Designing for people with visual impairments

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Abstract:
This paper is meant to show the process of how the design challenge is defined and what our main findings during the process are.
Firstly, the literature study is mainly about some social insights of people with impairment, especially visual impairment, how to apply human-centered design and some potential Co-design methods that might be useful to work on further.
secondly, a persona and storyboard are created to visualize the situation that the participant is facing and the specific scenario.

Keywords: Co-design; LHON; Human centered design, Design for a specific user, DSU.

1. Introduction

This study contains a literature study, persona and storyboard.
With literature study, the most important topic is Co-design methods. The methods we found at this stage give an idea of what we can do during our design session with a visually impaired co-designer, and therefore contribute to the actual design.
The persona is something that is being concluded after further analyzing the data of the participant himself and his frustrations, can be considered as a profile of the participant and his frustration.
The storyboard would give a more detailed scope of the situation where it is going to be designed for.

2. Literature Study

2.1. Social trends and changing perspective

People with disabilities have had challenges throughout the history of their social, daily, work and community lives due to the fact that there are plenty of examples of discriminations, harder job conditions, not being able to get the service needed and so on.

In recent years the view on disabilities has started to shift to disability being an outcome of environmental and societal factors which become obstacles that prevent people with disabilities to fully cooperate and engage in their communities and get the help they need. (Smeltzer, Mariani, Meakim, 2017) This raise in awareness allows an environment of listening, understanding, helping each other and working together.

2.1.1 Participation in community life as a visually impaired person

When trying to understand problems visually impaired people complain about and searching for solutions, finding extensive information, research and interviews help to understand and analyze the conditions, experiences and feelings thoroughly.

From the findings of a research study about the research conducted with visually impaired people, two of the aspects mentioned that still need improvement are access to the environment and social support. Ease of mobility and transportation is lacking improvements, adaptation and thought even though this issue upon mobility is an important aspect of visually impaired people's life for them to actively and easily participate in their social and work life. (Duckett & Pratt, 2001, p. 820) Besides transportation, social support, understanding and empathy needs to be reflected into the changes and improvements made.

2.1.2 Daily life from the eyes of affected LHON carriers

The co-designer participating in this project suffers from a genetic mutation called LHON which caused him to lose 95 percent of his vision. Affected LHON carriers struggle with daily tasks such as reading, using transportation, house work etc. and indicate the effects of LHON to daily life are not explored and researched enough. A related research done highlights the feelings and results obtained from the participants which sum up: Even though affected LHON carriers are assured and relieved that the level of the vision is very rare to get worse with proper service, care

and methods they can still actively participate in their community. (Kirkman et al., 2009, p. 3112)

This encourages researchers, community care services, designers and other related fields to help to focus, understand and develop for improving daily life for LHON patients. Words of Affected LHON carriers about challenges of daily life and knowing that it is possible to improve the quality of participation within their community also encourages co-design projects to search for methods, techniques, lacks and points to improve in the daily life of a person affected by LHON.

2.2. Assistive technology

2.2.1. What are assistive technologies?

By definition the 'Assistive Technology Act of 2004', "ASSISTIVE TECHNOLOGY DEVICE.—The term 'assistive technology device' means any item, piece of equipment, or product system, whether acquired commercially, modified, or customized, that is used to increase, maintain, or improve functional capabilities of individuals with disabilities." (US Congress, 2004, p. 4) Assistive technologies are one of many opportunities to reduce the disabling influence of many environments. (Gatchalian, 2019)

Assistive technologies are aimed for people with disability, as well as elderly, whose disability progresses. Assistive technologies are aimed to help doing basic mundane tasks to let the user feel more independent.

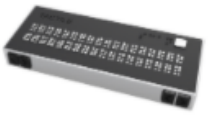
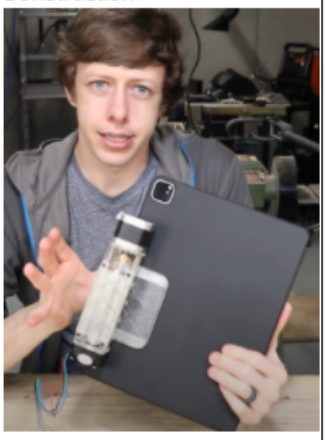
2.2.2. Ideas, theories and concepts that may help the design of a successful AT.

