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Using the Design Thinking Process to Develop a Smartwatch Solution Using Assistive Technology for Individuals with Vision or Hearing Impairments in Austria

The development of a prototype following the assessment of public train systems in Austria for accessibility using the seven principles of Universal Design.

Submitted by:

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Austria, 1/03/2023

Declaration of Authorship

I hereby declare that

- I have written this thesis independently, have not used any sources and aids other than those indicated, and have not made use of any other forms of unauthorized assistance.

- I have not previously submitted this thesis, neither for evaluation to an assessor in Austria or abroad nor in any form as an examination paper.

- This thesis corresponds to the one evaluated by the supervisor.

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Abstract

Lack of accessibility within public transportation is a major obstacle for individuals with disabilities all over the world who are striving for independence in their everyday lives. Lack of accessible transportation or necessary improvements is often due to inadequate funding, lack of awareness and/or accessibility for all not being prioritized. Mobility is essential for social integration and for the economy; preventing people with disabilities from using public transport due to lack of accessibility is harmful and needs to be addressed so that all individuals might have an equal opportunity for participation in society. By creating solutions for accessible transportation, individuals with disabilities will have the ability to access essential services, care, employment, social interaction and other activities within society that are necessary to thrive. Being able to independently participate in society improves the overall quality of life for individuals with varying disabilities and decreases the chance of isolation and loneliness that can come from lack of social interaction and essential services due to inaccessible public transportation.

In order to solve the issue of inaccessible public transportation in Austria, it is necessary to understand the current accessibility levels of local transportation. The train systems were assessed using the seven principles of Universal Design and then a solution was created, using the design thinking process, in order to solve the lack of accessibility within those systems. The focus group, people with hearing and vision impairments, was interviewed and observed in order to get a better understanding of their feelings and what they deal with in society on a daily basis. Intimately knowing and understanding the user group is essential when creating an efficient solution that fits their specific needs and wants.

After necessary research was complete, a smartwatch prototype with haptics was created in order to assist people with disabilities with their travels. The application gives the user necessary notifications and guidance paired with haptics that alerts them to changes on their trip and other essential information necessary for their journey that is often hard to locate otherwise. The smartwatch solution was tested and necessary

changes were made due to user feedback followed by one iteration of testing. The target group commented how much they enjoyed the solution and the positive difference it would make in their life and personal independence if they were able to use it on a daily basis. Using the prototype would create a comfortable and less stressful experience within public transportation, which is extremely important to the overall well-being of the user group.

The solution created proved how essential the topics of accessibility and inclusivity are in modern society; these issues need more awareness in the public. By not making changes in order to make society more accessible for individuals with disabilities, they remain isolated which creates harmful barriers within society.

1. Introduction

The Global Goals and the 2030 Agenda for Sustainable Development highlight the importance of making cities inclusive, safe, and sustainable. They also emphasize the significance of providing accessible and sustainable transport systems for all citizens, especially by expanding public transport with a special focus on the needs of those in vulnerable situations, such as disabled people (Turner et al., n.d.). According to the World Health Organization (WHO), more than a billion people currently live with some form of disability. These make up about 15 percent of the world population or about one in seven persons (Klakow, 2021). Specifically, according to Statistics Austria, 18.4 percent of the resident population in Austria lives with a disability, which corresponds to about 1.3 million people.

1.1 Seven Principles of Universal Design

Public transportation is an essential part of many people's lives in Austria and the entirety of Europe. Although public transportation is a revolutionary service offered to the public, there are many issues that still exist within it revolving around accessibility and inclusiveness. The United Nations Convention on the Rights of Persons with Disabilities makes it obligatory to make transport accessible to persons with disabilities so that they can participate in society "on an equal basis with others". Making transport accessible not only helps those with disabilities but also the elderly population, who suffer similar side effects regarding vision and hearing. "For a significant number of visually impaired and blind persons, public transport plays an important role in productivity, community involvement, and independence, since it may be the sole viable mobility option to seek education, work, medical care, food and many other venues in their community" (*Assisting Visually Impaired People in the Public Transport System Through RF-Communication and Embedded Systems †*, n.d.). For public transportation, specifically in Austria, to meet the requirements of being universally accessible, it must satisfy the seven principles of universal design when considering the overall experience

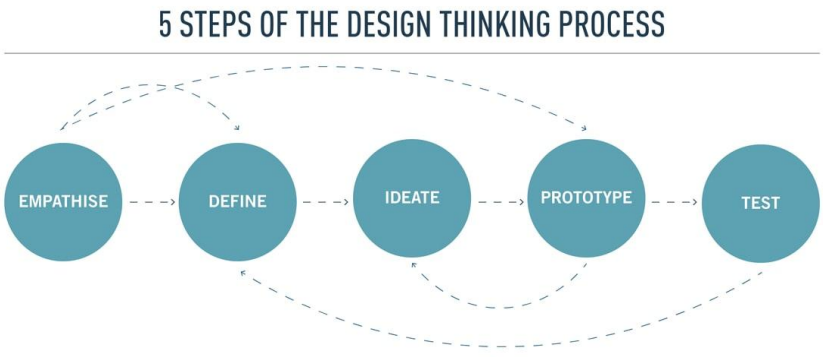
of a person on public transportation. By creating the most accessible and inclusive environment on public transportation, customers will have a great user experience and therefore, the company behind the public transportation will benefit.

To create a solution for public transportation that is accessible for all, the train system must first be evaluated for the seven principles of universal design to see the specific areas in which there are issues. According to the Transformative Urban Mobility Initiative (TUMI), “public transport must be designed, built and operated on the principles of Universal Design to ensure that transport meets the needs of all users. These principles ensure that infrastructure and services are easy and intuitive to use, with minimum physical effort and provide adequate space for wheelchairs users”. They also say that “Universal Design is incorporated in the United Nations Convention on the Rights of People with Disabilities (2006) and needs to be incorporated into national legislation so that standards for disability inclusive transport can be set, implemented, monitored and enforced.” (Turner et al., n.d.)

Once the system has been evaluated using the seven principles of Universal Design, the process of design thinking will be implemented to come up and execute a new solution that satisfies the need of the target group, people who require accessibility in public transport, as seen in figure 1. The design thinking process consists of five stages: discover, define, ideate, prototype and test. Each step in the process is essential to building an efficient solution that perfectly caters to the needs of the focus group.

Figure 1

The 5 Steps of the Design Thinking Process



1.2 Benefits of Accessible Public Transport

"The benefits of increasing accessibility for those with different abilities don't just benefit them. "Visually and hearing-impaired benefit all public transport users, as they increase user-friendliness and comfort, as well as safety and make it easier to travel by public transport" (MoViH: "Mobility of Visually and Hearing Impaired People in Public Transport," n.d.). Creating accessible public transportation for all is no small task, and although the European Union has continued to strive for implementing accessibility among all its member countries, it is still up to the Member State to continue the work to install such large changes. "Taking such measures would clearly be economically beneficial for transport companies as many people, currently limited in their mobility, would use public transport services again resulting in higher passenger counts and revenues. Moreover, the general attractiveness of public transport would rise which helps all passengers to get along with the services provided" (Aeffner, 2022). It is important to remember that most journeys involve using more than one mode of transport. Therefore, the overall objective of creating accessible transport services should be to develop a "seamless" system in which disabled people can access, travel on, and interchange between modes easily and safely (Improving Transport Accessibility for All, n.d.).

2. Discover

To learn more about train systems and how they function in Austria, I analyzed them based on the seven main principles of universal design, which are equitable use, flexibility, simple and intuitive, perceptible information, tolerance for error, low physical effort, and appropriate size and space for approach and use. These seven principles are essential for making design accessible for everyone. The European Union Guidelines about railway accessibility also state that "The Technical Specification for Interoperability for Persons with reduced mobility (TSI PRM) applies to heavy rail across

Europe. Within the TSI PRM, rules are set up for the design of stations and rolling stock to provide level access for passengers, tactile and visual guidance, obstacle-free routes and parking, and ramps with handrails and/or elevators or alternative accessible routes in case of their dysfunction" (Aeffner, 2022).

2.1 Evaluation of Public Transport using Universal Design

2.1.1 Equitable Use

I spent many hours on trains throughout Austria to research the quality of their accessibility services. The main train company is OBB, which is used throughout Austria, as seen in figure 2. Equitable use means that it can be used by anyone despite diverse abilities. Depending on the station, screens with train times that display the necessary information needed to navigate the train station can be found throughout the stations. There are also intercoms that announce changes within the ride schedule or if a train is delayed/canceled. This can help both blind and deaf people when navigating the train system. Although it can be difficult to find working screens at some train stations, the crowds within the station can be loud and distracting, making it difficult for people to understand the intercom announcements. Due to the nature of my findings across Austria, train stations do not provide equitability for everyone with different abilities and needs.

