Grocery Shopping Experience for Visually Impaired People

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ABSTRACT

Individual grocery shopping might still be frustrating and time demanding for visually impaired people. A lot of uncertainties are involved to this action, such as navigation to the market, finding specific products or reaching out for help to strangers. We aim to explore the possibilities of how to improve this process. Further we investigate the usage of current assistive technology and propose a way of how actively forming social bonds, can lead to a barrier free experience for visual impaired people.

Author Keywords

HCI, user-centered design, grocery shopping, user studies, visually impaired people

CCS Concepts

•**Human-centered computing** → **Human computer interaction (HCI);** *Haptic devices;* User studies;

INTRODUCTION

Grocery Shopping is not just the consumption of goods but rather an emotional interaction with the environment and community around. As a major daily activity it needs to be available for everyone. But with multiple hurdles for people with special abilities, such as visually impaired, it becomes a real challenge for those. Navigation, distinction between products and the payment process is just the obvious peak of a longer list. The research is aimed to explore this issue in terms of the possibility to improve the shopping process for people who could probably do shopping more independently.

In general it needs to be said that visual impairment is a very broad term, ranging from little symptoms to complete blindness. Our research is addressing those individuals with strong impairments and total blindness which for the sake of simplicity will be designated PVI (People with visual impairment). This study considers blindness as no ability to recognize visual impacts such as light or movement and strong visual impairment as people with some rest sight that are able to recognize some visual information like contrast.

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The whole shopping process was divided into four stages, namely Preparation - Shopping - Payment - Transportation. Preparation for grocery shopping begins at home and can include such steps as identifying expired products, making a list of products, calling for a taxi, calling in the store to notify an employee or volunteer that help is required. Then the shopping itself proceeds, and a person has to know the store well to navigate clearly and distinguish the products on the shelves. Paying and packaging is the third step in user flow which may include multiple issues like inability to dial a pin code on the touchscreen, or checking change at the checkout counter. Then the last stage is carrying products home, which may also require additional help.

One of the possible alternatives can be online shopping with home delivery service. However, this option reduces personal independence and spontaneity, can be time consuming or not available at all [15]. Therefore, it was decided to concentrate on the live shopping experience and conduct our studies with participants who are able to use a smartphone and might shop individually, as well as fully blind participants.

This research is aimed to identify and analyze several issues concerning the four stages in our user flow described above, consider existing solutions and develop a possible direction in research. Many assistive technologies have been designed to address the problem of individual grocery shopping. Yet proposed application is mostly restricted to technical versed users with a good understanding or smartphones and computers. An accessibility aid introduced in this research is supposed to be accessible for users of all levels in prior knowledge.

Research Questions

Our research is aimed to answer the question of ***"How to make grocery shopping more accessible for visually impaired people?"*** **(RQ 1)**

To do so the following sub questions were defined:

- **RQ1.1:** *"What is the current state in grocery shopping of PVI?"*
- **RQ1.2:** *"What senses are mostly involved in the shopping process, and how can these be used for additional feedback?"*
- **RQ1.3:** *"What kind of alternatives are there for PVI (e.g. Online shopping)?"*

RELATED WORK

According to the BSVÖ (Austria's largest self organisation for blind and partially sighted people) there are around 318,000 PVI living in Austria by 2008. There are several systems that were built to improve daily challenges for PVI, however these systems mostly convert information into auditory. Some UbiComp systems provide aid for navigation and obstacle avoidance solutions. For instance, in 2013 there was a presented system with depth camera (Microsoft Kinect) and sonification, which identifies structures from the depth map and conveys obstacle information to the user [7]. Tactile graphics can be also a solution for indoor and outdoor navigation. For instance 3D printers now offer an alternative to present 2D graphics, and can be augmented with audio labels. Positive results were shown in the recent study of accessible 3D maps which were used for Orientation and Mobility training [11].

Mobile Devices

According to the study about visual challenges that PVI face in everyday life, 28 percent of photographs taken by them are related to the food and beverage objects [5]. And the most difficult is to find desired products on the store shelves.