For an AT to be deemed useful, and thus successful, it must have good User Experience and Usability. Furthermore, the AT must be flexible and matching with the user's environment, "needs and preferences of the user, and the functions and features of the technology"(Sherer & Craddock, 2002, p. 1). The reasons behind the high rate of abandonment of ATs, how to evaluate appropriateness of the technology and its relation with abandonment of technologies will be further discussed.

2.2.3. AT examples relating to our project

Some already existing assistive technologies that might be useful to get familiar with and learn from when co-designing with a visually impaired person are listed below. The main problems that the co-designer is facing in his daily life as a visually impaired person are being able to take notes with a regular pen and paper, easier travelling to get daily tasks done (e.g. taking the bus to work) and finding misplaced objects.

Table 1. AT examples relating to the project

Assistive Technology Device	What does it do?	Why are these important for our case
Blindness cane 	This is a simple AT consisting of a long stick with a rolling ball at the end which solves some problems when persons with impaired vision walk, however, before and after use this cane is deemed unhandy to have with.	Our Co-Designer is using this device to walk around in public from time to time, and it is a noted nuisance and unhandy for him after it is not needed when walking.
Portable Real-Time Text-to-Braille Converter 	This is a device that is to be connected with an electronic device such as a computer. The text that the user selects, or the text that a program selects for the user, will then be sent to the braille converter for it to give an output in braille. This is done by lifting up pins in specific spots to spell the text in braille.	Even though this is an ingenious idea, it has some problems. The problem our Co-Designer has is that it is too much trouble for him to read the Braille instead of just using a text to speech software/program.
Vision-to-Touch Construction 	The device made in the video by StuffMadeHere converts what the electronic devices sees, an ipad in this case, with the use of its sensors and software to a 3D image, with distances, this will then be converted into information for the handle, where pins are located to touch the hand in a specific way. This can be then be interpreted by the touch of the hand, and then understanded by the user to know where he can walk or not. This AT can be compared to one of the new uses of technology.	Even though he does not have the biggest problems with walking, this is an interesting idea which could be eventually improved to a device that maps out the visible area of the user completely and convert it to the touch of the user.

Most of the existing technologies listed above do not fully qualify for a solution that our team is looking for but they are a good start to further develop or to tailor some functions to the product/technology that will be designed.

2.2.4. 'Technology Abandonment' , Technology 'Appropriation' and Methods Assessing the Quality and Usability of AT

Technology abandonment is a major factor to evaluate if an AT is useful or not. This comes along with the amount of flexibility the AT has for the user, as their needs and priorities can change over time. Where before the abandonment the question can be asked if the AT is still appropriate for the case or not.

A survey to evaluate the usefulness of ATs and its abandonment has been done based around the aspects of device selection, acquisition, performance and use, with participants with various disabilities. From results it concluded that almost a third of all of the AT devices were disregarded, where mobility ATs crowned.

Forward came four factors, lack of user opinion in selection, availability of similar if not better devices, bad performance and changes in the needs or priorities of the user. These four factors have to be considered with the addition of the aspects of the survey, to evaluate its appropriateness, to then consider its abandonment or not. These four factors are important and can be used during co-designing and later in the evaluation phase of the project for the product ,that is designed at the end, to be functional, responding to the user's needs and used for a longer period of time.

2.3. Human centered design

2.3.1. An Introduction to Human Centered Design

Human-Centered design creates solutions by involving the human perspective throughout the design process (Lyon A.R., 2020).
When designers create a product they too often focus on solving their own needs or those of the technology - which may be totally different from what the users want (Shamir, S., 2019). Keeping the user in mind is essential to creating a product for them.
There are many approaches to Human-Centered design. The first step is often contact with the user through interviews or observations, where the designer will try to "get inside the user's head" and get to understand them (Philips, M. (z.d.)). Through this, designers will realize the user's needs, goals and issues and design the product by solving those needs.

2.3.3. Human Centered Design in Our Project

While designing a solution for our end user with a visual impairment, we need to consider what those solutions might cause our user. The product should be an improvement for all groups of people with impaired vision and therefore universally accepted and not create benefits to one group of users by harming the other ones (Byrne-Haber, S. C., 2019).
Therefore an interview with our participant took place where we tried to understand him, his needs, what pains him and what his main challenge in daily life is.
Our solution should help the user by enabling him to do things that he wasn't able to do until now or at least improve the experience. Without proper involvement of the user in our design process, we could not adequately address his needs because we are in a very different situation and target group and he adds a unique perspective. To do this properly we are going to implement methods commonly used in Co-Design.

