enforces feelings of belonging to a social group or subculture	**6. Strengthen the product's brand identity** Avoid negative brand associations and reinforce positive brand associations
Product use	**7. Eliminate physically or mentally confronting moments** in product use Adapt the product's functionality or its usage rituals accordingly.	**8. Integrate additional benefits and experiences** Incorporate experiential benefits that pleasantly surprise the user beyond the strictly practical and functional product aspects.	**9. Manage the frequency and intensity of product use** Adapt the product so users can limit the frequency or intensity of product use and reduce social tension and exposure.	**10. Focus on the ultimate product goal.** By exclusively addressing this ultimate goal, the product could become obsolete in all other situations.
Material & technology	**11. Reshape product meaning through advances in technology** Applying new technology can make a product smaller, more performing, cheaper to buy and own, etc.	**12. Reshape product meaning through advances in material technology** Applying new technology can make a product lighter, more ecological, etc	**Interaction**	**13. Reflects on meaningful interaction with other products.** Strive for a semantic cooperation between complementary products / mimic the typology of a product that is accepted.
	14. Endow the product user with extra abilities Instead of adding disabilities, try to increase the user's abilities above those of 'abled' users. Extra ability can also be suggested.	**15. Boost the user's social skills.** Make the user rise above the reactions of others by making him or her visually or verbally more assertive.	**16. Campaigns or interventions** that educate or change public views. Also consider interventions in public space to promote interaction or appropriate behaviour	**17. Increase positive social visibility/product endorsement.** Increase the social 'visibility' of the product/ product endorsement by influential political, sports or media figures

User interventions   **Culture interventions**

Figure 54: *The product intervention model for stigma framework (PIMS) developed by Vaes (Vaes, 2014)*

Ideation and conceptualisation

Product interventions

De-identify

1.. Camouflage or disguise

2. Diversion of attention

Identify

3.

individual identity

4.

institutional identity

5.

group identity

6.

brand identity

Product use

7.

physically or mentally confronting moments

8.

additional benefits and experiences

9.

frequency and intensity of product use

10.

ultimate product goal.

Material & technology

11.

advances in technology

12.

advances in material technology

Interaction

13.

meaningful interaction with other products.

14.

extra abilities

15.

social skills.

16. Campaigns or interventions

17.

social visibility/ product endorsement.

User interventions

Culture interventions

Figure 55: *Ideas clustered by the PIMS model. Each idea is represented by a dot.*

13 | Evaluating the ideas.

This section contains a selection of ideas. These ideas and idea clusters were the basis of the final concept or served as inspiration while deciding on the functionalities and the final design approach

VIP pulse cane

Strengthen the product's group identity in such a way that it enforces feelings of belonging to a social group or subculture.

One way to enhance group identity is to communicate it towards the majority society, like in the idea "VIP scout vest". This is a way to communicate the achievements that are related to being a VIP, for example, training completed and skills cultivated.

Another approach is to cultivate relationships and camaraderie inside the VIP subculture. In the idea "VIP message board" the whole city is turned into a messaging board for cane users, where messages are deployed and accessed with the help of the cane.

In the idea "The VIP beat" the pulsating cane handle transmits the 'pulse' of the community to each cane, this way symbolising the connectedness.
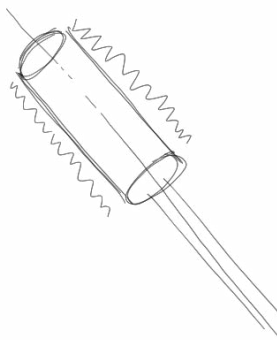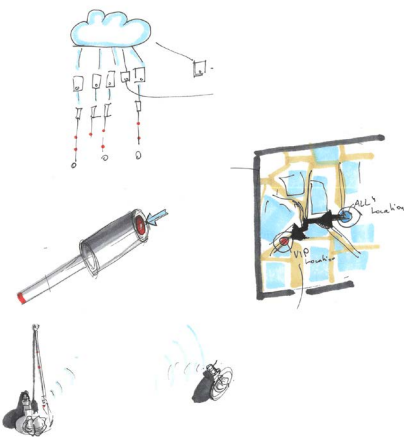
Be a VIP ally

Reshape product meaning through advances in technology

There are many ways technology can be used to aid VIPs in the daily struggle surrounding commute. In the "VIP ally community" the community of allies goes to the aid of VIPs in need of help. The distress signal can be sent by the help of the cane, and the closest allies are notified that their help is needed.
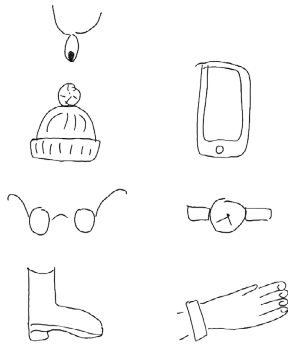
Everyday objects as spy gadgets

Autonomous guide suitcase

Figure 56: *Sonar hands*

Camouflage or disguise stigma-sensitive product features

The first idea group, that I found especially inspiring, contains ideas that in some way hide the impairment or provide aid in a private manner. This can be achieved for example by embedding sensors and haptic actuators in a set of every day looking objects, to create a VIP spy gadget kit. Another, rather futuristic idea is to enhance user abilities by body modification, thus creating the VIP with Sonar hands.

In the case of the Autonomous guide-suitcase, the functionality that the product fulfils is more similar to the guide dog's role. The suitcase is housing sensors for information gathering and obstacle detection and is also responsible for navigation and route planning around the obstacles.
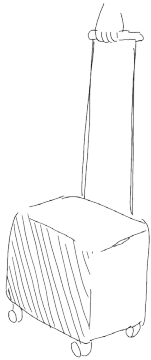
The problematic feature in this group of ideas is that by disguising or hiding it the mobility aid is stripped of the semantic qualities enabling the signalling of the impairment. Being recognisable and visible is one of the main goals of my starting point, the white cane. As Vaes puts it, "By virtue of its contrasting white colour and universally recognizable shape (identity and character), it bears important semantic qualities that identify its user and radiate outwards towards its social surroundings." Losing this would lead to a lower level of safety while in commute.

The technology-aided information gathering about the environment and translating it to non-visual stimuli is an approach that played an important role in the final concept.
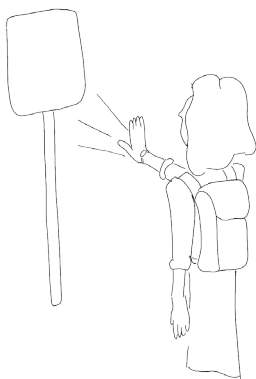
14 | The DotBot concept.

The DotBot is a navigation aid consisting of a network of location-specific information nodes (Dots) and a cane. The meaning of each dot is personalised, based on the user's choices and the user's experience with the area/route. The personalised information packages can be accessed with the help of the cane.

The chosen concept contains elements of more than one idea or idea clusters.

Its goal is to provide navigational and environmental information to VIPs in a manner that is accessible with the cane. The information is stored in the form of audio messages and descriptions. And is mostly created by the userbase of the product, by creating a virtual community to facilitate sharing of commuting know-how. The information points make use of the stopping points of an existing VIP relevant infrastructural element: the tactile paving.

The interaction is inspired by ideas aimed at camouflaging or disguising the impairment. As visibility is important in safe commute for VIPs, I decided to keep the semantic qualities of the product, therefore making it recognisable like a white cane.

However, there are moments where the effects of impairment are preferred to keep private. Thus I aimed to keep the moments where asking for help or directions to the minimum and aid VIPs in cultivating pride and the feeling of competence with exercising their ability to navigate autonomously. This is made possible with the way the information is stored and accessed: for the outsider eye accessing information from a road stud on the tactile paving is invisible.

The concept is aimed to enhance the already existing positive sides of being part of the VIP community, cultivating feelings of connectedness and belonging. These aspects are inspired by the ideas about group identity and added technology described in the idea clustering section.

Elaboration.

Localisation technologies

System architecture

Form giving

Build-up

App design

Use scenario

15 | Localisation technologies.

In parallel to the form-giving, the localisation technologies used in the concept were explored. There are a plethora of positioning technologies that can aid both in micro and macro navigation. In this section, these technologies are compared based on their performance and other characteristics, as described by Mannay et al. (2017).

Most common navigation systems work based on the GPS data received by the sensors of a smartphone. This can be an effective method of macro navigation. It has its limitations when it comes to VIP navigation and positioning.

Firstly, the accuracy of GPS navigation is not sufficient to efficiently aid in micro navigation. The second drawback of GPS technology is that it is not suitable to use in indoor environments (for example train stations, malls, hospitals, museums, etc.), as it needs the signal from the GPS satellites to be able to provide position data. This means that in daily navigation it has lots of 'white areas', and is not able to aid through the whole route.

To achieve a system that is capable to aid in both micro and macro navigation, a hybrid system is ideal. Complementary solutions can be used next to GPS positioning to help with micro navigation. When using more than one positioning technology, the redundancy of the position data means more robust positioning, which allows for a higher level of safety and reliability. From the possible positioning technologies for micro navigation purposes, RFID positioning was selected for its low cost, sufficient accuracy, and low energy demand.

16 | System architecture.

The DotBot concept has four equally important components, the Dots, the Cane, the Dot Database and the DotBot app.

Database in cloud storage

DotBot App

Cane

Dot

The Dots store the identification of each location point. They are specific road studs (tactile pavement elements) containing a passive RFID tag.

The cane is used to read the dot ID and connect it with the database of information.

The DotBot app is the connection point between the Dot database and the user. It also enables the user to set preferences, plan routes, and connect with other Dot Bot users.

The database of location-specific information contains the audio notes and descriptions for each location node.

82
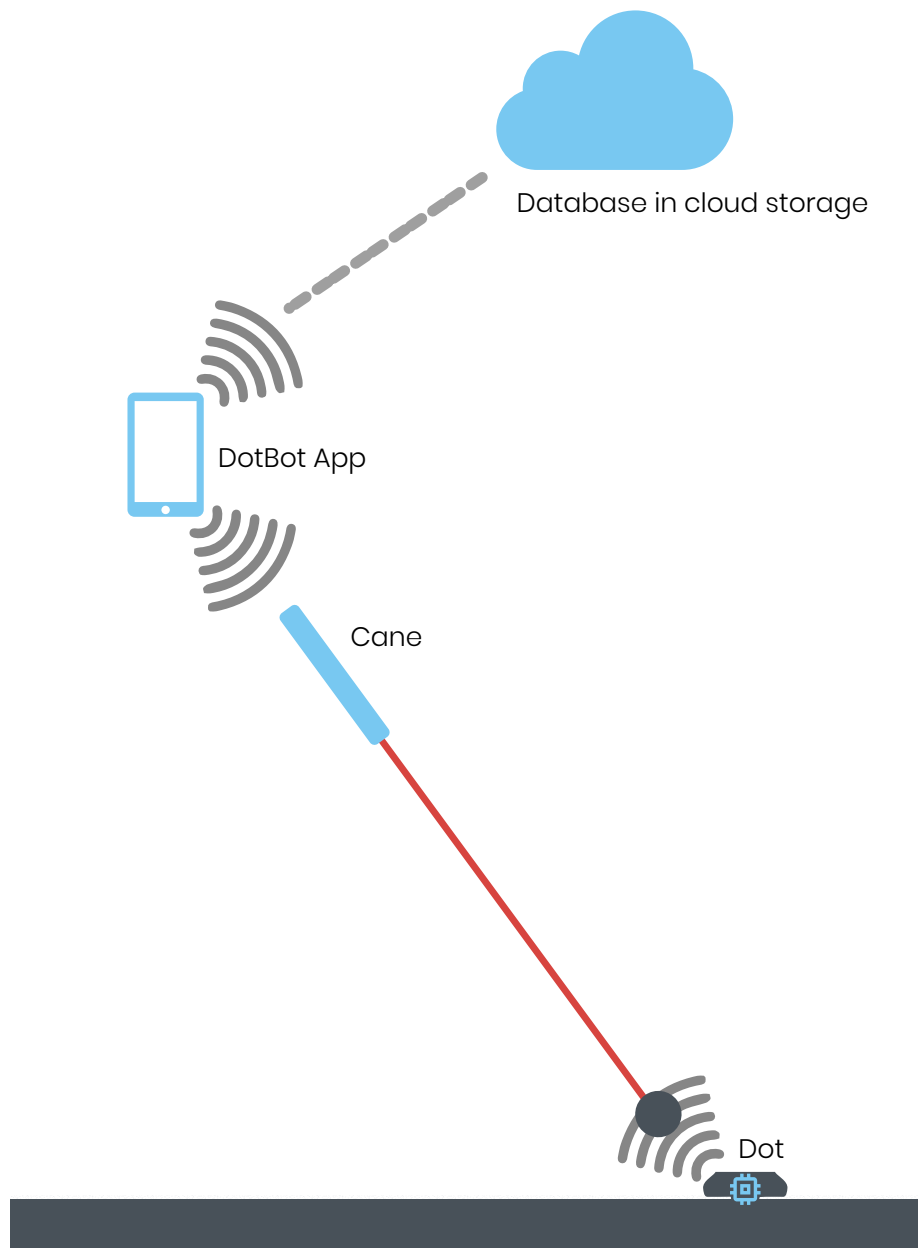
The database of location specific information. The information stored in the database is created mostly created by VIP users. It is stored in audio format, and can be filtered by relevancy to the remaining functional vision. Therefore the users only receive information that is useful for their specific vision state.