Figure 2

Wien HBF Station with limited screens/intercoms

2.1.2 Flexibility

The second principle is flexibility, which means that the design accommodates a wide range of people's preferences and abilities. Most stations I visited in Austria provided screens at the platforms as well as in each train car that provided information about the ride. It provided information about the current station, next station, and what time the train was arriving to each destination. At the platforms, there were speakers that announced changes in flights or other important information. The screens also indicated if there was a change to the scheduled ride by changing the departure time or platform. Although there were changes on the screens, the screens possessed a lot of different information on them and could become complicated quickly. The speakers also were louder in some areas of the platform and most announcements were only played once for the passengers. The OBB company, the main railway company throughout Austria, does provide guided assistance for passengers if requested, but it must be done ahead of time and the information is not easy to find on the website. It is required to book assistance days in advance, but some stations offer last minute bookings up to three hours before departure. Although this is a step forward in the right direction, the short notice assistance is only available at 19 total stations in Austria and still requires a form to be filled out. Having a guided assistant can also bring unwanted attention to those with disabilities or make them feel less independent, so this solution is not the greatest alternative. "Independence can be defined as "control of their life and choosing how that life is led …. (and) the amount of control they have over their everyday routine" (*First Validation of the Haptic Sandwich: A Shape Changing Handheld Haptic Navigation Aid*, n.d.)

2.1.3 Simple and Intuitive to Use

The third principle of universal design is to make it simple and intuitive to use. According to the National Disability Authority, this principle is defined as "making the design easy to understand, regardless of the user's experience, knowledge, language skills, or current concentration level" (Universal Principles of Design, n.d.). It includes

guidelines to eliminate unnecessary complexity, be consistent with user expectations and intuition, accommodate a wide range of literacy and language skills, arrange information according to its importance, and provide effective prompting and feedback during and after task completion. I would say that the screens within the train cars themselves were simpler and more intuitive to use compared to the screens at the train stations and platforms. These screens were complicated to read and overwhelmed with information, making it hard to grasp at times. The screens also changed too quickly to accommodate the number of departing rides, making it easy to lose your place or the information you were looking for, which was essential to your trip. For most blind people, the screens and directions are not simple and intuitive to use.

2.1.4 Perceptible Information

The fourth principle of universal design is perceptible information. This means that the design efficiently communicates to the user regardless of their language, experience, or abilities. Announcements, both verbal and in writing, throughout the train system were provided in both German and English. Certain trains also provided the written screens in three languages, depending on where you were located. When the train was delayed, the times would change on the screens but there would be no announcement. If there was an announcement, it was done just once. As a result of the nature of train stations, during rush hour it was significantly more difficult to understand the announcements or get closer to the screens due to the large volume of people present. It was also harder to hear the announcements in certain areas in the station or on the departure platform. “A 2012 survey carried out during an accessibility event organized between the RNIB and Android London revealed that the most desired mobile application among members of the blind and partially sighted community would be a navigation application with access to important information such as signage or information panels, found mainly in written formats” (*Survey of User Needs: Mobile Apps for mHealth and People With Disabilities*, 2020).

2.1.5 Tolerance for Error

The fifth principle of universal design is tolerance for error, which means that the design can withstand potential errors. This was one of the main concerns with the train systems in Austria when it comes to accessibility. Because of the lack of announcements with loud volume and crowded stations, the tolerance for error is very low. If a train was to be delayed and it was loud in the station or incredibly busy, it could be hard for some people with deafness or blindness to recognize the change in the schedule. This could potentially lead to missing trains due to time or platform change which is a big problem, especially if the person was independent and relying on the system to inform them. A resilient transportation system can provide accessible service to the public even during disruptions, emergencies, accidents, and special events (Transportation Systems Resilience Section, 2017).

2.1.6 Low Physical Effort

The sixth principle of universal design is low physical effort, which is defined by the National Disability Authority as “The design can be used efficiently and comfortably and with a minimum of fatigue.” There are many obstacles that can be found within PT for those with mobility and other disabilities. This can include unsuitable steps, significant differences in height between floors, long distances, slippery floors and excessive space between the platform and vehicle (*Obstacles in Public Transport*, 2022). Most of these, except for long distances, could be applied to different stations that I have visited and observed throughout Austria. Although some areas of Austria lack this principle of design, Wiener Linien in Vienna is a shining example of barrier-free access. “Barrier-free access to all underground stations and to over 95 percent of tram and bus stops is ensured by means of ramps and lifts, meaning that Wiener Linien is a leading example for accessibility throughout Europe.” In order to achieve this, they use ultra low floor (ULF) trams and low-floor buses that can be hydraulically lowered if necessary as well. (*Accessible Mobility*, n.d.)

2.1.7 Appropriate Size and Space

The final principle of universal design is appropriate size and space for approach and use; appropriate size and space is provided for approach, reach, manipulation, and use regardless of user's body size, posture, or mobility. Guidelines include: provide a clear line of sight to important elements for any seated or standing user, make reach to all components comfortable for any seating or standing position, accommodate variations in hand and grip size, and provide adequate space for the use of assistive devices or personal assistance. From observation, it was clear to see that some of the digital signages through the train stations and train cars themselves were hard to see from a seated position. Sometimes it was impossible to find the nearest screen depending on the exact seat you were sitting in, which raises concern for those who need to access a visual of the screen, as seen in figure 3.

Figure 3

Train Section with No Screens Example

2.2 Accessible Public Transport within Austria

Austria, especially Vienna, is generally known for being an accessible country, especially when it comes to mobility. A few of the larger stations provided a variety of screen sizes which in turn allowed for bigger font sizes and readability, but you had to go to a specific place in the station to access it. When using the OBB app, it was hard to find changes in the schedule as well, so people cannot rely on this as a secondary source to guide them to their destination.

Despite a lot of the OBB stations lacking in accessibility, there are a few branches of public transport that exceed expectations when it comes to providing accessibility for those with vision and hearing impairments. Wiener Linien, a train system in downtown Vienna, is the greatest example of accessibility in Austria. Unfortunately, their system is only in Vienna, not the rest of the country. According to their website, Wiener Linien worked with disability associations and created a guidance system for blind people called POPTIS. It stands for “pre-on-post trip information system”. This guidance tool can be found on their barrier-free website which contains a screen reader and allows the user to access necessary information in real time during their travel from their smartphone. This has proved to be a successful innovation and continues to assist many people with vision impairments. Although it is a step forward in the right direction, it is just one company within Vienna and doesn’t apply to the whole country. (*Accessible Mobility*, n.d.)

2.3 Research and Observation

Besides accessing the train system for the seven universal principles of design, I was able to observe and talk with people who had both hearing impairments and limited eyesight. This was a great help when aiming to empathize with my target group and revealed more about the system from their point of view. I have learned that although some train stations in Austria have good accessibility for people with different abilities, there are still a lot of places that are lacking which is an issue that needs to be addressed. Most people who use the train system independently are familiar with their

routes, unexpected changes can be difficult to navigate, especially in less accessible environments. Most people I talked to said that they felt more comfortable when they were with a group of people and not alone, however they felt less independent. When one feels less independent, it diminishes their confidence and can be demoralizing and discouraging. Needing a guide provided by OBB is also deemed to be inconvenient and takes independence as well.

3. Define

"Accessible public transport systems are to be understood as systems which integrate all people – including those with mobility, sensory, cognitive impairments, mental health problems, environmental sensitivities and allergies – when delivering transport services. They include not only being able to get on and off vehicles, but also being able to understand how the public transport system works, being able to get to and from terminals or stops, to buy a ticket and travel with confidence." (*Accessible Public Transport*, n.d.)

3.1 Defining the Problem of the User

Based on my findings in the first phase of the design thinking process, the train system throughout Austria does not have all the necessary principles of universal design. The train system lacks consistency when looking at overall usability, flexibility, perceptible information, simplicity and appropriate size for space and use.

> "Unfortunately, most visually impaired and blind people may experience difficulties taking the correct bus and getting off at the right destination. These situations may force them to depend on others to drive them around, to stay at home, or to settle for simpler jobs and activities where they do not need to travel far. Hence, efforts should aim to develop a public transport system that people

> with visual disabilities can navigate autonomously, especially in developing countries, where the public transport services are very challenging." (*Accessibility for All in Public Transport and the Overlooked (Social) Dimension—A Case Study of Stockholm*, n.d.)

Although some stations do better than others, there needs to be consistency across the board for people with different abilities to have an accessible experience. Accessibility and ensuring equal opportunity for all is often overlooked due to budget limitations or lack of awareness. In 2014, the Global Alliance on Accessible Environments and Technologies (GAATES), conducted a survey amongst people with disabilities and asked them to identify their main problems that affected their mobility. The main answer was "inaccessible public transport, followed by the attitude of drivers and other staff." (*Accessibility for All in Public Transport and the Overlooked (Social) Dimension—A Case Study of Stockholm*, n.d.)