2.4. Our groups impairment and needs

2.4.1.What is LHON?

Leber hereditary optic neuropathy causes loss of sight due to a mutation in the mtDNA. This makes cells die and thus affects the eye nerve. The mutations can only be passed by the mother, with males being 4 to 5 times more likely to develop symptoms of LHON (Yu-Wai-Man, et al., 2000) The average age in which these symptoms occur is between 20 and 30.
The first symptom is blurring of vision which starts with a small dot in the middle of the eye.The blur will spread over the complete eye. This is caused due to damage to the eye nerve and doesn't feel painful (Hudson, et al. 2007). The second symptom, dyschromatopsia -which is the loss of seeing colors- can also occur together with

losing the ability to focus the eyes. According to GARD (2021) about 95% of the affected will lose their vision before the age of 50. Our participant retains 5% of his vision and has experienced no colour loss.

2.4.3. Experience with LHON

Based on research of 7 participants with LHON, the following results were obtained by Ferguson, J & de Abreu, G. (2016).
Some psycho-social losses were being unable to read non-verbal language and partial loss of their freedom due to increased difficulty in travelling alone. One of the challenges they found was taking the right bus. Due to this loss of independence most participants experienced a form of depression for some time.
Another study (Harper L., 2018) found that the vision loss had a big impact on further education and employment prospects of participants. Since LHON symptoms develop in the late teens to early adult life, many of the affected had to stop pursuing a university degree. They also repeated the findings of the other research, that the impairment impacts social life and independence hugely.
Over time participants say they learned to cope with these difficulties by using their other senses or assistive devices. They developed skills they didn't have before.
Another insight is that the cane isn't preferred by the participants. This is because people associate the cane with people who are 'blind' and do not know sight. As for the question if they could get over their loss of sight, most answers were no. This, because all stages of life have parts that you wish to see, like your children.

2.5. Co-Design

In co-design (participatory design) someone from the target group becomes a co-designer during product development. To prepare for our upcoming co-design activities with a co-designer who is visually impaired, research on co-design sessions with visually impaired people was done. The papers discussed below have implemented different non-visual approaches to designing.

One example are cubes designed to display different sensors to stimulate thought processes (Leveufre et al., 2016). The loaded dice prototype test demonstrates that having access to the different technologies that may be used in a future device helps imagine concepts more broadly and triggers new, unexpected ideas. Magnusson et al. (2018, p.416) states that users should have access to unfamiliar technology to test it and be able to apply it properly in a concept.
A workshop by Magnusson et al. (2018) used a mix of three strategies in their design session for the optimal result. They ask participants to keep a diary with related questions for a week before the workshop. There, a range of prototypes simulating possible devices could be tested. Thirdly, participants were asked to walk around and demonstrate the prototypes in a live setting to trigger relevant issues. Another approach was a role-playing session where participants were presented with a challenge they had to solve. They verbally set the scene and explained how they would overcome the challenge using a given prototype or their own methods (Brewer, 2018).

For our own co-design sessions, we can make models representing sensors similar to the dice by Leveufre et al. (2016). Even clay, foam or cardboard models encourage engagement and help keep the focus. Asking the co-designer to think about the

challenges they face a few days before the workshop was suggested by Magnusson et al. (2018, p.417). We can employ this method in our co-design process.

If we are unable to meet the co-designer physically, we must find solutions for online design sessions. We could send sensor models to him to assist with the design. But in general, we will have to rely on voice-based design. Then the roleplay techniques mentioned by Brewer (2018) can be used. To improve immersion during role-play we might ask the participant to walk around and imagine the steps they take during their daily life.

3. Engaging with the practice

Multiple in-depth interviews were carried out using Microsoft teams as the main tool of communication due to distancing measures. This proved to be effective and time efficient.

The Storyboard, Figure 1, portrays a scenario where the user with visual impairment cannot find some of their belongings and makes use of the product to solve this problem. It mainly describes the context and the design challenge that this group is going to focus on.

The user collage, Figure 2, shows some typical parts of our users daily life. He needs the computer for work and relies on assistive technology like a screen reader for digital devices or a cane for navigation outdoors when necessary. His touch and hearing senses are heightened, which is both an advantage and a problem sometimes. We need to take the assistive technologies and senses he relies on into consideration during our design.

The Persona, Figure 3, portrays an adult figure who has started a family, working at a job and with visual impairment. The persona's presented challenge is having hard time finding stuff in the house.