There are four layers in the database of auditory information in connection with the goal of the walk.

Navigate

This layer contains the basic navigational information on the current route.

Note

The second layer consists of the notes of the user. These notes can be personal, but some of them are useful for the VIP community. These notes can be shared.

Community

This layer consists of the notes of the individual users, thus creating an image of the area as perceived by the VIPs. This can also be personalised, as the individual user's Community layer is the sum of the shared notes of the people, institutions they follow. They can also have notes shared with only them, as personal messages hidden in the city, visible only for them.

Explore

This is the highest layer, and contains descriptions of places in a way that is focused on the aesthetic qualities and the poetic value.

83

17 | Form giving.
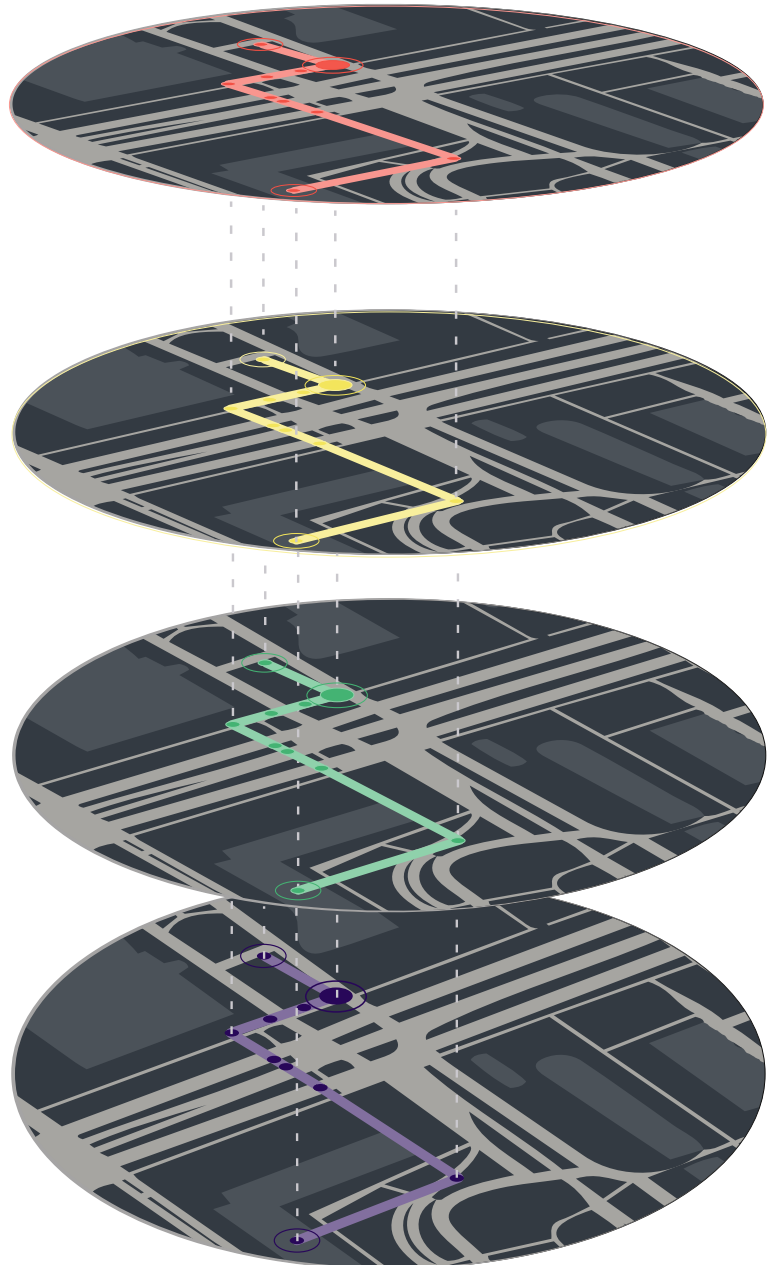
It was prominent from the results of the field research that VIPs do care about the aesthetics, and the image they present about themselves by products. For this reason exploring the aesthetics of the physical product had a great importance in the elaboration phase of the project.

Figure 57: *Experimenting with clay during the form giving process*

Aesthetic directions

The following section contains the aesthetic directions that served as sources of inspiration in the form exploration process.

The simplicity of the form-language makes an object easier to take in and understand. It can also serve as a source of poetic beauty.

The mindful and meaningful use of edges leads the hand during the use.

86
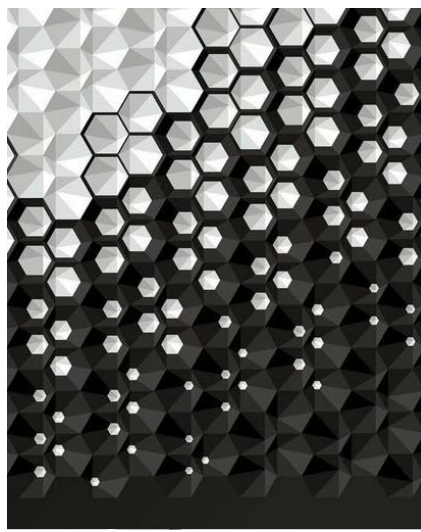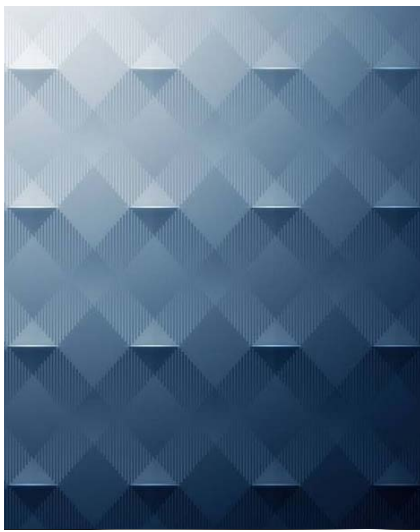
These colour gradients created with patterns and textures were inspiring for the final design.
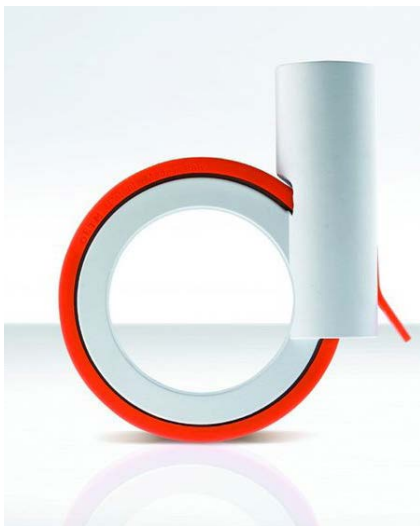
It was inspiring to see products in white and red, but outside of the medical realm.

Form exporations

To arrive at the final form, iterative form experiments were carried out. I used different techniques, to explore different aspects of the form.

Clay was used as a medium to experiment with basic forms and ratios. A high number of different form varieties were created by this method.
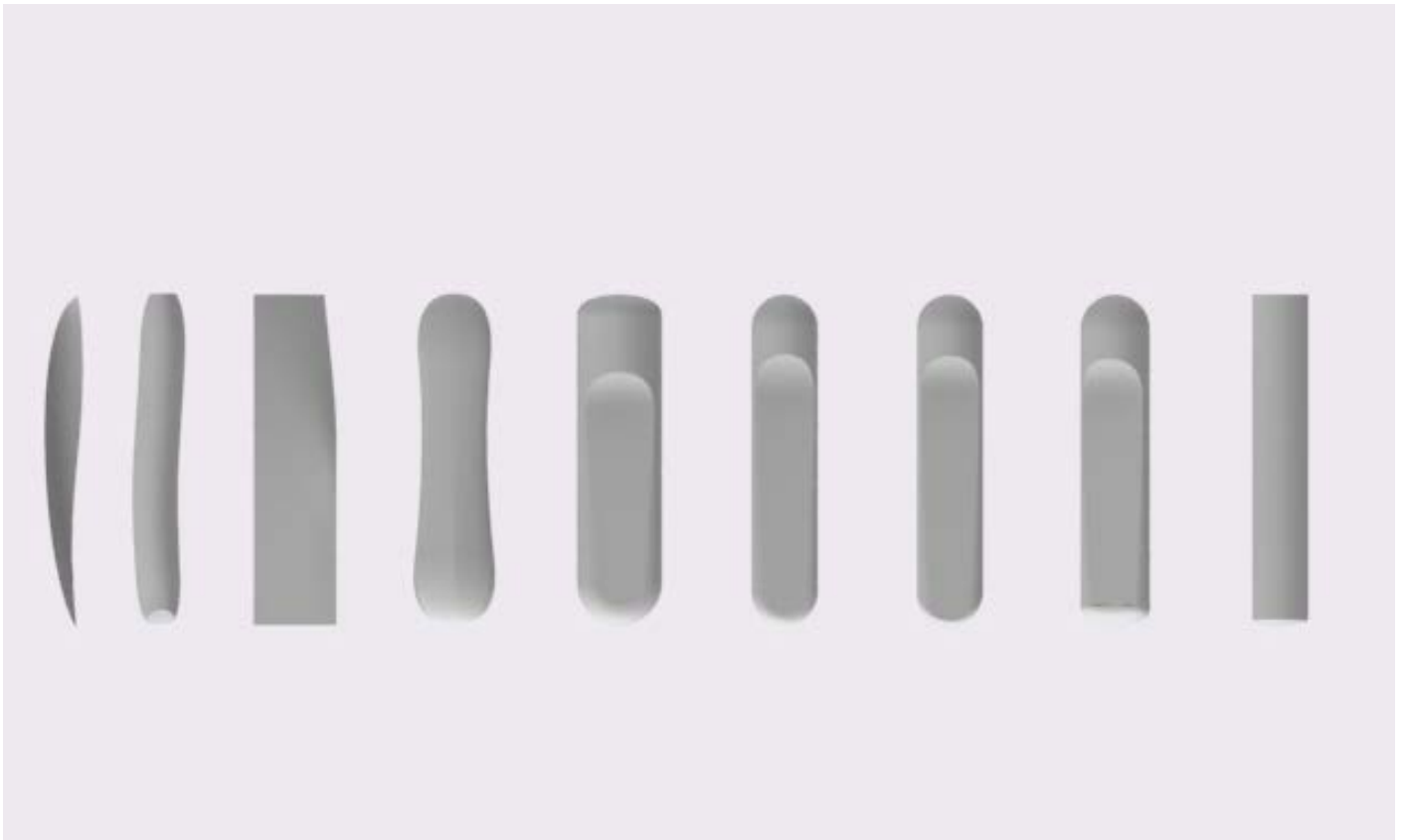
Figure 58: *Digital form experiments and 3D printed forms*

Digital modelling was used in pair with rapid prototyping (3D printing) to iterate on the selected base form Examples of the forms created during this process can be seen in the figures above..