There has been an increasing interest in mobile assistive applications that allow PVI to access bar codes, bills and brand names of the products. The next step was a development of OCR-based (Optical Character Recognition) applications for smartphones which are complemented by high quality on-board cameras. However, these systems have one main flow correlated with the ability of blind person to correctly pose a smartphone in order to get a readable picture, which can be easily done by a sighted person [8]. Another issue is that the capabilities of tools that include OCR, GPS, sensors, Bluetooth etc. are mainly dictated by the state-of-the-art technology rather than by real human problems.

Mobile devices include screen reading software that enables fluent eye-free use of the content. Within a few years touchscreens and especially iPhones which were once not accepted by blind users are more preferable now due to well-designed multi touch interfaces that leverage the spatial layout of the screen [14].

"Lookout" is a free Android app from Google that uses computer vision to assist people in gaining information with spoken feedback, ear-cons or other signals [2]. For now it has only three modes: explore - for identifying objects around you, shopping - for scanning bar codes etc. and quick read - for reading.

"Seeing AI" is one of the most popular apps which identifies products by reading bar codes and uses audio cues feedback to inform about the presence of the bar code [1]. The user can understand that the bar code is closer when the beeping becomes faster. However, the app restarts reading if the camera moves which makes it more challenging for people with tremors.

Wearable devices

With regard to wearable products, "Third Eye" project is certainly one of the possible solutions [16]. The product consists of smart camera prosthetic that enables people with visual impairments to select desired products and shop on their own. Another example is FingerReader2.0 which is an alternative method of using the mobile phone [4]. It's an integrated wearable system with an on-board machine learning algorithm that explores the task of acquiring a product in the store. This project differs from related work by emergent algorithms and implementation of the discrete interaction technique. A relatively new product in the area of navigation is the product WeWalk, a smart cane. It automatically detect obstacles at head level and warns the user with vibration. The company states an improved outdoor navigation, including way finding features and public transportation integrations [3].

METHODOLOGICAL APPROACH

For the study dedicated to the detailed analysis of everyday life practices we decided to follow the interpretative paradigm, which allows us to consider challenges and issues that appeared in grocery shopping. User-centered design approach was considered as a better choice to ensure that the opinions and preferences of the user group (visually impaired people) are reflected. Therefore, we acknowledge users as subjects of inquiry and information. User-centered design methodology implies multiple methods including online interviews and digital ethnography which we considered as the most appropriate in the current situation.

Study (Interviews)

In order to analyse the behavior of visually impaired people, we conducted semi-structured interviews with participants. A set of the same questions was prepared to be answered for each participant and some additional questions that were asked in some cases. In this way of data collection researcher has direct control over the flow of the process and has a chance to clarify certain issues during the process if needed [9]. Totally, 5 interviews were conducted (3 with visually impaired people and 2 with experts in this field). Each of them were asked about their own experience in shopping, their knowledge about navigation and assistive tools for blind/ partially blind people, main barriers and habits. The interviewer guided the discussion and another researcher made notes about the feelings, attitude, pain points and other aspects while a participant described a typical user flow. All interviews were audio recorded and last about 40 minutes. Citations from interview and ethnography findings are marked with abbreviations in order to keep the text slim and easy to read. User participants start with an **U** followed by a number, experts starting with a capital **E** followed by a number, and the acronym **DE** followed by a number stands for digital ethnography.

Recruitment

User participants need to have any kind of intermediate or strong visual impairment and the ability to do shopping on their own or with little assistance. While the study is strongly dependent on audio feedback, we further defined that the group should be able to communicate properly and independently. Also participants should be able to use smartphones or other assistive technology. Users need access to a computer and online communication tool or a phone as an alternative for a successful participation. Regardless the gender our group is defined in an age between 18 and 60 years.

Expert participants need a background in the field of assistance/care for visually impaired people, work at a organization for visually impaired / blind or do research in a related discipline. They need access to a computer and online communication tool or a phone as an alternative. Gender as well as age are no further defined.