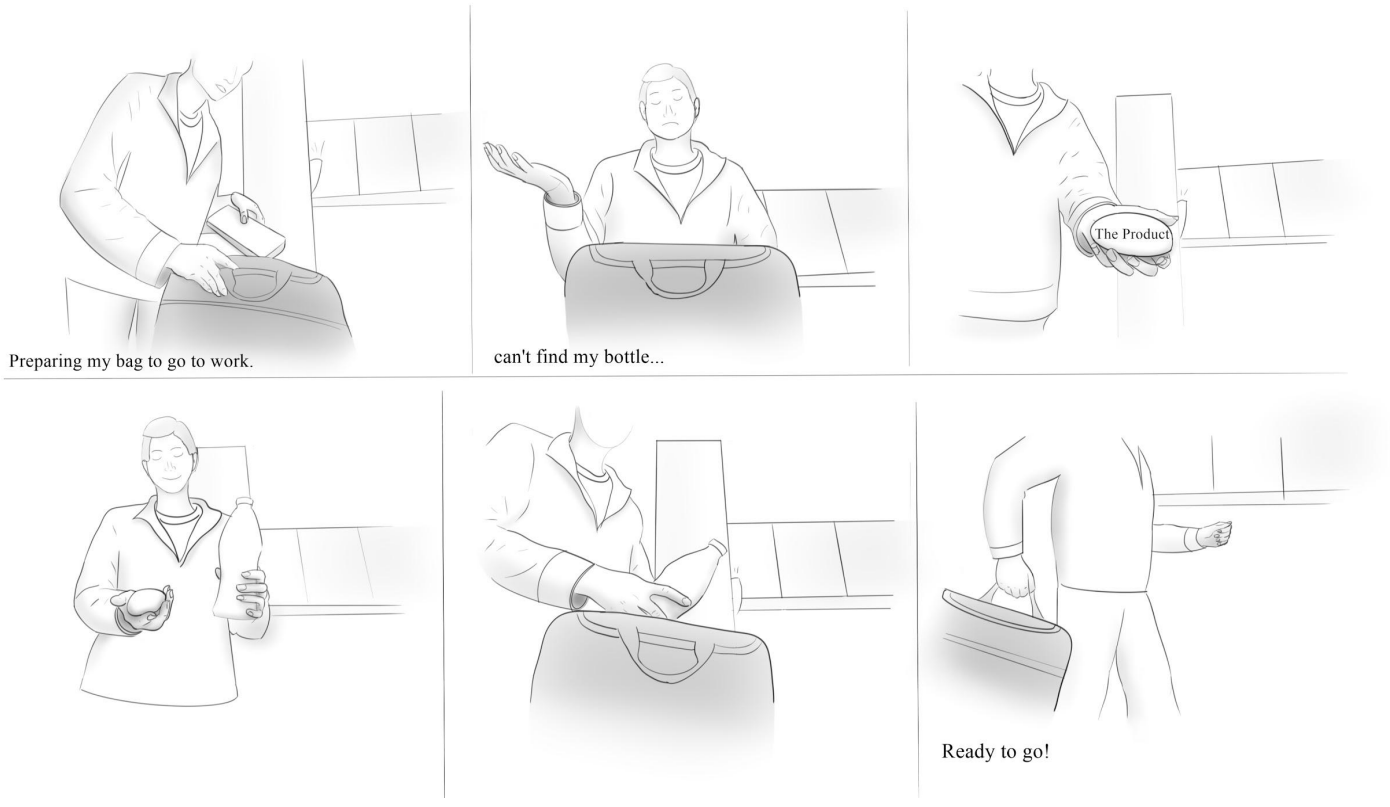


Figure 1. Storyboard of the design challenge

Figure 2. User Collage

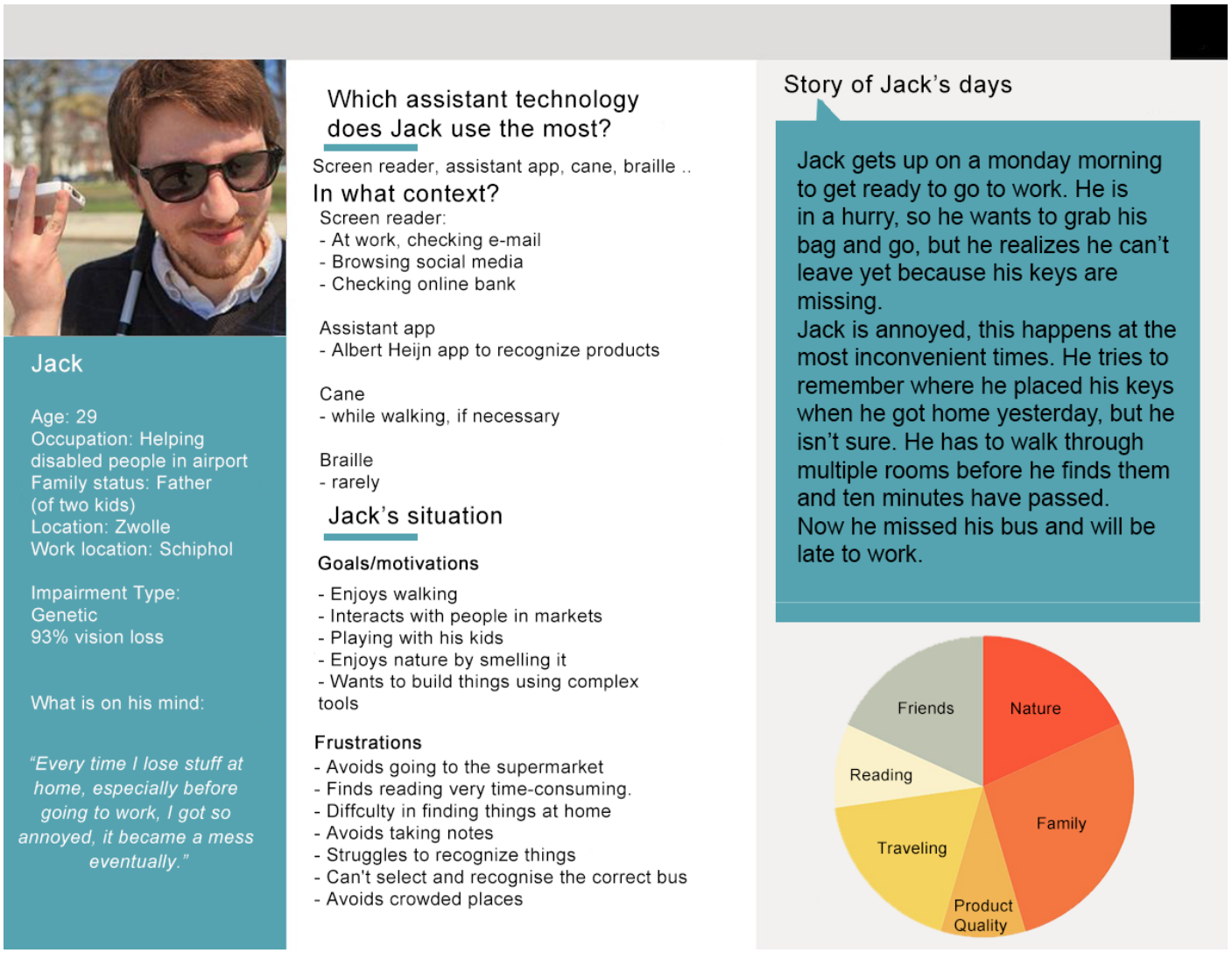


Figure 3. Persona

4. Discussion and conclusions

After exploring a range of topics within the literature study and interviewing the participant multiple times we found a few challenges our Co-Designer faces in daily life. He struggles with finding an item he lost at home, recognising and choosing products in supermarkets, or finding a bus that had changed to a different bus lane. We talked over our findings with the Co-Designer and asked him to decide which presents the biggest challenge to him. Based on his decision and the fact that it has potential for users outside of his target group as well, the design challenge became: helping find lost items in his place. The vision is designing a product that helps our Co-Designer find important items in his home, like misplaced keys or his wallet. It can be used and sensed by visually impaired users, but should also be usable by other users. Our vision was later changed as we found that organization also plays a big part in finding things, and helping our Co-Designer organise would add value to our design.

4.1. Vision

Helping our Co-Designer to organize and find everyday objects (in a way that is also inclusive of other target groups/a wider target group).

4.2. Design values

The product should help the user find a lost item within their home.
The product should improve the users day-to-day life by locating items efficiently.
The product should not interrupt daily life or be a disturbance to the user.
The product should be optimised for users with up to 95% blindness, like our user.
The product should be usable by other target groups, for users with 100% blindness as well as non-visually impaired users.

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