90

Figure 59: *The final cane handle, as a white form*

Figure 60: *Exploded view*

Housing front

USB port

Battery

ON/OFF switch

Housing back

Vibration motor

PCB

Push button
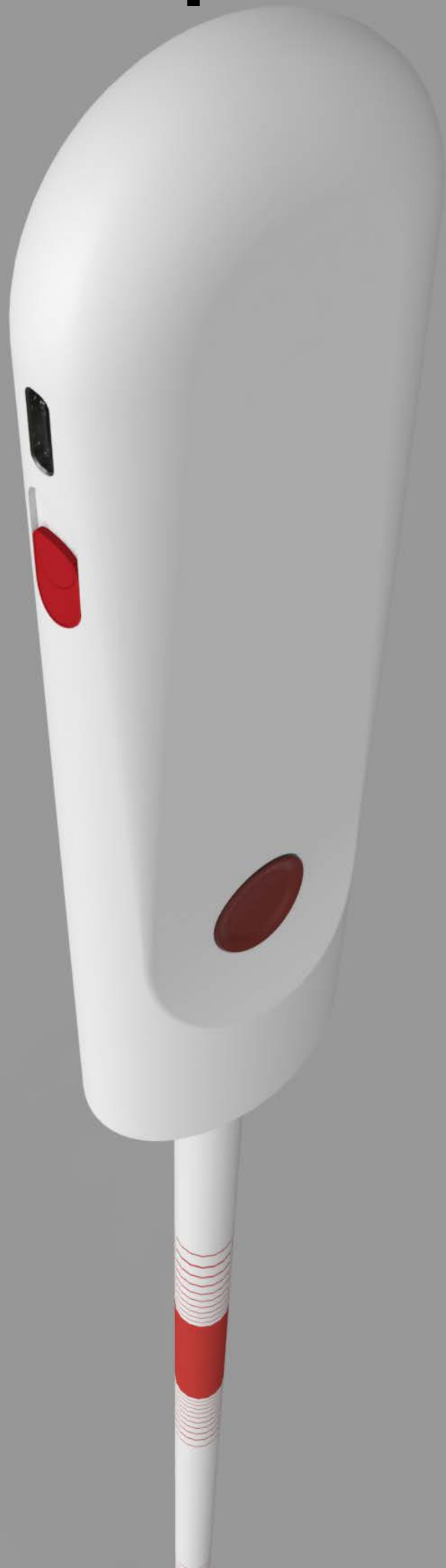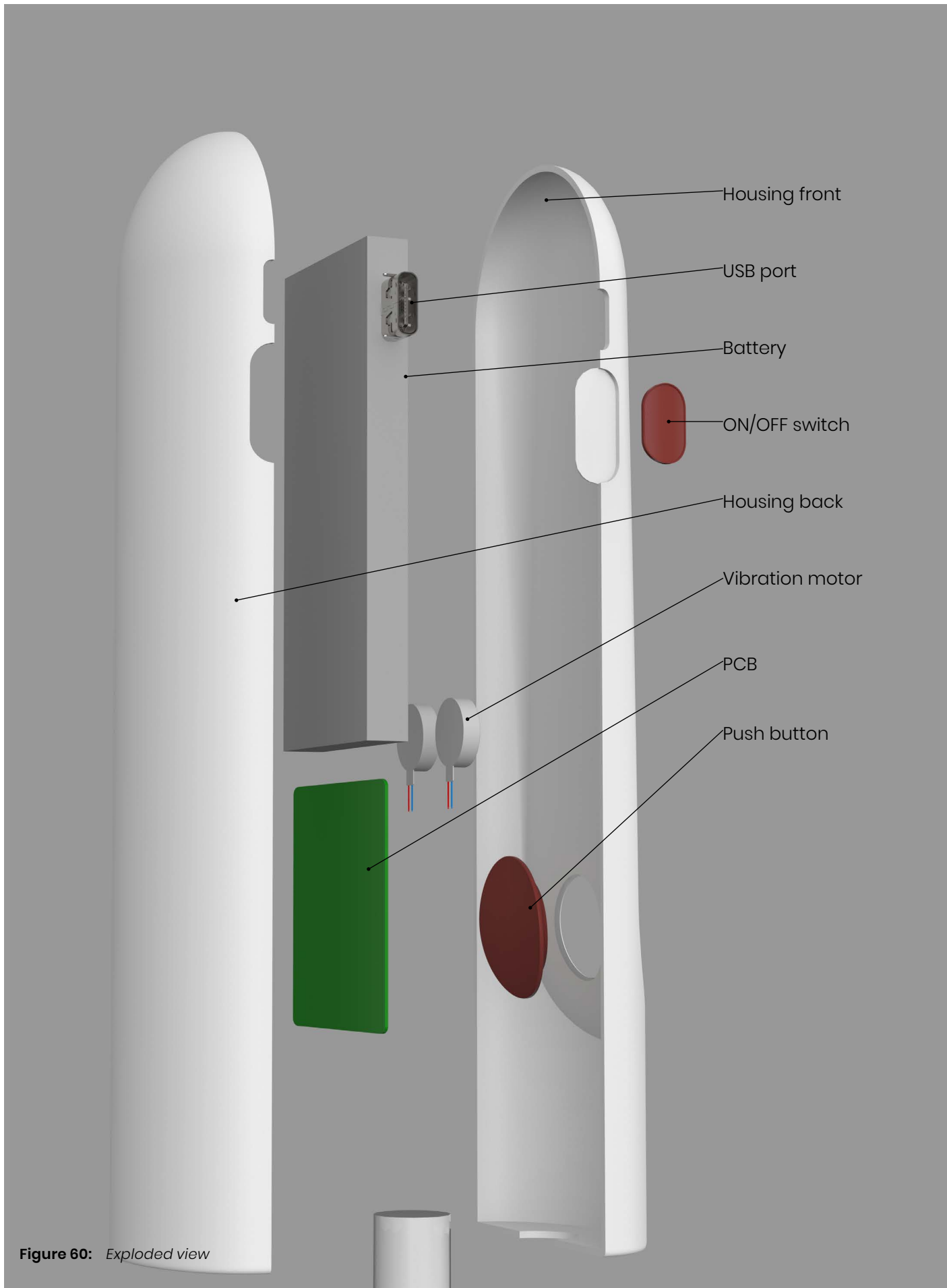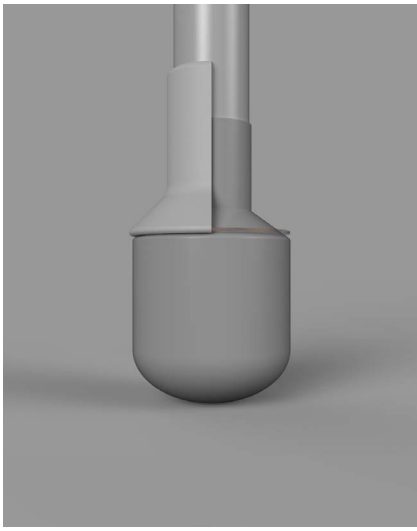
Figure 61: *The cane tip*
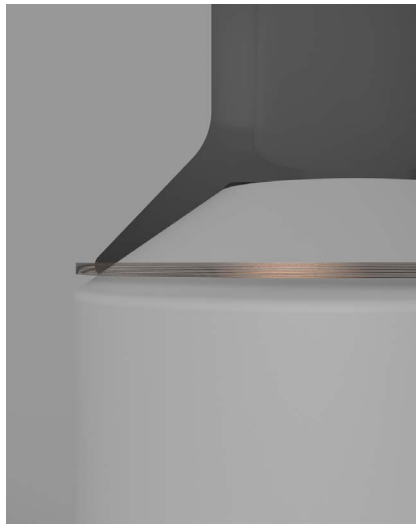
Antenna

The cane tip contains a robust, embedded RFID antenna. As this antenna consists only of a coil, there is a minimal risk of damage. As there are no other electronic components in the cane tip, no extra weight is added. The antenna is connected to the cane handle with a single wire, contained by the cane cavity.

PCB and Battery

The handle contains the PCB and the battery of the device. An important component on the PCB is the Bluetooth antenna, responsible for the connection between the user's smartphone and the cane. With a large battery, the cane can be operational for a long period without charging.

PCB   Battery
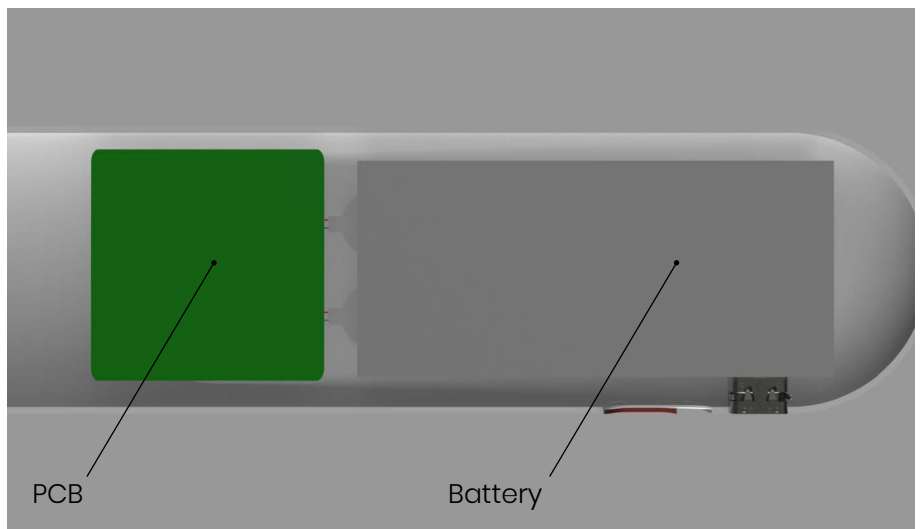
Figure 62: *PCB and battery placement*

Push-button and vibration motor

The vibration motors are installed on the housing, and the vibrations are transmitted to the users' grip by the housing material. The push-button has a noticeable colour and a relatively large size, therefore it is easy to find it with or without remaining vision.

Push button   Vibration motor
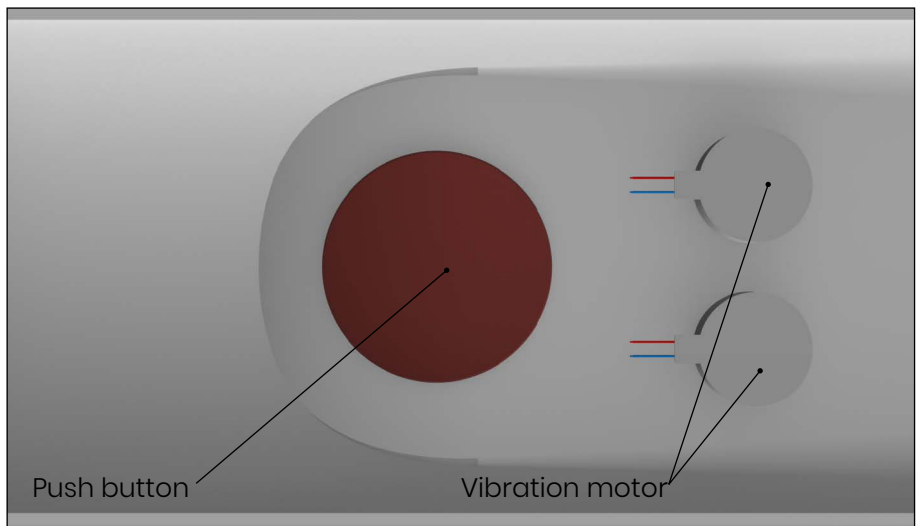
Figure 63: *The vibration motors*

94

Charging and on/off switch

The cane can be charged by the USB 3 port located at the side of the cane handle. The cane can be turned on with a slider. The textured surface of the slider provides a better grip for easier sliding. The slider has a distinct colour to help to locate it.

Figure 65: *Push button*

Figure 64: *Details of the final design*

Figure 66: *On/Off slider*

19 | The DotBot App.