The discovery phase is about understanding the user and the needs that drive them in their everyday life. To do so, it is important to get insight from people who are a part of the target group and not just able-bodied people speaking for them as a whole. "While many countries have policies and guidelines requiring that these challenges be addressed, effective responses and implementation are often very limited largely because there lacks in-depth data and studies carried out on the mobility needs of the disabled and the elderly. Furthermore, often, limited resources are allocated to design, plan or develop barrier- free transport systems."

It is easy for most able-bodied people to forget the importance of making all of our surroundings accessible since it doesn't apply directly to them. "The creation of fully accessible public transport is a complex process. It requires not just accessible vehicles – buses, coaches, trams, trains etc. – but also an accessible environment understood widely. In general people with disabilities tend to be less well off than their able-bodied peers." (*Accessible Public Transport*, n.d.) In order for accessible transport to be understood, we need to understand what it is like to be in the shoes of someone with different needs than our own. "Accessible public transport systems are to be understood as systems which integrate all people – including those with mobility, sensory, cognitive

impairments, mental health problems, environmental sensitivities and allergies – when delivering transport services. They include not only being able to get on and off vehicles, but also being able to understand how the public transport system works, being able to get to and from terminals or stops, to buy a ticket and travel with confidence." (*Accessible Public Transport*, n.d.)

3.2 Problem Statement

To further work on solving this issue, it was important to come up with a one "how might we" problem statement that can be solved at the end of the project and also be referred back to during the duration of the project. The final problem statement and question after considering all research and feedback is,

"How might we create an accessible environment on train systems within Austria for people with hearing or vision impairments so that they gain independence and confidence in the community?"

To work on answering the problem statement, it is important to further the defined phase and create empathy maps, user journeys, storyboards and a persona that reflects the target group. Using these methods will help guide me in the right direction to start the next phase of the design thinking process, ideation. See figures 4-6 for examples of documents used in this phase.

Figure 4

Empathy Map for Persona, Ben

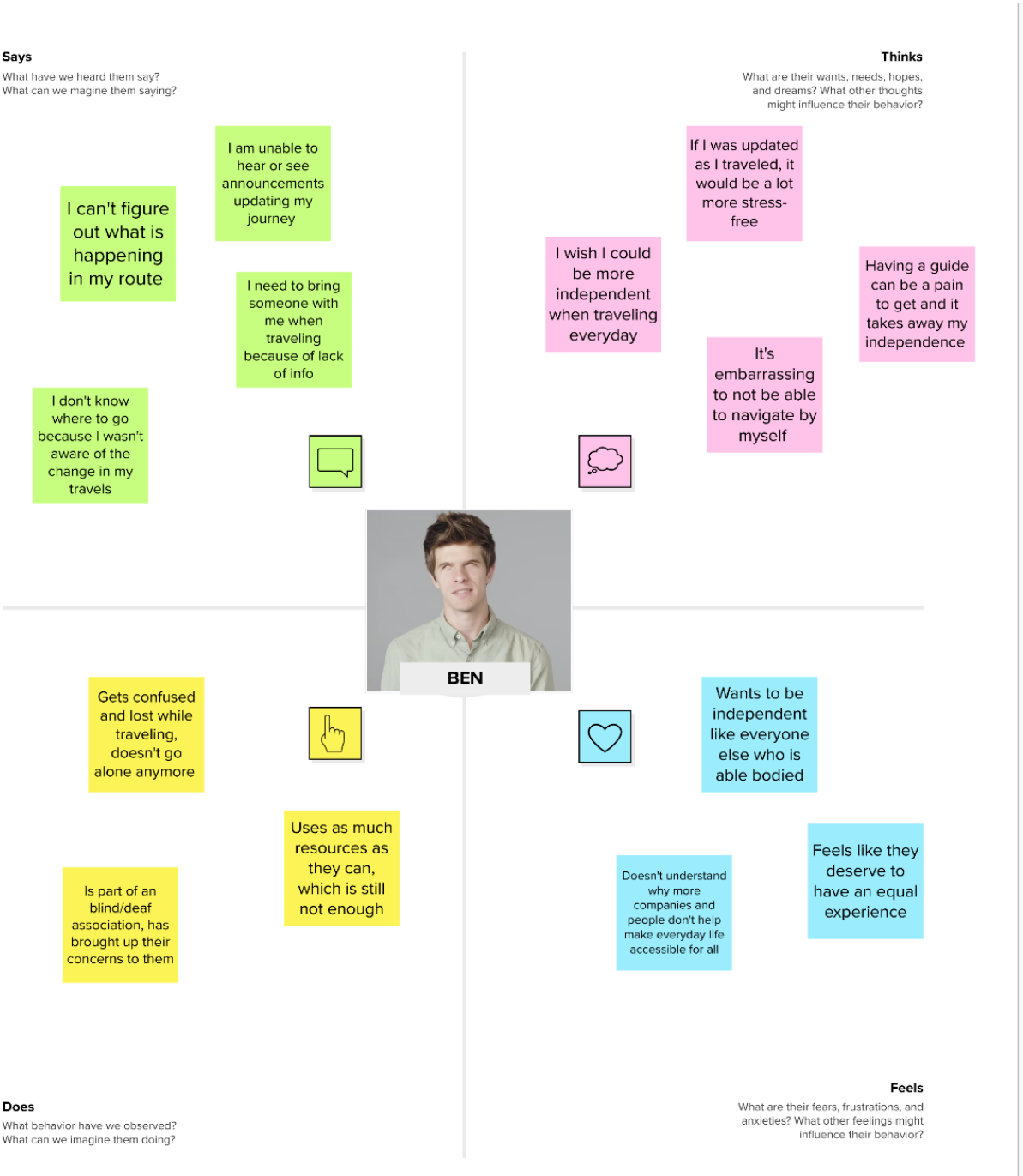
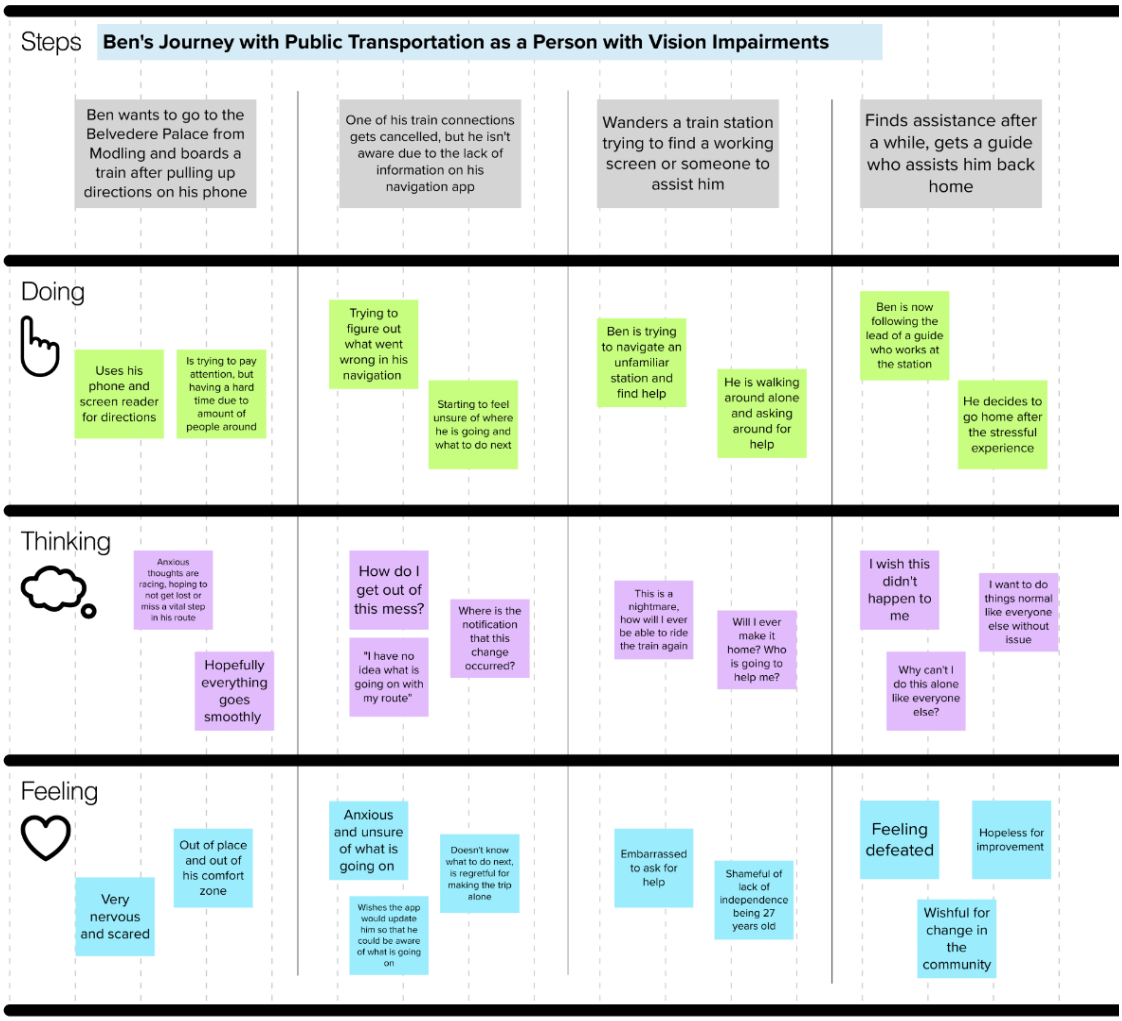