The DotBot app is the point of connection between the Dot Database and the user.

The first app functionality is the filtering of the information available in the database. The type and amount of information received throughout each walk is determined by the user characteristics, like age, functional vision, interests, the user's experience with a certain area and the goal of the walk.

The user characteristics can be set before the first use and can be modified any time. The functional vision is an important filter as it determines the type of navigational cues accessible for a certain user. For example, users with no remaining vision won't receive information about visual cues, while someone with tunnel vision might be still able to read signs, will receive more visually based information. The experience level in a certain area is based on the routes taken by the user in the past. The goal of the walk can be set whenever starting a new walking session.

The app is also used to plan routes. It is possible to set favourite places to make rout planning more convenient and quick.

The Dot Bot app is to access the notes provided by other users (or in some cases, institutions). By following notes created by users experienced in a certain area, the relevant navigation cues can be shared with users who have a similar level of functional vision.

96

Phone 1 — MY FAVOURITE PLACES

MY FAVOURITE PLACES

Phone 2 — PLAN ROUTE

Home

Visio Den Haag

PLAN ROUTE
?

Phone 3

Home

Visio Den Haag

START

Phone 4 — MY FAVOURITE PLACES

MY FAVOURITE PLACES

Phone 5 — MARKED NODES

MARKED NODES

Visio
main entrance

Station
platform 7

TU
at the the library

Spui
in front of the city hall

ADD NOTE

Phone 6

Only me

Friends

Community

Custom

SHARE NOTE
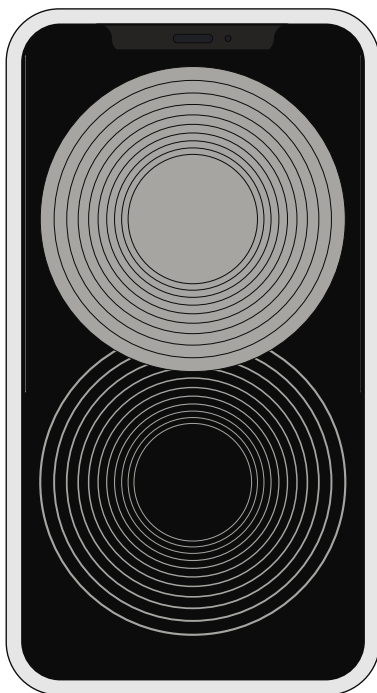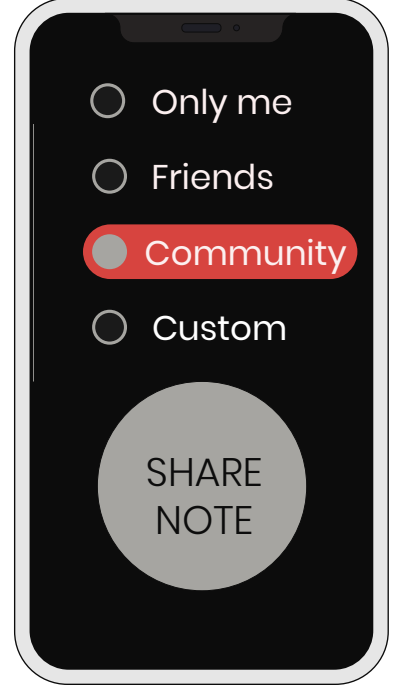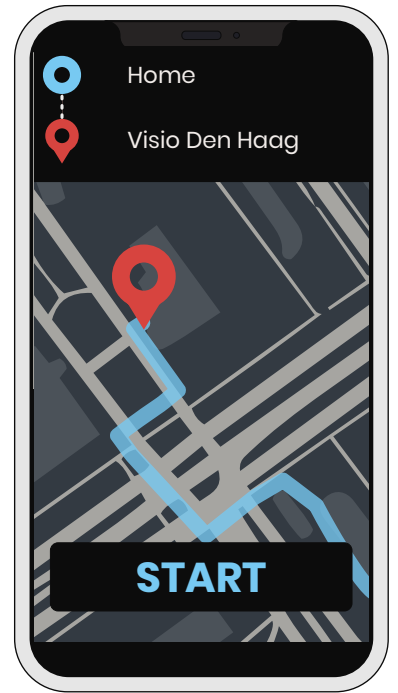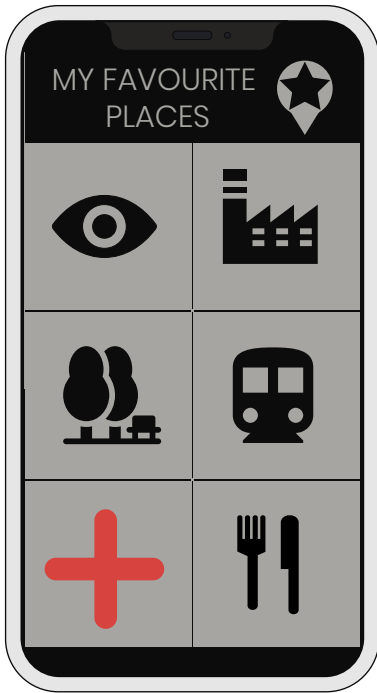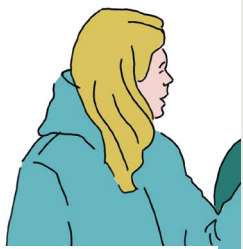
This is Roos,

VIP. She is gradually loosing her vision. She can still function fairly independently, but she will need a mobility aid in the near future.
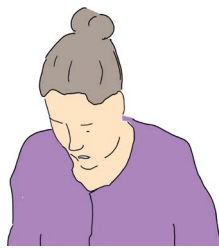
This is Anna,

Occupational therapist. She has 15 years of experience in training cane use, and got acquainted with the product 6 months ago.

This is Joost,

VIP. He has been an experienced cane user when he started to use the product. He met Roos at Visio 2 two years ago. .

Elaboration

First contact

Roos first hears about the product from her occupational therapist at Visio, when they talk about her options to increase mobility.

Peer example

Her friend, Joost is already using the product, and tells Roos about his positive experiences. Roos decides to start to use it as well.
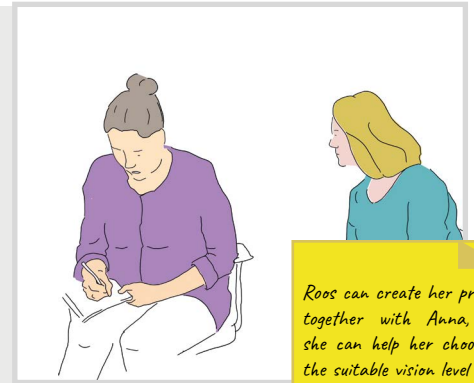
First steps

She is creating her profile to join the community. She adds Joost to her community already, so that she will have access to his notes and tips on navigating the city. She also adds Anna to the people she will follow.

Roos can create her profile together with Anna, as she can help her choosing the suitable vision level and experience level.
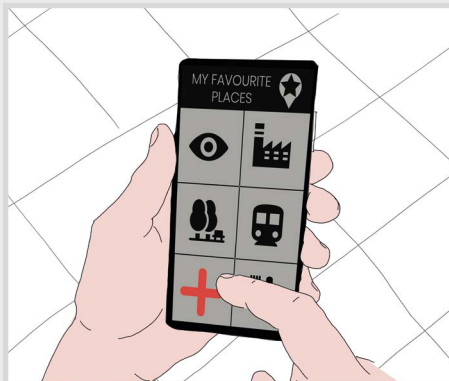
Locations

Roos also adds a few important locations to the system, to have them at hand on the go.
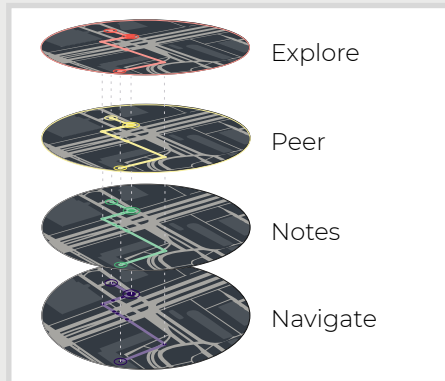
Preferences

Roos can select her preferences before the firs use. She can specify the types of information and the information level .

Explore

Peer

Notes

Navigate
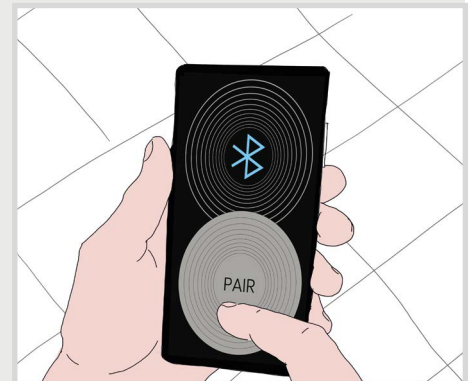
Connect to cane

Roos pairs her phone and her new cane via Bluetooth.

Plan a route

Roos needs to go to Visio to her appointment with Anna. She plans the route with the app.
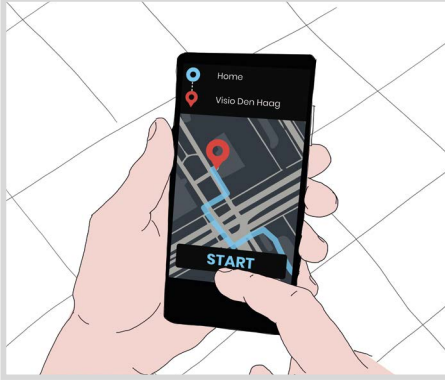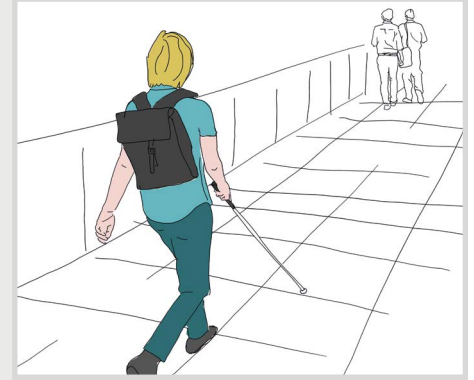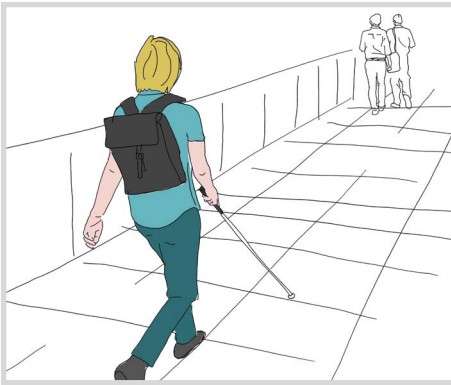
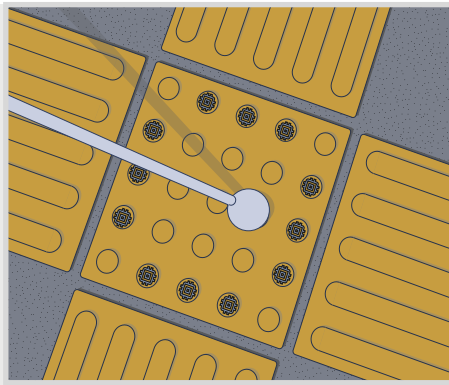### Ready to go

Roos can start the rout with the app.

Start the walk

Roos indicates the goal of the walk. This step sets the default information level.
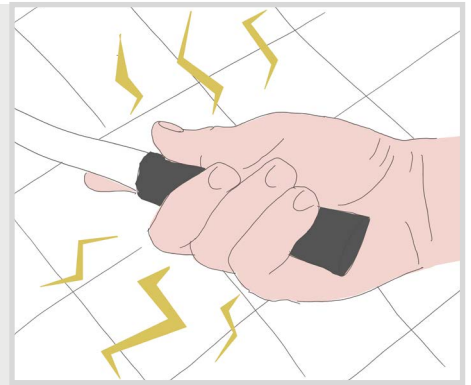
Elaboration

99

Start the walk

Roos indicates the goal of the walk. This step sets the default information level.
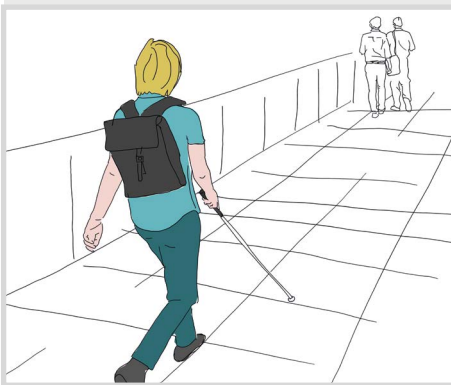
Reach a Dot

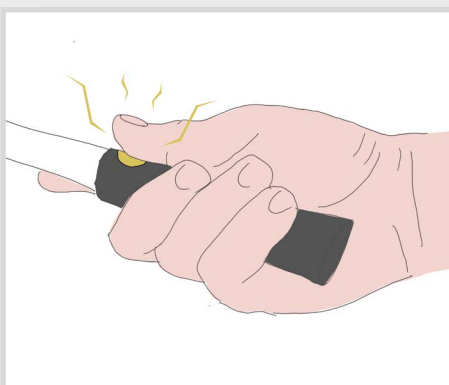While walking Roos reaches a node in the pavement.

Tactile feedback.

Roos feels the vibration in the handle. This notifies her that here is available information on the spot she reached.
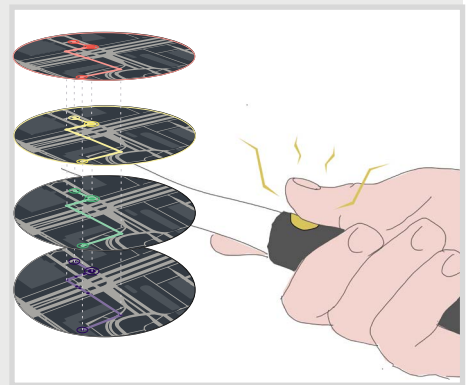
Keep walking

Roos feels confident, and she has a clear goal. As she doesn't want to interrupt the walk, she keeps walking without listening to the available information.

Pick up the note

If she is unsure on how to continue her route, or needs support or guidance, she can push the button on her cane to listen to the notes.

Switch the layer

It is possible that Roos was looking for something else. If she feels that the guidance was too much, too little, or she wants to just experience the ambiance, she can switch between the layers any during her walk time.
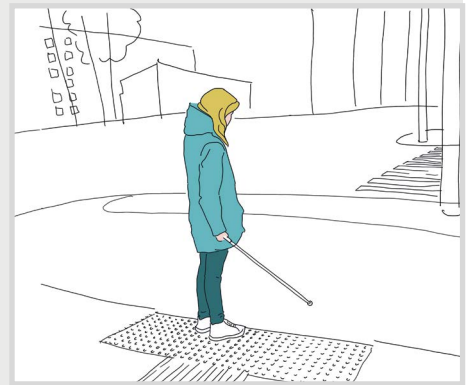
Add a note

Roos marks the pace to add a note. She noticed that the smell of the flower shop around the corner isn't mentioned, but she thinks this can help her peers and herself to navigate the area more safely.
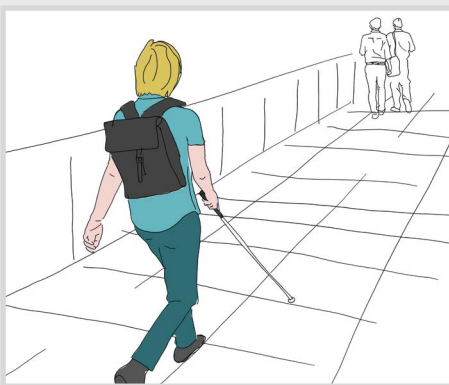
Continue with confidence

The auditory information helps Roos to continue her route. She got basic navigational information, and information on where she is exactly. She is also richer by a few tips from Joost, who is experienced in navigation with the cane in the area.

Explore

Roos is curious about the neighbourhood. She goes that way often, but have never seen it. She decides to stop for a moment, and listen to the description of the place, to explore it in an aesthetic way.
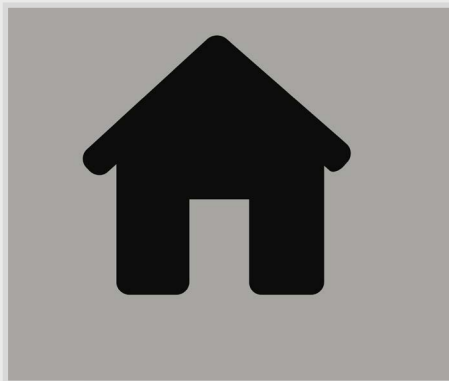
100

Add a note

Roos marks the place to add a note. She noticed that the smell of the flower shop around the corner isn't mentioned, but she thinks this can help her peers and herself to navigate the area more safely.
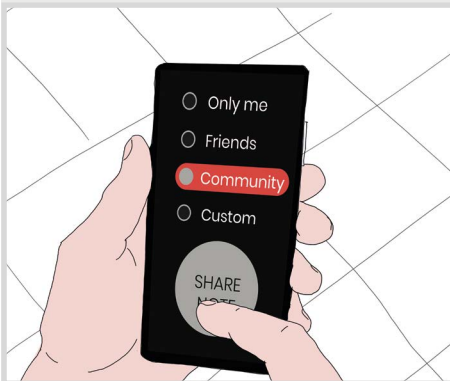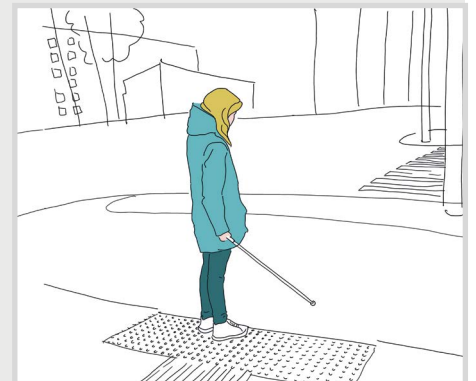

Share it!

Roos can share the note with the community, and help other VIP to commute.

In a quiet place

Roos records her audio-memo after reaching home. She decided to record the memo in a more private and quiet place.

On the spot

Roos decides she will record an audio-memo on the spot. She feels she is not in a rush and the street isn't too busy or noisy.

101

Prototyping.

Iterative prototyping was used during the course of the project to explore the functionalities and user interaction of the concept. For the final validation session two functionality prototypes were made, to allow for comparison in the user feedback. An aesthetical prototype was also created to show the envisioned proportions and form of the device.
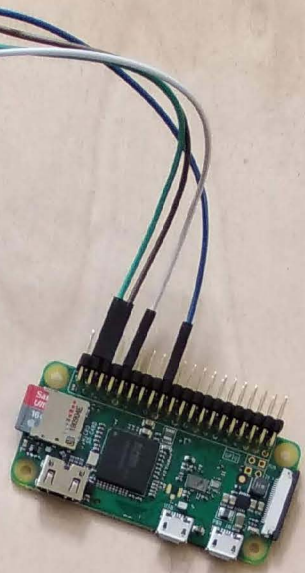
21 | Functional prototypes.

The end goal of the functional prototype was to illustrate the envisioned functionality and interaction during the testing. In the case of the early iterations, the goal was slightly different, as the prototyping process was also an exploration of the possible functionalities and interactions.

While developing the functional prototypes used in the testing, I aimed to mimic two aspects of the functionalities of the DotBot concept, the user interaction when arriving at a Dot and adding information to the Dots. For feedback comparison, two prototypes were built, one with auditory feedback and a second with a haptic actuator (vibration motor).

In this section, the prototype with the auditory feedback is described. This prototype consists of the following components.

> Raspberry Pi Zero W microcomputer. This was chosen for the small size and the multiple connection possibilities (WIFI, Bluetooth)

> Mifare RC522 RFID reader and writer. This cheap RFID module is able to read and the most common RFID tags.

> A buzzer for feedback.

> A push-button for user input.

The housing of the electronics was 3D printed from PLA, and the cane was represented by a bamboo stick. The RFID module was placed at the cane tip and was connected to the Raspberry Pi by wiring.The connections schematics are visible on the following figure.
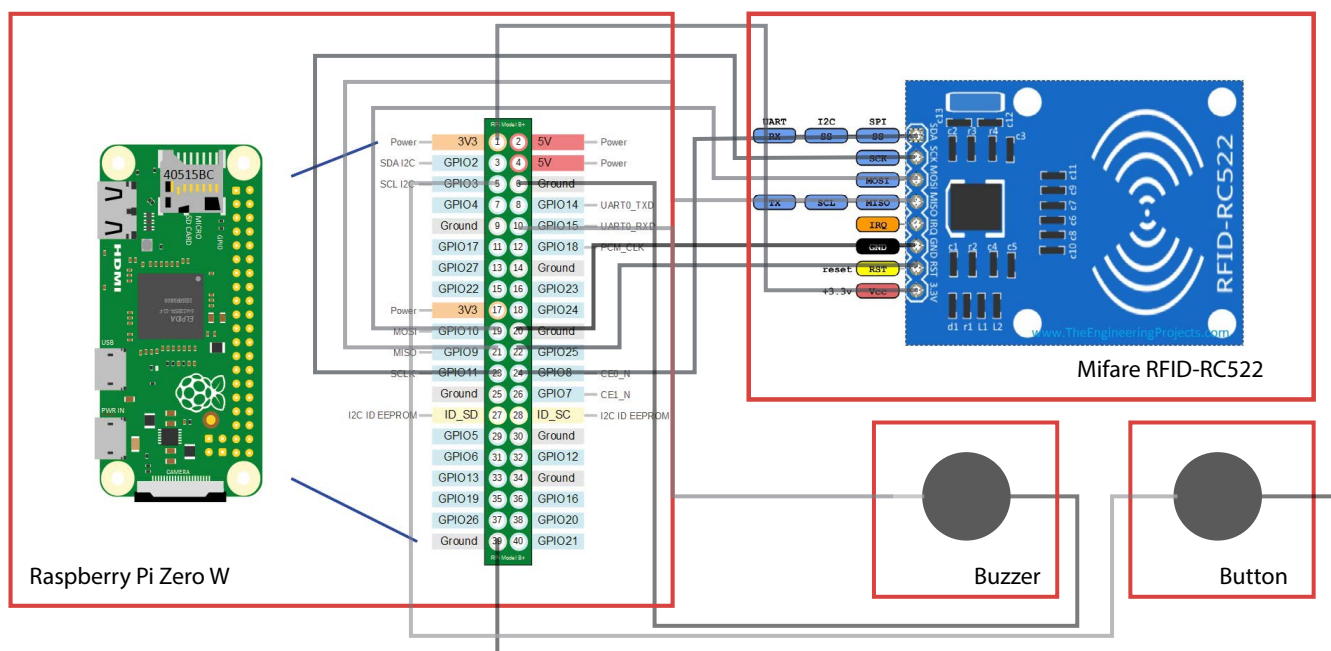