Figure 5

User Journey Map for Persona, Ben



4. Ideate

4.1 Methods Used

Once I defined the problem that needs to be fixed concerning accessibility in train systems throughout Austria, the ideation phase of the project began. I decided to use many methods to come up with different solutions to the “how might we” question raised at the end of the define phase. In my original Marshall Plan Proposal; I had a set solution in mind that I had previously come up with but decided to complete the ideation phase fully after learning the importance of each step in the design thinking process. I brainstormed for over an hour and came up with a list of around a hundred ideas that could fix the problem, some more realistic than others. After coming up with the list, I chose the top three solutions and did more research revolving around the idea. It was important to consider the viability and desirability of each idea so the ultimate solution would be based on which idea was most matched with these requirements. Along with brainstorming, I created an empathy map and storyboard that aligned with the ideation part of the design thinking process.

4.2 Current Solutions

Examples of current solutions can be found all over the internet; many countries around the world are doing their part to create accessible public transportation for all. Cities in France have audio signage for people with blindness or vision disabilities. The main solutions that are overall noted are around the following subjects: training for staff and other public transportation employees, implementation of simple, easy to use equipment and finally, digital solutions using technology that can be both multi-sensory and multi-channel. Technological aids exist which can help to compensate for impairments. This branch of technology is referred to as Assistive Technology or AT and has an array of AT aids available including powered mobility, walking aids, and communication aids.

Scientists in the Netherlands conducted a survey among disabled commuters and discovered that an easy-to-use, smart information tool would be the most significant component to improve commuter's journey planning and willingness to travel. Implementing simple tools is something that many countries are starting to lean towards. Researchers from the MOBI Mobility, Logistics and Automotive Technology Research Centre at the Vrije Universiteit Brussel (VUB) are conducting a pilot study in Antwerp. These research facilities are testing a new method to assist visually impaired people at pedestrian crossings by sending audio and vibrating messages to their smartphones, so they can safely cross the road. (Pappas, 2021) Another example is the "InnoMake"- a shoe equipped with a warning system that is attached to the front of the shoe. With the help of distance and foot movement sensors, a vibration unit, an ultra-bright LED, and a processing unit, as well as a wireless connection to the smartphone, the shoe detects obstacles and informs users either tactilely, acoustically, or visually. (Klakow, 2021)

Current technology is a huge aid for people with different levels of abilities. This will be the focus of the formed solution. Most of the disabled population has access to smartphones and watches with special technology on them to assist them with everyday tasks. "To rise to the challenge of universal accessibility, cities can benefit from innovative technologies that promote a barrier-free and inclusive society. Solutions may involve the use of augmented reality, wearables and artificial intelligence." (Pappas, 2021) The information within new technology innovations is key and therefore traditional ways of presenting timetable and other transport information need to be re-considered. "Technology is having a major impact on the availability, accuracy and accessibility of transport data. It allows relevant information to be delivered to transport users in a manner suitable to their needs. For people with disabilities, this is invaluable where it is leveraged to assist them with planning journeys along routes where they are confident their needs will be accommodated and presented with enough clarity to make those journeys easily." There are cases of third-party companies currently creating apps that are used for transport planning and information delivery. These apps were created using open access data rather than the public transport companies creating them themselves. (Dagar, n.d.)

4.3 Researching the Final Solution

Although there are many solutions throughout the world that use new technology to create accessible fixes for the problems that individuals who are vision or hearing impaired face each day, current solutions available in Austria address mobility accessibility problems first and don't target the needs of people with disabilities that are not related to mobility.

To best assist the target group, the final solution is an app for smartphones that will assist the user by using haptics to alert them of a change or any other type of announcement during their journey using public transportation. Because this project focuses on two subgroups, hearing, and vision impaired, it is important to use features that cater to the senses of both persons. "Haptics uses a vibration motor/actuator for pattern generation, driven by an electronic circuit. Haptic/vibration feedback is widely used for notification systems and is especially useful when the user's auditory and visual senses are occupied. It is language-independent, can work in a noisy environment, and does not have an information privacy problem." (Dagar, n.d.) There are also studies which demonstrate how haptics can help decrease the cognitive performance of the user, creating ease in the tasks they are completing. "Evidence shows that the haptic system operates independently of the auditory system, further suggesting that assistive technology utilizing haptics is an optimal sensory modality for conveying dynamic information without increasing mental processing."

Ideally, the final solution would include the ability to link the application directly to a smart watch as well, where haptics would be the most noticeable. This application could be used in conjunction with the public transport application provided by the company or it could be implemented as a part of the app maintained by the company. For the sake of this project, it will be its own independent app that can be linked to the public transport app containing the necessary information. Therefore it can be used in many different locations with various public transportation companies and therefore not limiting the user to a single area. In previous research, most apps similarly used to create accessibility apps were created by third party companies in conjunction with the public transportation company. There are three types of haptics: graspable, wearable

and touchable. For this project, we will be focusing on technology that can be worn, on the wrist or in a pocket, as the solution. Wearable designs also provide discrete assistance, more immersive interfaces, and a larger field-of-view for the wearer (Real & Araujo, 2019). Individuals can offset their cognitive load by relying on navigational technology that can transmit information from their environment.

One example of wearable haptic technology used for people with blind or visual impairments was created by a company called Sunu. Sunu created an armband that uses sonar and echolocation to detect objects within the user's path followed by haptic vibrations to supply information on proximity, see in figure 6. Although wearable technology is a great aid for those with disabilities, it is important to note that this "is not envisioned as a replacement for a white cane or a guide dog but as an additional novel layer of sense enhancement." (Dagar, n.d.) Haptics are in simple terms, an additional sense enhancement that can be used in sensory substitution technology due to its "large coverage area and keen ability to recognize spatial and temporal information". For this project, the solution will be based less on spatial and object awareness and more on a notification that provides the user with essential orientation information prior or during travel.

Figure 6

Sunu Band with Haptics for Blind People

5. Prototype

5.1 The Use of Haptics

The use of appropriate haptic sensations for navigation could therefore reduce attention demands for both sighted and visually impaired individuals. Interest in the recently announced Apple Watch illustrates the widespread potential of such technology. The Apple Watch features a non-vibratory haptic interface that may be used to provide navigation instructions (‘turn by turn directions’) without the need for visual or auditory attention. Phone companies have also developed similar technology that can be used for navigational purposes. “Features existing in the latest smartphone like different high-quality sensors, faster network connectivity and higher computational capability of hardware can be investigated further to develop assistive systems for navigational support with relevant facilities and features for their effective and practical use” (*Apple Watches*, 2022)

After thorough research, I decided to focus on a smartwatch to be the main prototype and then if time permits, transfer it to mobile form. Both devices are up to date in technology required for navigational purposes and equipped with haptics. Additionally they are discrete and don’t restrict motion, which is necessary for people with visual and hearing disabilities. The assistive technology that will be implemented is called Position Locator Device and uses GPS technology, which provides information on the exact location of the user in possession of the device. GPS programs may be designed to offer route directions through Braille, text, or speech. Some packages may include additional features, such as data on speed, altitude, GPS coordinates, and information on areas of interest.

5.2 Accessible Technology with Haptics

An app called Wayfinder, is a great example of a personal location tracking program and navigation system for people with low vision and cognitive disabilities. It

uses audio and visual cues to support independent travel. It can be downloaded onto a smartphone where the user can even create and input a desired route into the program. However, it is very expensive, costing 799$ for the program. Although Wayfinder is a great assistive technology, it does not apply to most users in Austria using public transportation because it only uses output audio and is void of any tactile notifications. Most other assistive technologies like Wayfinder are geared to helping individuals with Autism Spectrum disorder and dementia, so in that regard it doesn't fit our target audience.