Figure 67: *Electrical connections*
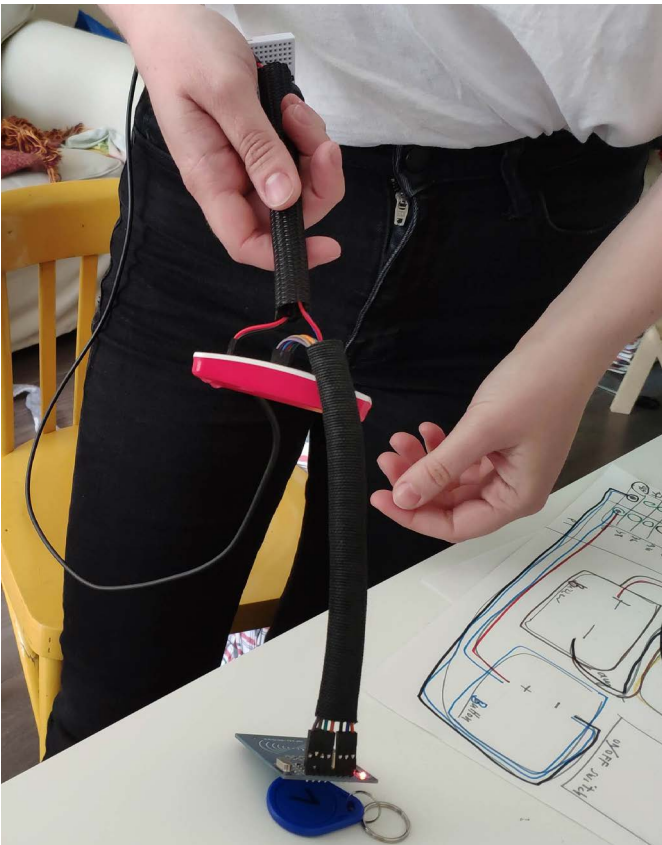
Figure 68: *Testing an early iteration*
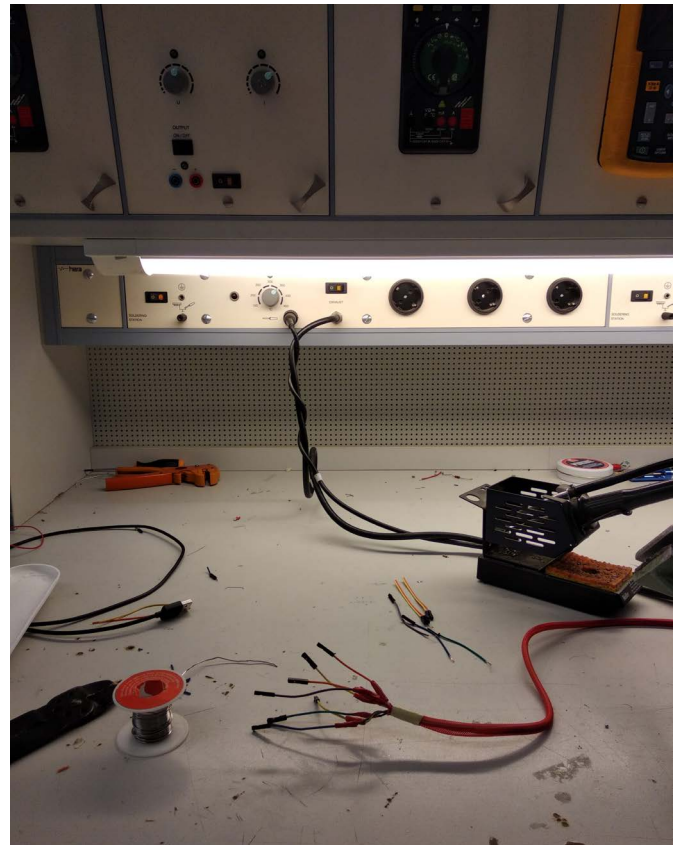
Figure 69: *Soldering the connections*
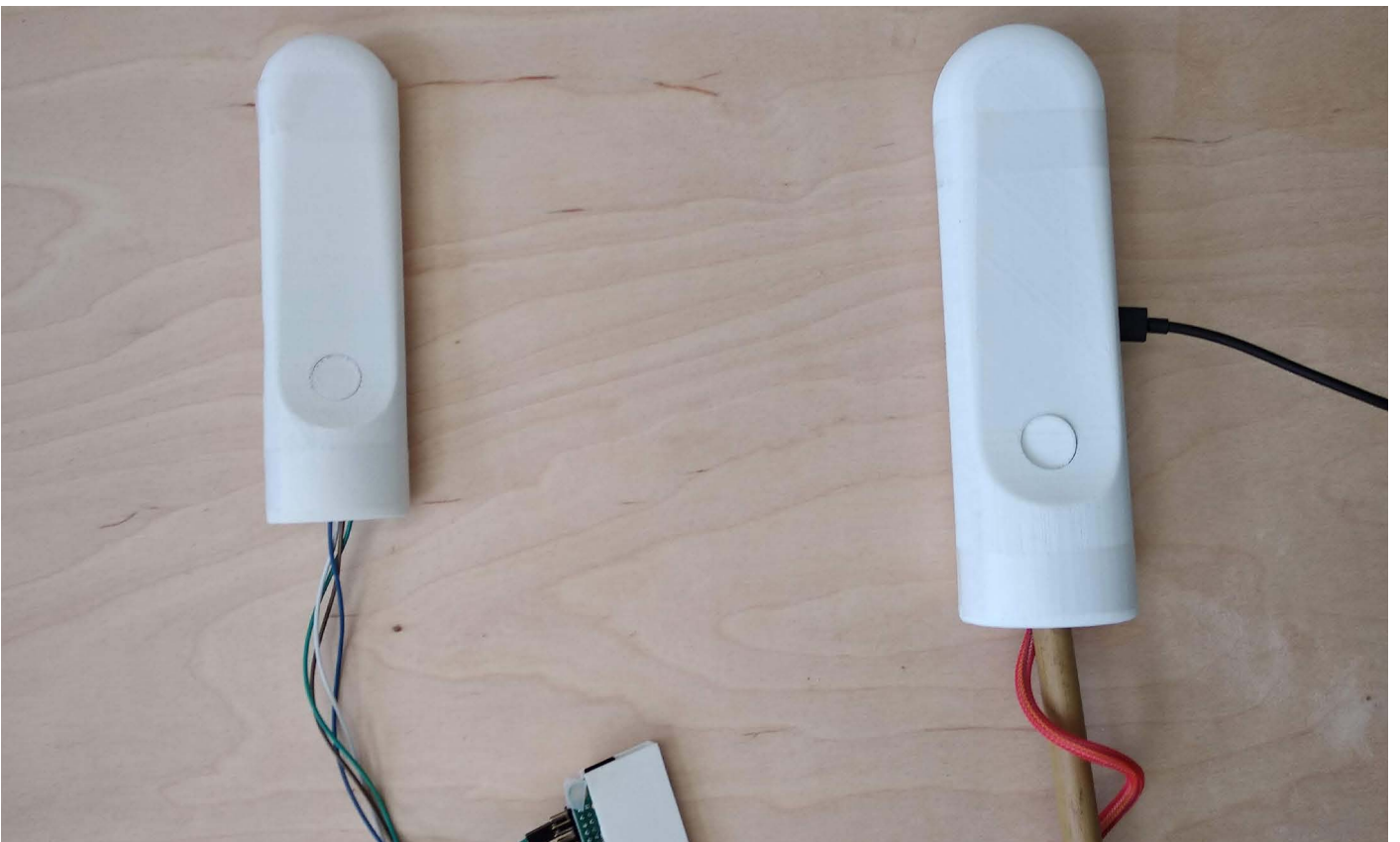
Figure 70: *The functional prototypes used in the testiong*

Prototyping

Node searching

Power on
↓
Scan fo cards
↓
Card found? —— NO
↓ YES
ID in database? —— NO
↓ YES
Alert user
↓
Wait for button push
↓
Button pushed? —— NO
↓ YES
Print information

Saving information to a node

Power on
↓
Scan fo cards
↓
Card found? —— NO
↓ YES
ID in database? —— YES —→ Overwrite? —— NO
↓ NO   ↓ YES
Ask for user input
↓
Add record to database
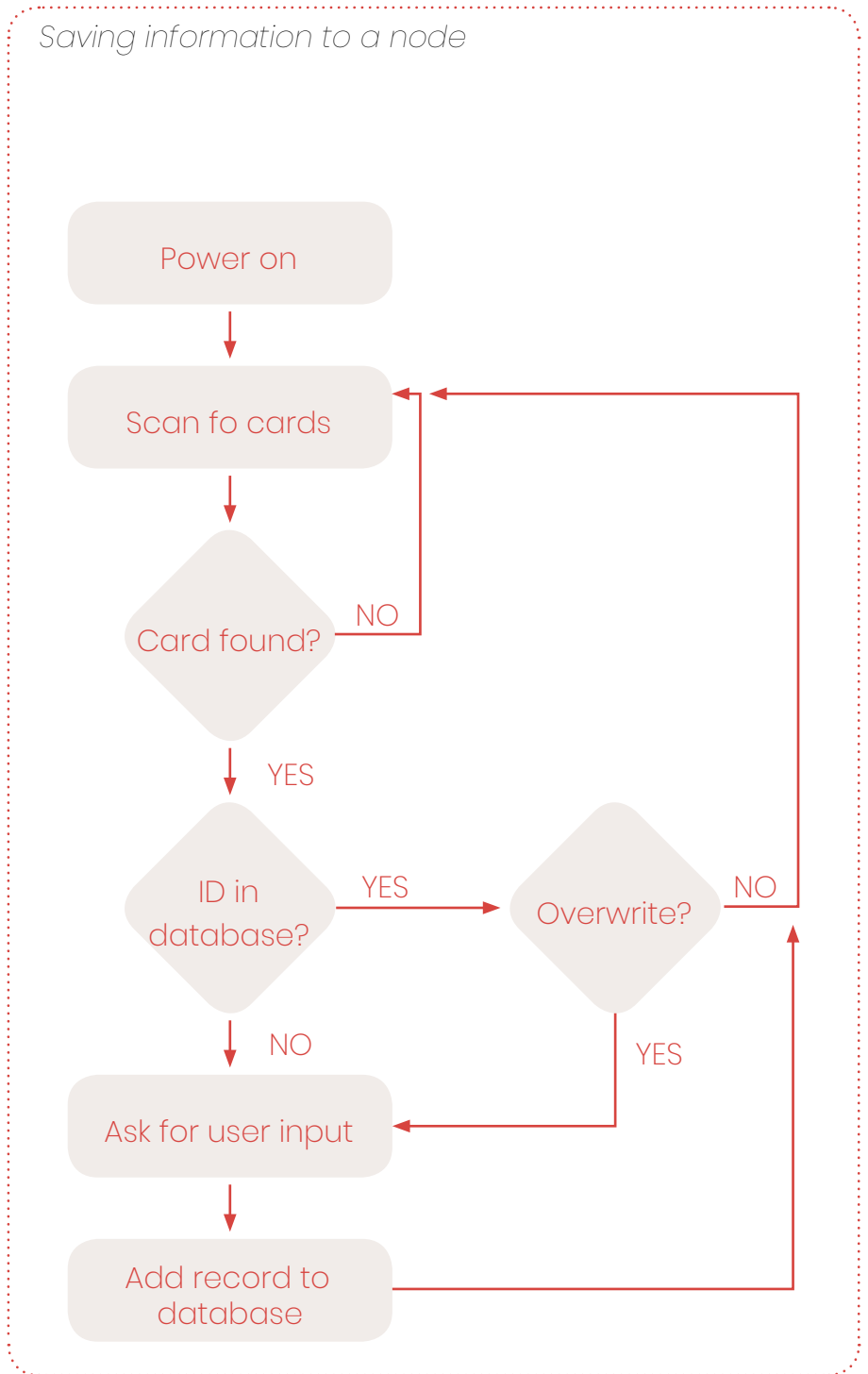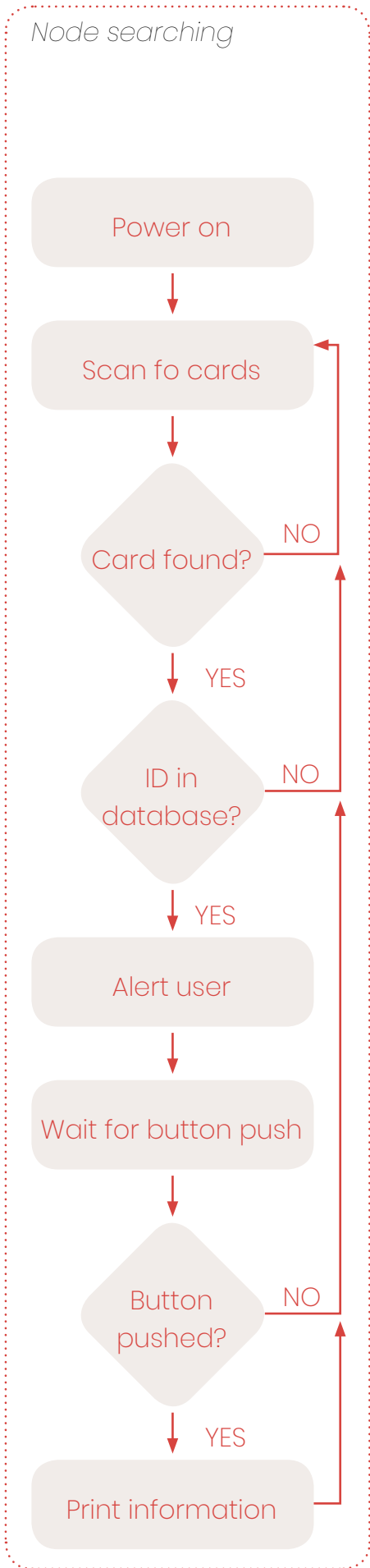
Figure 71: *Working schematics of the prototye*

Buzzer

Housing front

USB cable for power

Raspberry Pi Zero W microcomputer

Push button

Housing back

Mifare RC522 RFID reader and writer

Figure 72: *The buildup of the prototype*

The working schematics of the two functionalities are visible on the previous page. The code for the mimicked functionalities was written using the Python 3 programming language and can be seen in Appendix H. The build-up of the prototype used in the testing is visible on the figure below.