5.3 Prototype Description

Using inspiration and features found in Wayfinder, the prototype solution I will be creating will include navigation systems and location tracking to assist people with hearing or vision impairments. The user interface will be set up to fit the needs of both deaf and blind people, incorportating both voice output and tactile output as the method of notification. "For instance, if you're designing an app with a map interface, you can use haptics to guide the user's finger to the right location. You can also use haptics to provide feedback when the user clicks on buttons or selects items from a list" (*Haptic Feedback: Why Your App Needs It and How to Use It*, 2022) The user will be able to input their route of public transportation or journey while being assisted with both tactile and audio output when they are approaching or at points of importance within their route. This will help promote independence and comfortability to those with visual or hearing disabilities as they use public transportation using their smart devices.

5.4 Designing UI for People with Blindness

Before I began the designing of the prototype, it was critical to learn how to design user interfaces specifically for persons who are blind, because they rely on their hearing and tactile senses alone. On the other hand, most deaf people still possess

their sense of vision so other interfaces used will be beneficial if it uses haptics as the primary mode of communication.

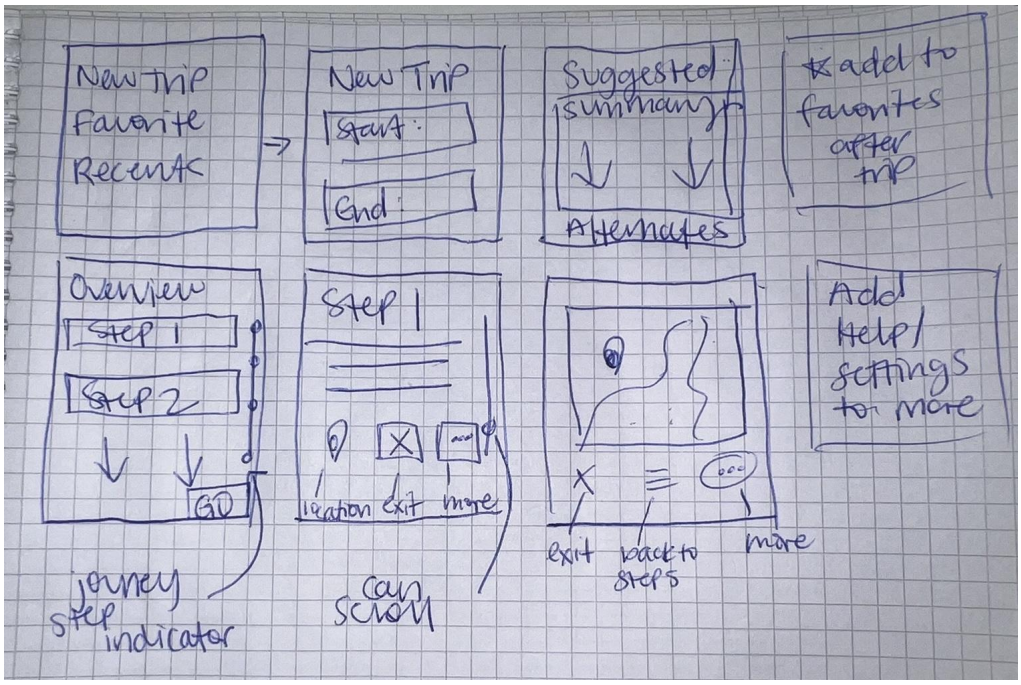
To design mobile applications for visually impaired individuals, the design must include enlarged text. Many people with visual impairments are not fully blind therefore, they can function with and rely on enlarged texts within mobile applications. Minimalizing the design of the app as well as providing consistency will benefit the user greatly. By using haptics and other necessary features to assist, people with blindness will be able to navigate the application successfully. They will also be able to navigate around the app using voice output and screen reader assistive technologies. For those with hearing related disabilities, the audio output can be switched off since it is not necessary for their experience on the app.

5.5 Prototype Development

I began the prototype phase of the design thinking process by creating paper prototypes of the final solution that was decided on in the ideation phase, as seen in figure 7. Aided by sketching, I was able to create detailed paper prototypes that would assist in the creation of wireframes on a computer program. Once the drawing was done, wireframing of the paper prototypes began in Figma. After wireframes were completed, they were transformed into gray comps, providing a more detailed version of wireframes but without media or text. After deciding the color theme and other design preferences, I replaced the content of the gray comps with real data and other necessary text. After the high-fidelity design of the prototype was complete, it was essential to add functionality to each of the elements to make it suitable for testing. By doing so, the user could click on features and elements on each page thus receiving a response within the prototype. An example would be diversion to a new page which would occur on any other web application.

Figure 7

Prototype Development Sketches and Mockup Example



One challenge throughout the development of the prototype was in adding haptics to the functionalities requiring it to work. The point of the app is to guide with the use of haptics so this process was critical in order to test and achieve the best user experience possible. Haptics are not usually incorporated into mobile device prototypes, so finding a way to add them to my designs was a challenge. In order to fix this problem, I was able to download Origami Studio, an in-depth prototyping platform that allows you to integrate more features into your prototypes such as sound, vibrations and movement. I was able to use the site, Captain AHAPS, to design custom haptics for the application. There, I successfully adjusted the strength and pattern of the haptic to fit different features, as seen in figure 8. Once the design of the haptics was complete, I exported the new haptic's exact code which I copied. I took the new code and pasted it into the "haptic section" in Origami Studios, as seen in figure 9. Once the new code was added, the prototype would respond accordingly and the new haptics would appear when needed.

Figure 8

Captain AHAP Site

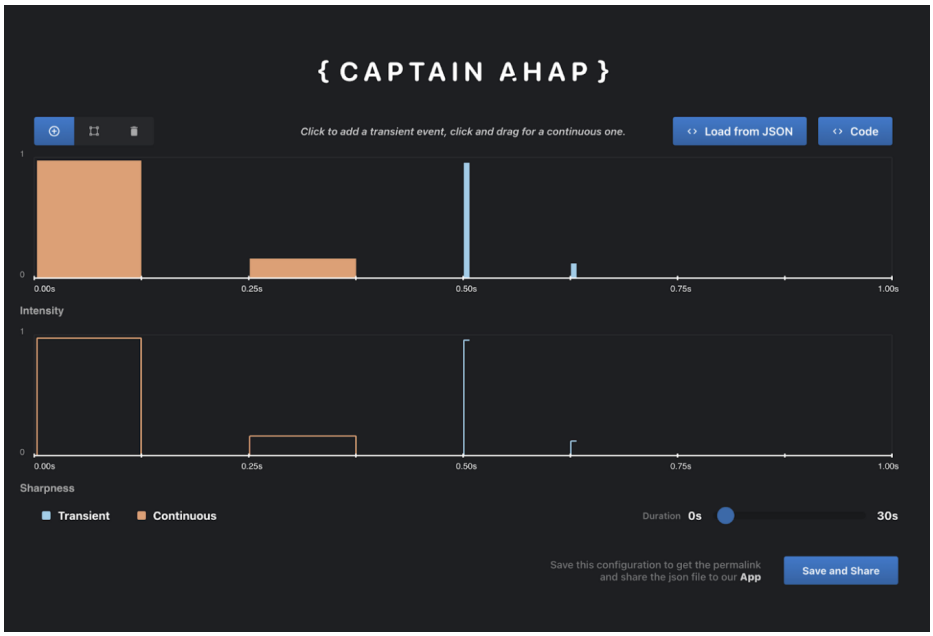
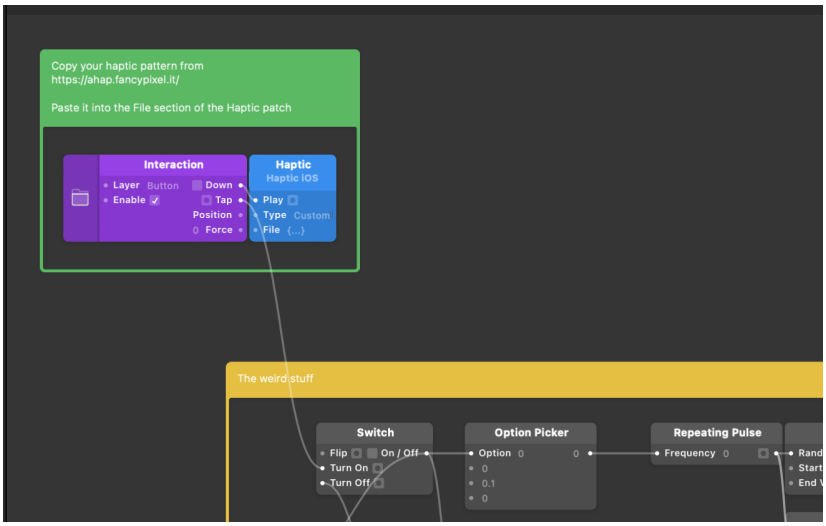


Figure 9

Origami Studios with Haptic Feature Implementation



After the completion of the prototype, it was time to name the application. This involved a lot of brainstorming as well as some A/B testing. The name of the application needed to reflect its contents and mission. After a considerable time of pondering, the app was named “Lookout”. This matches the app perfectly and allows the user to feel as if it is a helpful guide looking out for them.