22 | The aesthetical prototype.
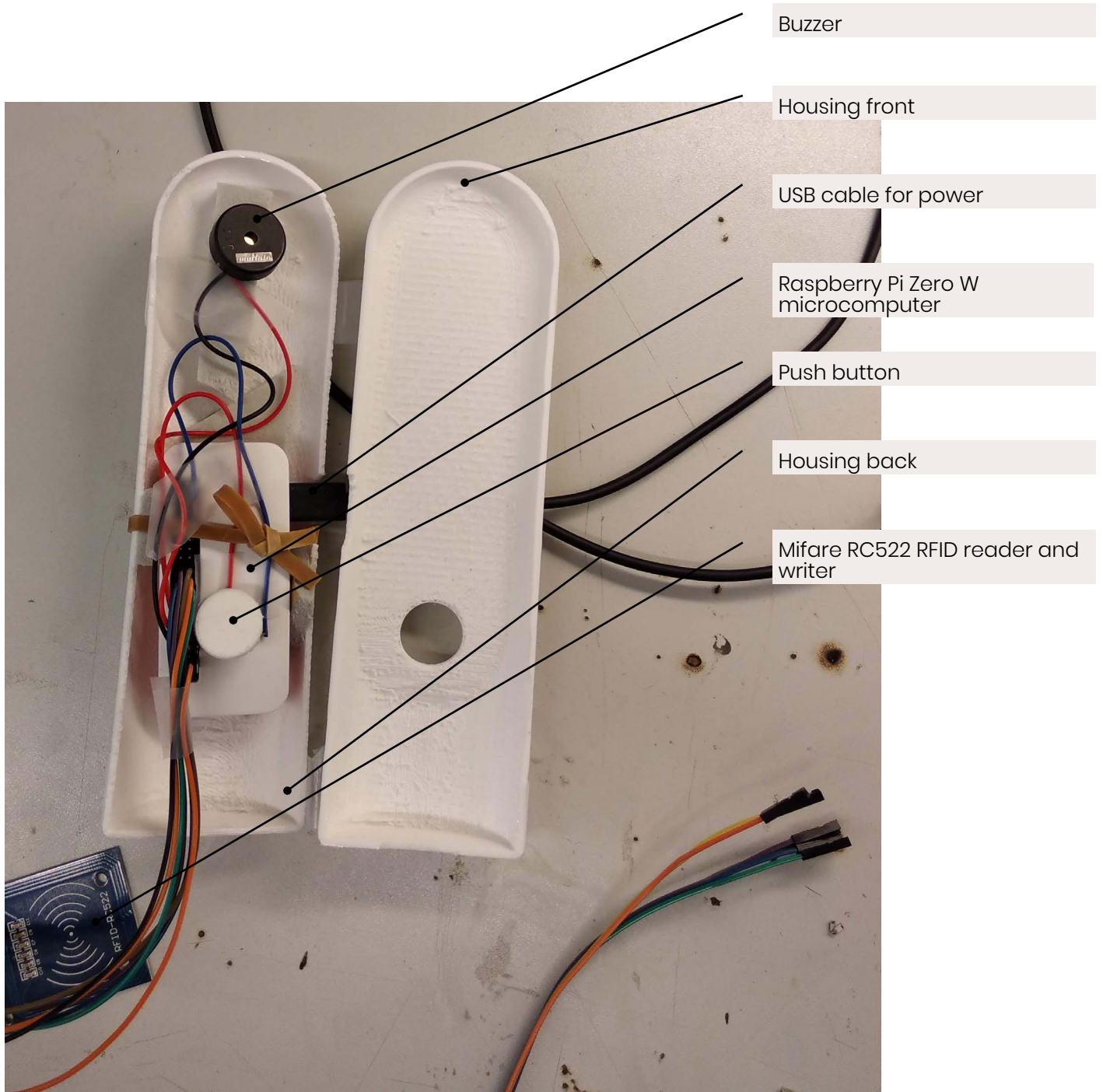
While prototyping the functioning, several concessions were made to allow for a quicker building process, lower costs and easier usability of the prototype.

The functional prototype was enlarged to enable the housing of the prototyped electronics. In the final design proposal, the room required for the electronics is smaller, allowing for a smaller size. The RFID module used in the prototyping is significantly bigger compared to the one planned for the final design. This is due to the fact that the antenna of the Mifare RC522 is integrated into the PCD of the module. This way the PCB of the RFID reader in the functional prototype is visible at the end of the cane. For these reasons, the look of the functional prototype is not showing the envisioned aesthetics of the Dot Bot concept.

The housing of the aesthetic prototype was 3D printed from PLA. The print was sanded and spray painted. The cane is represented by a cylindrical wooden rod, and the cane tip was mimicked by a ping pong ball.

108

Prototyping

Validation.

To create a user-centered design proposal, the design process contained more validation points, to enable iterations.

Preliminary concept

Design proposal

Final design

Idea validation

Concept validation

Recommen-dations

Validation

24 | Idea validation.

The goal of the session was to get insights into the first iteration of the Dot Bot concept, as well as to get answers to a set of more specific questions. The information insights extracted from the session were used as input in the concept elaboration phase.

Method

This validation session was carried out at Visio Den Haag with three visually impaired participants, one Visio employee and two researchers. The VIP participants were:

> Margot Scheltema, who is a future cane user

> a current cane user, who has also participated in the generative session carried out in the research phase of the project,

> a VIP who walks with a guide dog as well as a symbol cane.

The composition of the group was ideal as it was varied enough to have rich insights. The different experiences and relations to the cane helped in exploring all the aspects of the scenarios.

The Visio employee was a social worker, and the two researchers were me and Thijs te Velde.

In the first part of the session, participants introduced themselves and described their connection to the project. Afterwards, the two researchers briefly explained the goals of the session. The goals were twofold, as each researcher had a different goal, but these goals were woven together in a common session plan, each building on the other. This section will concentrate on question group A.

Group A:

> *What information is most important for VIPs at a crossing? How does it differ with known/new places? In what form is it best communicated?*

Group B:

> *What data can be shared amongst visually impaired people and their confidantes?*

> *Which types of data can help promote shared understanding amongst the two? When is this data most relevant?*

> *Which types of data need to be absolutely private? When is this most relevant?*

To answer these questions, a series of scenarios were used. After each scenario was described, it was discussed with the group, first concentration on the first set of questions (navigational information needs in different situations), and then the discussion was steered towards questions of privacy. The detailed session plan can be found in Appendix F.

During the session, an audio recording was made to aid the data processing phase. The observations and main points were written down, and these notes were expanded by the help of the audio recording. These notes can be found in Appendix F.

112

Results

This session was focusing on the information needs during the everyday commute but touched upon scenarios that lay outside this category as well.

The most important findings of the session are the following.

There is a hierarchy of information needs

The first finding is that the information needs during a commute are hierarchical, similarly to the hierarchy of needs as described by Maslow (Maslow, 1943). A higher level of information need can only appear after the need level below is fulfilled.

The most basic need is the need for safety, so information received first needs to help the safe commute. This information is mostly micro-navigational information. It, for example, is about obstacles, safety hazards, the layout of the intersection, and traffic situation. Some typical questions to represent these needs: "Can I cross here safely? Is there a bike route? How many meters is the crossing?"

The second layer is the information on macro navigation: directions and orientation. On this level of information-need, one might ask "Am I going in the right direction? Is this an optimal route? "

If safety is ensured and there are no worries about the navigation, then the need for aesthetic perception appears. On this highest level of information-need, you can find questions like: "I wonder how this area looks like. What is the ambiance of this neighbourhood? Am I surrounded by modern buildings?" This phenomenon can be illustrated by the following quotes:

"the information about walking in a safe way is most important, and if that is going well, it would be nice if there is some more information about the environment where you are. But in the first place is the information on walking in a safe way."

"I'm living now in a neighbourhood that I don't know, and it would be great to know how it looks like. But if I just want to go to the stores, then I don't give a damn, I just want to go to the stores"
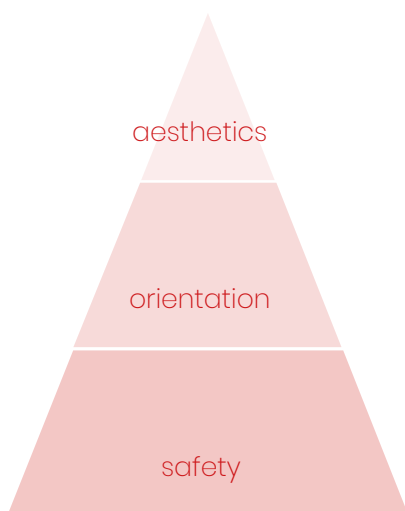
Figure 73: *The hierarchy of information needs*

113

Information needs differ between familiar and new places

New places require more detailed navigational information for a safe commute. As the familiarity is higher, the only information-need that remains is to get notified of the out of the ordinary events and obstacles, and the current traffic situation. This phenomenon can be illustrated by the following quote.

"If you walk a familiar route, you don't need to be reminded of the stairs. You know it is there. "

Navigation cues might not work for everyone

There is no one size fits all when it comes to what information is needed during navigation. The usefulness of the cues depends on the impairment characteristics (mainly on the functional vision), but other factors, such as age, socioeconomic status, and experience play a role too. This is illustrated with the following quote.

"You have to find your own ways. What is working for me might not work for him. He can tell me that there is a flower shop around the corner, you can smell it, that is a good sign, but..."

"People who do not want to navigate, don't have navigation problems"

There is a need for experiencing walks in an aesthetic and exploratory way

The fact that they might not be able to take in aesthetic experiences with their own eyes doesn't mean that the need is lost. VIPs who are in transition or have recently lost most of their vision have fresh visual memories, but people who have been living with low vision for years can still visualise their environment based on descriptions and the ambient sounds. According to the session participants, this need to have aesthetic experiences is present while walking, but it is high in the information hierarchy.

It depends on the situation. If you are on holiday, you might want to know the environment around you, how it looks like. Not only the navigation but also what the place is like.

For one of the participants, navigation is so demanding that when she listens to a description she has to stop and only listen.

"To take it in, you need to stand still."

114

25 | Concept validation.

To evaluate the Dot Bot concept, a second validation session was organised. The goal of this session was to evaluate the envisioned interaction from a cane user's perspective, and also to gather insights on the concept. Possible feedback types were also investigated.

The session was carried out with a VIP participant, who is a long cane user, Visio employee and myself. The concept was presented with the help of a scenario. At certain points of the scenario, the envisioned interaction was demonstrated by prototypes. To allow for comparison of feedback types, two prototypes were used: one with only auditory feedback and a second with a selection of possible vibration patterns.

The questions I was focusing on while leading the discussion were the following:

How does the envisioned concept influence the cognitive load of the user?