6. Testing

In order to efficiently test the prototype that I created, I needed to test it on users from my target audience. If unable to reach the target group, I would test able bodied people, blind-folded or wearing sound-proof headphones to represent each subgroup of the target audience.

6.1 Methods Used in Testing

I reached out to many different associations within Austria to try and find participants within the user group to test the prototype in person but unfortunately I received no response from these groups. Due to this setback, I was able to test the concept and demonstrate the application to people I came across in public who had hearing impairments, walking canes or guide dogs. At first, the goal was to complete usability testing on the train but due to lack of participation from the target group, concept testing turned out to be the more fruitful option. Although I did mostly concept testing, I did blindfold and/or used earplugs on 5 able bodied people to complete usability testing in a similar scenario to what individuals with hearing or vision impairments would experience.

6.2 Testing Scenario

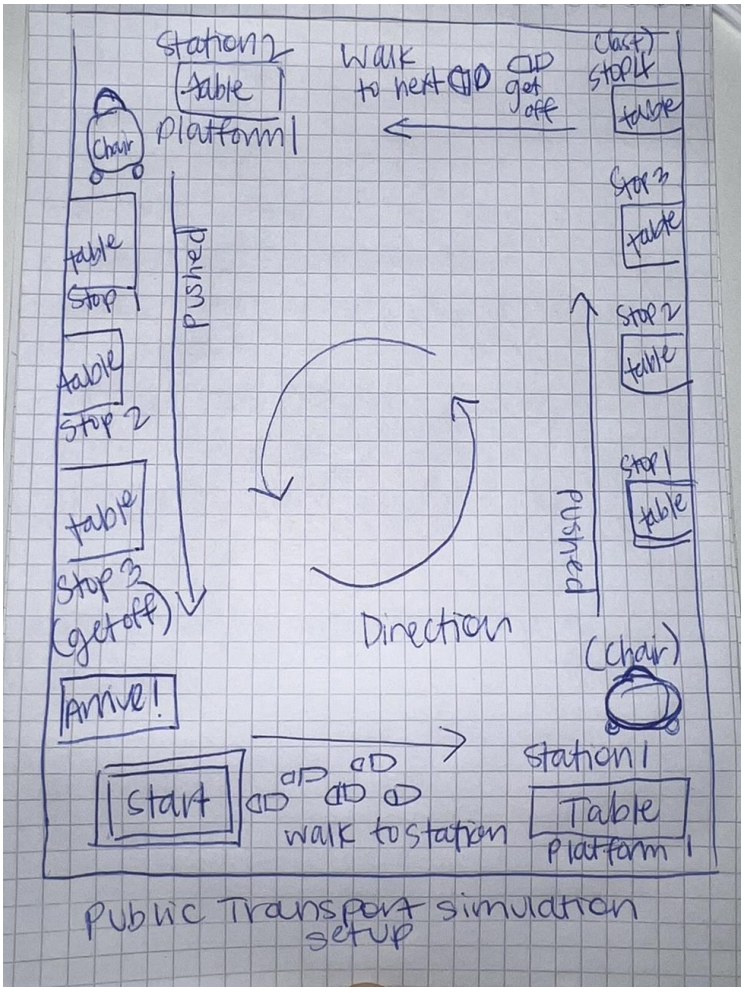
Throughout the train station in Austria; I was able to talk to many types of people with different hearing and vision impairments- ten people in total. I positioned myself in the areas designated for people with disabilities, increasing my opportunities to contact my target group. Once I encountered someone that was in the specific target group, I asked if they would be interested in briefly talking to me about a project I was completing about technology that would help people with hearing/vision impairments in public transportation. I made sure they were comfortable speaking English, since my German is not very good. Most people that I encountered during this phase were extremely kind and very open to talking to me about the project. I described the prototype in a detailed yet succinct manner and then showed them the prototype on my Apple watch. I demonstrated what would happen when you approach your stop, if possible delays occurred, and other unique features within the prototype.

For usability testing, I recruited five able bodied peers to help with this part of the project. It was not feasible to complete the testing on the trains due to financial restrictions buying tickets and other logistical reasons, so I completed the testing in a classroom with a simulation of what the public transport would look like. Participants were blindfolded for the first test and then asked to wear earplugs(but with no blindfold) during the second test. For the third test, they wore both earplugs and a blindfold. The room used for testing was cleared and consisted of rolling chairs to simulate riding public transportation, and signs on whiteboards to indicate stations and platforms. The user was asked to wear the watch with the prototype and complete

the simulation. They would follow the directions of the watch and haptics while walking to different platforms and getting on chairs. The chairs would be pushed by a volunteer to simulate riding public transportation. The simulation was made to be as close to an experience in public transportation for someone with hearing or vision impairments without actually being in a public transportation setting. You can see a description of the environment and simulation in figure 10.

Figure 10

Usability Testing Public Transport Simulation Layout



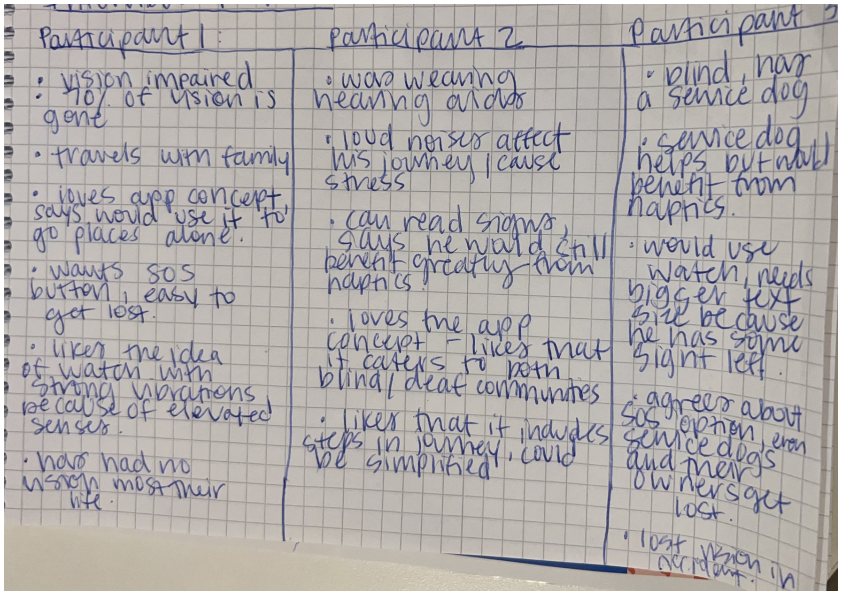
6.3 User Testing Feedback

Conversing with people on public transportation while explaining/demonstrating my prototype to them was an amazing experience and I learned even more about my target group than I had previously known. Overall, the feedback was extremely positive and eight out of ten of the people I talked to said that it would improve their independence significantly. They also mentioned that it would bring them comfort during times of chaos, such as rush hour or when things got confusing (delays, cancellations). Every person that I discussed the prototype with was very excited about the idea and said they would use it for various reasons. The main reasons they would use the prototype were: strong haptics for notifications that were important to their journey, clarifications to their journey, and ease/comfort during their journey that would help them be more independent. A few of them asked if there was a way to make it possible to use on their phone, but the others were very interested in having a watch to use. A few of them already had smart watches, and those who didn't were interested in purchasing a watch if it had features like I showed them.

Beneficial feedback I received included simplifying the transportation instructions and making it more about the notifications and haptics. Individuals were more interested in being alerted to stops or other important notifications relevant to their journey. A few people were interested in having a voice over for instructions along with the haptics due to vision impairements. Interestingly, I learned that individuals greatly benefit from a SOS call button, which would direct them to somebody who could assist if they got lost or stuck during their journey. This was a meaningful discovery, especially since a member of the user group brought it to light and others within the target group strongly agreed. Often individuals with disabilities need to find a SOS button to call for help within the train stations by themselves, which can be difficult to locate. Most of the user group I talked to did not have assistance from a guide dog, so I made sure to note these things that would elevate their overall experience regardless. An excerpt from the notes taken during the concept testing can be found in figure 11.

Figure 11

Concept Testing Notes Excerpt



Usability testing was successful. Each member that participated voiced that they previously didn't know what it was like to have hearing or vision disabilities, and the testing simulation helped open their eyes to challenges impaired people face on a daily basis. They were able to empathize on another level with the target group, which was a lovely bonus for the project. Regarding test results, everything went smoothly and I received similar feedback to what was discussed with the target group during the concept testing which I completed. Similarly, feedback received was to simplify the design, taking away distracting points in the navigation. The design of the prototype was inspired by Apple Maps, which gives the user a lot of information during their journey, but is not necessarily tailored to people with hearing or vision disabilities.

Each user in testing felt like the simulation was an accurate summary of what a public transport journey would look like and voiced that the watch helped them significantly throughout the process. They enjoyed the haptics paired with notifications, especially when they had a sudden change in their journey or their stop was approaching. A few of the participants voiced how it was nice that the prototype alerted them that their stop was approaching as soon as they left the previous stop- this gave them time to prepare for departure of the train. They also enjoyed that it alerted them again once they were approaching their designated stop. Each

participant was able to complete the simulation journey and said that the watch was a lifesaver at the end of their testing. Many of the testers said they didn't know how they would navigate a cancellation or change in their journey without the notifications to alert them and couldn't understand how people with impairments managed to ride public transportation comfortably without such aid. I think this was a crucial piece of feedback, and shows the importance of implementing smart technology and haptics for people with disabilities in order to be independent and comfortable while completing every day tasks.

6.4 Changes Made According to User Feedback

I was able to go through the prototype creating a more minimal appearance with bigger fonts and icons. One key learning point was that my perception of "big and bold" for people with hearing or vision impairments was not big enough. That was an important lesson for me to learn and I'm grateful for the honest feedback from people with real impairments. It opened my eyes and allowed me to empathize even more with them, understanding their point of view on a deeper level than I had previously. Additionally, I simplified the instructions and tried to minimize them while maintaining efficiency and key details intact. The last change I made within the prototype was adding a SOS call button in case the user needed assistance or had an emergency.

6.5 Iterations

Once the prototype was changed according to the user feedback received, I repeated the process of concept and usability testing. I was able to discuss the improved prototype with 5 people who had either a hearing or vision impairment, and did the usability testing on the same five able bodied participants who were in the first round of testing.

The overall feedback was even better than the first and the concept testing went really well with members of the target group. I showed them the first prototype and then the second prototype while explaining the changes I made according to previous feedback from others in the user group. Each person really liked the improvements made and said that they thought it was a great idea which they would use either on their smart phone or watch. Each participant also approved of the SOS call button and said that was a crucial feature and excellent addition to the prototype.

Usability testing also went perfect- each member was able to compare their first experience with the prototype to their second and said that the experience was improved by the changes that were made. They also said that the SOS button was a wonderful addition, we even tested it out to see if the concept fit into the application. They really enjoyed being able to get help from a helping hand during the testing in situations where they got lost within the simulation journey. Every participant was pleased with the prototype and couldn't think of any more improvements after the second round of testing, which was great feedback indicating success of the application.

6.6 Final Prototype

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The final prototype was portrayed mainly on a smartwatch due to time restraints and the desire to complete the best version of the application possible, you can see a copy of the final prototype in figure 12-15. The prototype is able to be seen and used on the smart watch using the prototype application, Origami Studios. The front page contains a list of favorite locations as well as recently accessed locations. At the top, you can add a new trip (Figure 12). Once you add a new trip, the user is brought to a new page where they can search for a destination or choose from a list of suggested locations based on categories such as cafes, groceries, or banks. (Figure 12). They can use the keyboard to search for their desired location. For the purposes of the prototype, the user searches for Belvedere Palace (Figure 13).

Figure 12

Prototype Home Pages

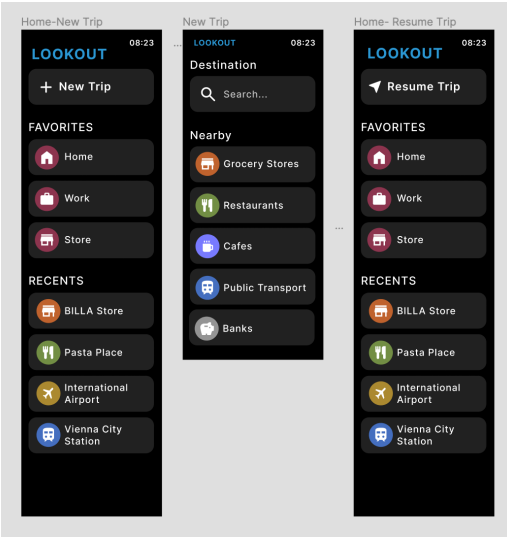
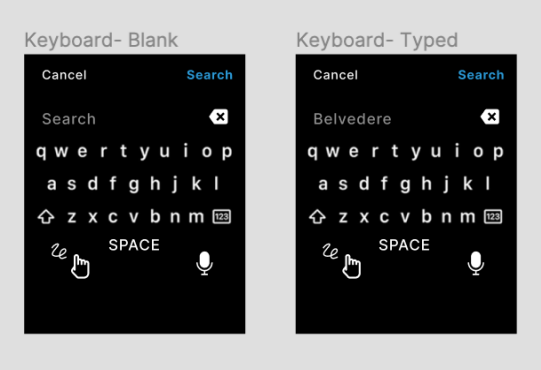


Figure 13

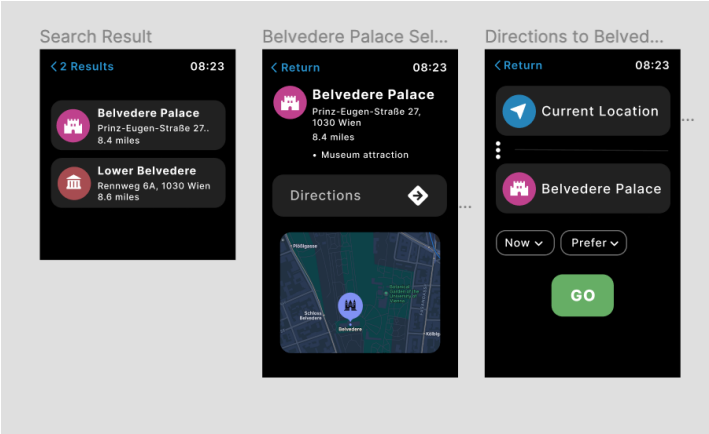
Prototype Keyboard



They are offered a list of locations containing the words “belvedere” that are located nearby, and the user can choose their correct suggestion (Figure 14). Once they click on their preferred location, they are shown a summary of the location and a map that shows where it is located. The user can click on a button that says “directions” to proceed with getting directions to the location selected. They are then brought to a page that has a starting point and a destination point, which is Belvedere Palace. The starting point is automatically put as “current location” of the user, but they have the option to change this if desired. The user then pushes go and it takes them to a page of possible routes. There is a suggested route, which is the fastest and most efficient, with a list of three alternates below. It shows the estimated time of the journey as well as which public transportations required in order to get to their end location. Each type of public transport is indicated by an icon with the type of transport it is, such as S-bahn or REX train as well as the associated number. Once the user decides on which route to choose, they click on it (Figure 14).

Figure 14

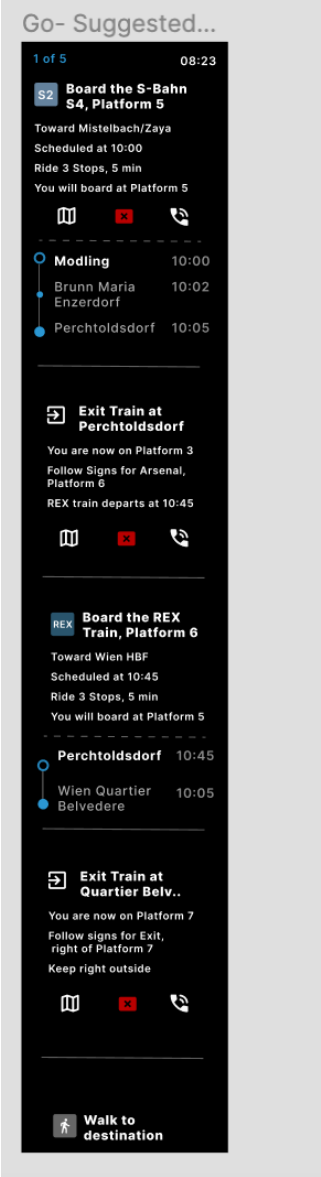
Search and Picking a Location in the Prototype



This takes the user to a page that shows an overview of the journey so that they know what the route looks like, which is important to people with impairments so that they can prepare for switching platforms or types of transport. You can see the whole overview in Figure 15. The overview contains what the watch will show during the journey, how many stops are between each point in the route, how long specific steps of the journey will take, and when each step of transport departs and at what platform. Most of this information is not shown on regular maps, but it is important for people with impairments to know since they cannot access information the same way that able-bodied people do. The information included in the route overview and notifications throughout the journey is to make sure that people with impairments have the smoothest journey possible with all the necessary information to travel safely and at ease at their disposal on the application. This part of the prototype can be seen in figure 17.