What are the characteristics of ideal feedback? Is the audio feedback sufficient in a commute situation? Does added vibration feedback interfere with the navigation?

During the session, an audio recording was made to aid the data processing phase. The observations and main points were written down, and these notes were expanded by the help of the audio recording. These notes can be found in Appendix F.

The most important insights of the session are described below.

Feedback

The auditory feedback was seen as not sufficiently noticeable on its own. The feedback needs to be able to catch the user's attention in a noisy environment. Therefore vibrotactile feedback is preferred. When it comes to vibrotactile feedback, the intensity and length of the signal need to be sufficiently strong to be noticeable among the vibration resulting from cane use. Stronger vibrations weren't described as intruding during the session.

"there is traffic and noise and, especially in the city, buses, trams, so it is better that it is longer and harder"

Different signal patterns can be used to differentiate between nodes, to signal if the user is following a planned route. The signals need to be sufficiently different to be quickly distinguishable from each other.
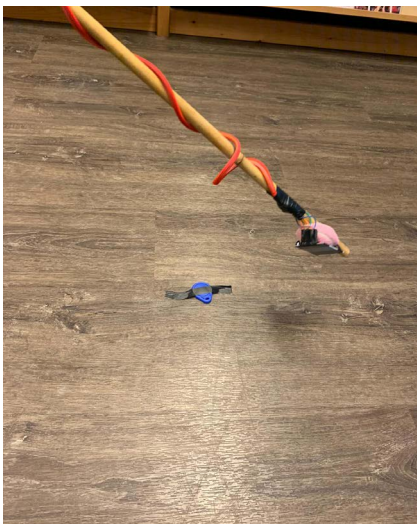
Navigation cues

During the test, the participant described the information provided by current auditory navigation systems as tailored to sighted users. The way the information is formulated contains elements that are not accessible to most VIPs, therefore they are not able to use it alone

"I can't use it alone, because I always have to hand it over to someone with eyes."

It is important that the information received by the user is relevant and useful. Therefore it is useful to label the information stored in the database by required functional vision so that the user can filter out the useful navigation cues for their level of functional vision.

"I know people who are still use their remaining vision. Some of them are colour orientated, like after the orange billboard of the store, go to the right. But some of my friends have tunnel vision, but they still see 100% inside the remaining vision field, to them you can say "after Starbucks, go left". It really depends on what kind of rest vision you have"

"If you have too much information, you'll be listening to the information and you might get too distracted. Because there is also traffic ad trams and bikes and scooters…"

Placement of the Dots

The ideal placement for the Dots are locations where the user already slows down and pay more attention. Such places are the turnings, or before a crossing. It is also useful to have information before entering a store or at train platforms. The second type of ideal place for the Dots are areas with poor GPS signal, especially inside of public buildings.

"Just before you make a turn or cross the street. Because that is the point where you are already extra focused."

Possible uses of the system

As most VIPs have an already established route through places, sharing these already optimised routes by peers would be valuable to VIPs who are less familiar with a certain place. Therefore a functionality to learn certain routes and share them is useful.

At the same time, when the user is learning to use a new tool, the tool can also learn the preferences of the user. Similarly to the guide dog, where there is a transition period in which the dog also needs to get used to the new client, the dog user is the not only one who needs to learn the new way of navigation.

116
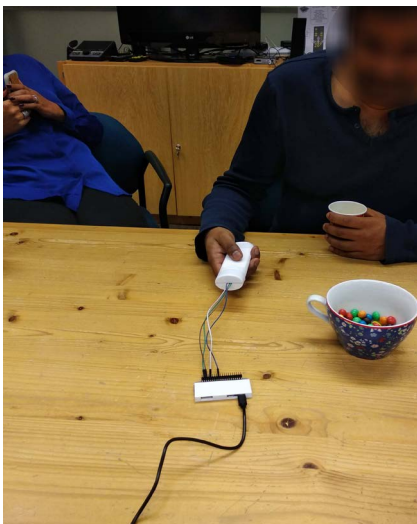
Due to the limited project scope and timeframe, certain parts of the design need further detailing.

Inner structure

The inner structure of the cane handle needs to be designed, taking into account the forces and moments resulting from everyday use.

The density of the nodes

The required Dot number and placement density need to be determined. This would require several iteration cycles.

Smartphone Application

The main functionalities of the application have been lied down during the process, but a fully functional app needs to be developed. This needs additional studies about the user group preferences.

The tag & antenna

Different RFID tag and antenna combinations need to be tested in use situations to determine the most reliable setup.

Vibrotactile feedback pattern and intensity

During the concept validation, a variety of different vibration patterns were tried out. As the session had only one participant and the test took place inside the Visio facility, further testing is needed. To determine the ideal feedback intensity and pattern, testing with more participants and in a commute situation is needed.

PCB design

During the prototyping process, I relied on existing electronic components, resulting in a complicated and bulky setup. To achieve a lighter and sleeker electronics and optimal structure a PCB needs to be designed or the device.

Wireless charging

In the current concept, the device is charged through a USB 3 port. Wireless charging possibilities need to be explored as an additional solution.

Future projects directions

Looking for stakeholders

To initialize the Dot Bot project, several new stakeholders need to be involved. Firstly, organisations responsible for accessible infrastructure elements, like train companies, hospitals, museums, municipalities should be probed about their processes and preferences in designing accessible public spaces, as well as about their willingness to initialize such new systems.

117

Reflections.

Validation

Completing my thesis came with many new skills and lessons learnt.

I gained a deep insight into the wold of Visually Impaired People, their struggles and hopes in life, gaining experience in several qualitative research methods on the way. As I am coming from a more engineering-focused bachelor programme, I had little experience in working with people, not numbers, and using a less rigorous approach.

During these months I learnt about so many different topics. This roller-coaster of a process gave me the opportunity to learn not only about the project, the context, the technology, my users, prototyping, etc, but also about myself. Working with emotions and dilemmas lead me closer to my own emotions and dilemmas, a tearful but rewarding experience. I've became mindful of how I react when working in a project with a lot of uncertainty. I practiced facing my limits day after day.

If I was to start this over again, I would definitely try to make decisions quicker and limit my scope earlier in the process. It was hard to accept that working alone means that some parts of the project cannot be worked out in detail. This would have spared me a lot of days spent overthinking less important details. And I would trust my gut feeling a bit more.

119

References.

Bartiméus sonneheerdt. (2014). Feiten & cijfers over blind of slechtziend zijn. Retrieved January 21, 2019, from https://bartimeusfonds.nl/wp-content/uploads/2014/05/BARTI1305_factsfigures4.pdf

Bradley, N. A., & Dunlop, M. D. (2005). An Experimental Investigation into Wayfinding Directions for Visually Impaired People. *Personal and Ubiquitous Computing*, *9*(6), 395–403. https://doi.org/10.1007/s00779-005-0350-y

Canes – Ambutech. (n.d.). Retrieved October 25, 2019, from https://ambutech.com/pages/canes

Corbella, M. B., & Acevedo, F. S. (2010). The Representation of People with Visual Impairment in Films, (1).

Cuturi, L. F., Aggius-Vella, E., Campus, C., Parmiggiani, A., & Gori, M. (2016). From science to technology: Orientation and mobility in blind children and adults. *Neuroscience and Biobehavioral Reviews*, *71*, 240–251. https://doi.org/10.1016/j.neubiorev.2016.08.019

Desmet, P. M. A., Ozkaramanli, D., & Özcan, E. (2013). Beyond Resolving Dilemmas: Three Design Directions for Addressing Intrapersonal Concern Conflicts. *Design Issues*, *29*(4), 1–5. https://doi.org/10.1162/DESI

Espinosa, M. A., Ungar, S., Ochaíta, E., Blades, M., & Spencer, C. (1998). Comparing methods for introducing blind and visually impaired people to unfamiliar urban environments. *Journal of Environmental Psychology*, *18*(3), 277–287. https://doi.org/10.1006/jevp.1998.0097

Garcia, G. A., Khoshnevis, M., Gale, J., Frousiakis, S. E., Hwang, T. J., Poincenot, L., … Sadun, A. A. (2017). Profound vision loss impairs psychological well-being in young and middle-aged individuals. *Clinical Ophthalmology*, *11*, 417–427. https://doi.org/http://dx.doi.org/10.2147/OPTH.S113414

Gori, M., Cappagli, G., Tonelli, A., Baud-Bovy, G., & Finocchietti, S. (2016). Devices for visually impaired people: High technological devices with low user acceptance and no adaptability for children. *Neuroscience and Biobehavioral Reviews*, *69*, 79–88. https://doi.org/10.1016/j.neubiorev.2016.06.043

Langelaan, M., De Boer, M. R., Van Nispen, R. M. A., Wouters, B., Moll, A. C., & Van Rens, G. H. M. B. (2007). Impact of visual impairment on quality of life: A comparison with quality of life in the general population and with other chronic conditions. *Ophthalmic Epidemiology*, *14*(3), 119–126. https://doi.org/10.1080/09286580601139212

Lederman, S. J., & Klatzky, R. L. (2009). Haptic perception: A tutorial. *Attention, Perception, & Psychophysics*, *71*(7), 1439–1459. https://doi.org/doi:10.3758/APP.71.7.1439

120

Limburg, H., & Keunen, J. E. E. (2009). Blindness and low vision in The Netherlands from 2000 to 2020—modeling as a tool for focused intervention. *Ophthalmic Epidemiology*, *16*(6), 362–369. https://doi.org/10.3109/09286580903312251

Mannay, K., Benhadjyoussef, N., Machhout, M., & Urena, J. (2017). Location and Positioning Systems: Performance and comparison. *4th International Conference on Control Engineering and Information Technology, CEIT 2016*, 1–6. https://doi.org/10.1109/CEIT.2016.7929105

Maslow, A. H. (1943). Elymus 71_e1a.pdf. *Psychological Review*, *50*, 370–396.

Ozkaramanli, D. (2017). *Me against myself Addressing personal dilemmas through design*. https://doi.org/https://doi.org/10.4233/uuid:5b-36ba74-d629-4ee2-9f08-edeb33d5ca59 Important

Park, D. C., Radford, J. P., & Vickers, M. H. (1998). Disability studies in human geography. *Progress in Human Geography*, *22*(2), 208–233. https://doi.org/10.1191/030913298672928786

Pullin, G. (2011). *Design Meets Disability*. MIT Press.

Rear, M. S. (n.d.). Reverse Flâneur. Retrieved July 22, 2019, from http://www.michaelsabine.com/

Rees, G., Tee, H. W., Marella, M., Fenwick, E., Dirani, M., & Lamoureux, E. L. (2010). Vision-specific distress and depressive symptoms in people with vision impairment. *Investigative Ophthalmology and Visual Science*, *51*(6), 2891–2896. https://doi.org/10.1167/iovs.09-5080

RNIB. (2015). My Voice 2015. Retrieved from https://www.rnib.org.uk/sites/default/files/My Voice UK Report-FINAL_0.PDF

Teitelman, J., & Copolillo, A. (2005). Psychosocial issues in older adults' adjustment to vision loss: Findings from qualitative interviews and focus groups. *American Journal of Occupational Therapy*, *59*(4), 409–417. https://doi.org/10.5014/ajot.59.4.409

Vaes, K. (2014). *Product Stigmaticity: Understanding, Measuring and Managing Product-Related Stigma*. Retrieved from http://resolver.tudelft.nl/uuid:f8471a93-0a6e-42c2-96e4-162984ddf84c

Van Houten, D., & Jacobs, G. (2005). The empowerment of marginals: Strategic paradoxes. *Disability and Society*, *20*(6), 641–654. https://doi.org/10.1080/09687590500249066

van Hoven, B., & Elzinga, M. (2009). 'Bikes are Such a Nuisance' - Visually Impaired People Negotiating Public Space in Groningen. *European Spatial Research and Policy*, *16*(1). https://doi.org/10.2478/v10105-009-0008-2

WHO. (2012). Global data on visual impairment 2010. https://doi.org/10.1016/j.ophtha.2013.05.025 2377

121