Figure 15

Prototype Trip Overview



On the page with the journey overview, the user can press go and it starts the navigation. As they complete different parts of the journey, various screens will appear to guide them and ensure they are getting off at the correct location and transferring to other steps within the journey efficiently. As they complete their journey, the smart location tracking follows them

and keeps track of when they have reached certain points within the journey and goes to the next page containing the next steps of their travels. It alerts the user when their stop is next after departing the second to last stop as well as alerting them that they are approaching their stop. This is to help the user prepare to get off the transport in a timely manner as well as remind them of their stop once they are approaching the station where they are getting off. Having two notifications about their station coming up is to give the user comfort and reduce stress during their exit to the next part of their journey.

While they are in navigation mode, they can click on the map icon and see their exact location on a map in real time as well as the location of the final destination. This is to keep the user informed and also comforted that they are heading in the right direction. The user can also cancel the journey by clicking the red button with an x if they need to stop the navigation. Finally, they can click the phone icon on the right in case they need to get assistance during their travels or have an emergency. This phone icon will use location tracking and connect them to someone that can assist them in the area who works for the public transport system they are riding. At first, the phone button was hidden in a tab of “other” on the page, but after user feedback, it was important to move the SOS button and make it readily accessible and able to be pushed immediately during the navigation process if needed.

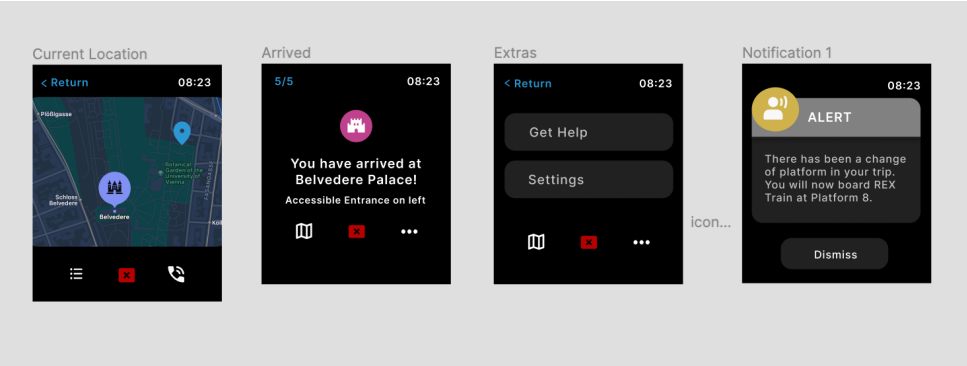
When the user arrives at the destination, they can exit the navigation and or add the location to their favorites if desired. This is to help keep all of their favorite locations easy to access on the front page without having to search for them each time they want to travel there. By just clicking a heart, it adds the location to their favorites. They can also remove favorite locations by clicking the heart.

Notifications for the app are similar to those on an apple watch, the notification pops up paired with associated haptics and an icon indicates what kind of notification has been portrayed. Icons are to help the user understand the type of announcement, such as intercom/overhead speaking, accidents, cancellations, or changes in the journey. The announcement or content of the notification is written below and then the user has to dismiss the notification to continue where they were previously on the watch. This is to make sure that the user doesn’t miss important notifications about their journey that would be crucial to the success of their journey without stress. Once they click dismiss, they return to the page of the app they were on and the application automatically updates itself and the journey according to the announcement if any changes need to be made. If significant changes need to be made on their trip, it alerts the user and they have to agree to the changes so that they are aware of what is going on in their journey.

The main purpose of the app is to assist people who often miss very important notifications while traveling on public transport, so it was extremely important to make an effective system of notifications and assistance to change their travel plans if needed. By doing this, it allows the user to be independent and handle problems if they occur with no issue. As the user is able to overcome challenges on their own, their confidence and independence grows and therefore their quality of life improves. Although this product is just a navigation app tailored to help people with hearing and vision impairments, it can also help anyone that needs assistance or a boost during their route. Elderly people, people with other types of disabilities, mothers with young children- the app is designed to be simple and helpful for anyone that would benefit from extra notifications. It is easy to get distracted and miss important notifications for not just people with disabilities but also able-bodied people so the fact that this app is designed in a way that could benefit all types of people is a wonderful thing. The rest of the app features can be seen in figure 16.

Figure 16

Prototype Additional Features



The app, when used on a smart watch, can also feature a voice-over/screen reader if needed. This is specifically meant to assist people with vision impairments. When they use the app they are not only assisted by haptics but also a voice to guide them along the way. At first I thought it would be difficult to design a prototype for people with blindness, but there are great resources out there that help designers tailor an app for people with vision impairments and

using those resources was crucial to creating an app that could benefit that population of people.

7. Final Overview of Journey

Creating an app that helps deaf and blind people navigate public transportation systems with haptics required a lot of creativity and careful planning. Here's how I would describe the creative process behind building such an app:

1. Empathize with the target users: The first step in the creative process was to understand the needs, desires, and pain points of deaf and blind people who use public transportation. This involved talking to them, observing them, and trying to put ourselves in their shoes. We needed to understand how they navigate public transportation currently and what barriers they face.

2. Define the problem and opportunity: Once we had a good understanding of the target users, we needed to define the problem we were trying to solve and the opportunity we were trying to seize. In this case, the problem was that deaf and blind people face challenges navigating public transportation, and the opportunity was to create an app that used haptic feedback to provide them with real-time information and guidance.

3. Brainstorm ideas: Next, we brainstormed ideas for how haptic feedback could be used to help deaf and blind people navigate public transportation. We considered a range of possibilities, from using vibrations to indicate which direction to walk in, to using different types of vibrations to indicate different types of public transportation (e.g., a train versus a bus).

4. Develop a prototype: Once we had some promising ideas, we developed a prototype of the app that incorporated haptic feedback. We tested the app with both deaf and blind people to see how well it worked and how easy it was to use.

5. Iterate and improve: Based on the feedback we received, we made iterative improvements to the app. We refined the haptic feedback to make it more intuitive,

adjusted the interface to make it more user-friendly, and made other changes based on user feedback.

6. Test and evaluate: Finally, we tested and evaluated the app with a group of people using a blind/deaf simulation to see how well it worked in the real world. We gathered feedback and data on how well the app helped people navigate public transportation, what challenges they still faced, and how we could improve the app further.

Overall, creating an app that helps deaf and blind people navigate public transportation systems with haptics required a lot of creativity, collaboration with users, and careful planning. By empathizing with the target users, defining the problem and opportunity, brainstorming ideas, developing a prototype, iterating and improving, and testing and evaluating, I was able to create an app that truly met the needs and desires of deaf and blind people who use public transportation.

8. Final Conclusion

I have a lot of experience when it comes to interacting with people who have disabilities of all kinds- hearing, visual, intellectual, mobile. I worked as an assistant manager at an apartment-style living facility for people who had intellectual disabilities specifically, but also dealt with vision and hearing impairments due to their differing diagnoses. I spent many years assisting this population of people in their journey to becoming independent and comfortable completing everyday tasks. I grew to become best friends with them and love them unconditionally- all I wanted to see was my friends with disabilities and different abilities succeed while through life and completing simple everyday tasks with ease, such as going to the grocery store or movie theater. I spent countless days coming up with solutions to aid them in their journey and saw firsthand how tough it can be to have any type of impairment in this world. It deepened my understanding of people with disabilities and their experience in life and has become a passion and mission of mine to improve this world for people with different abilities. This project has helped me understand the struggles of people with hearing or vision impairments on an even deeper level than before- especially in a country that is new to me with a different culture and way of living. It has been an amazing experience getting to talk with

people who have hearing or vision impairments during my time in Austria. I think it is so vital to understand what people with disabilities go through in order to appreciate what we are given.

People with disabilities are often so positive and grateful regardless of their situation and it really humbles you as a person. I am honored to have worked on a project that helps people with impairments and the ability I have had to research the subject at hand. I have learned so much about the hearing and blind communities as well as what other groups are doing in the world to assist those experiencing disabilities and desire independence in their everyday lives. I feel like my UX design skills have infinitely improved and my ability to empathize with the user group at hand has deepened. As a UX designer, our job is to understand the wants, needs and motivations behind our users so I feel like this experience was priceless.

I believe each country around the world should take the steps to improving everyday tasks for people with disabilities using the improved technology and knowledge that is offered today. Due to the feedback and results of this project, it is clear that technology can be used to improve the lives of people with disabilities. The world can be accessible with just a few improvements and changes in order to cater to people who aren't able-bodied. In order to start the improvement of our world and make it more accessible, awareness needs to be raised and spread in order to advocate for those in the minority. "The more people that know about different disabilities, the more likely research will be done into the cause and treatment of it. Spreading awareness of disabilities might encourage just one person to do some research into it. This could create a big impact. They may discover something new, or they might change their opinion on the matter." (How To Spread Awareness of Disability - Twinkl, n.d.)

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