Digital Ethnography

Our main task in the study was to observe the process and see from the user's point of view main barriers that appear while grocery shopping. Observation can meaningfully inform future design and seed useful innovation, that is why we decided to use digital ethnography method. It gives an opportunity to watch what people do by digitally tracking them or asking them to invite us into their social media world [12]. There are many ways of applying digital ethnography methods into study, we practically used digital tools for analysis the information that is not contexts or sites of digital media immersion. We decided to use social media platforms such as Youtube and make use of the data which is available for everybody such as videos, comments, images and online communities. Using Youtube for studying gives us insights on human behaviour and activity in real world settings from the user's perspective. The main focus was on understanding common problems that visually impaired people may face in the store and what solutions they might see to solve these problems.

Significant ethical challenges and debates around internet space concerning private and public data were also taken into account. There is a strong argument that data collected in a public space does not require individual consent from each participant [13]. The content that is available without a user account is considered as open data, in contrast, when a user needs to create an account to gain access to an online community. In this situation the decision to declare data public or private is less obvious [13].

Therefore Youtube was chosen as a data source for digital ethnography to see how visually impaired people do grocery shopping and how they share their experience digitally with others. This way there was a possibility to quickly gain access to vast amounts of information about typical people's problems in different countries, cultures and situations. Apart from the videos, thousands of comments with people's reactions and shares of their own experience made a huge interest to us.

ANALYSIS PROCEDURE

Thematic analysis was decided as a method for interpreting qualitative data sets by sorting them into broad themes. Thematic analysis is a flexible method that can be adapted to the purposes of the research. As this study was trying to find insights about people's behavior, knowledge, opinion and experiences this was a good approach to analyze interview transcripts and data gathered from social media. [6]

Methods

Two types of data were received, qualitative attitudinal data from participants interviews and behavioural data from digital ethnography. After transcribing the interviews we started examining the data to identify common themes - topics, ideas and patterns of meaning that repeatedly come up. In this phase we used different techniques to arrange data like journaling and affinity diagrams. Journaling mainly was used within digital ethnography, and the researcher was writing down ideas and thought processes. Building affinity diagrams helped to highlight data from the interviews and reassemble it into meaningful groups before themes can emerge.

Codes were developed to represent the identified themes and applied or linked to raw data as summary markers for later analysis [10]. The codes allow us to sort information easily and to analyze data to uncover similarities, differences, and relationships among segments. Based on these steps we could identify essential themes.

It is important to correlate both attitudinal and behavioural data as they can complement as well as contradict each other. Therefore, we coded different types of data separately and then compared and juxtaposed our findings to identify common themes. Themes later helped to inform the design process and further define our hypothesis.

RESULTS

Different perspectives were gained either supporting or weakening our hypothesis that there is a big potential in optimizing the current shopping experience of people with various abilities when it comes to visual perception. In the following section we discuss some of our recent findings.

RQ.1.1: What is the current state in grocery shopping of PVI?

The researched was aimed to identify the current state of grocery shopping by PVI not just in terms of their independence but also in terms of what tools and technology is involved. Big differences in the understanding and perception of shopping trips were discovered, varying from a joyful experience with a longer stay in the market to a preferably quick and efficient activity. As the shopping process was split into a model of 4 stages, namely preparation, navigation, identification and payment, the interviews support the 4 stages and showed us that the first stage is strongly reliant on the type of person, whether participants check offers and prepare more in advance or go for quick and small purchases. Results support this fact and just as just one participant mentioned checking offers in detail beforehand. The main preparation task is preparing a shopping list. This is done by using a voice recorder or memorizing things. "Most of the people prepared a shopping list. Either on their voice recorder or on their smartphones. This highly depends on the individual age." (E01) Interestingly, there are the subtasks that can make it hard to prepare such a shopping list. One participant mentioned the difficulty in checking the fridge for expired goods, which makes it hard to plan what goods to buy.

The second stage is the shopping itself which was further split into navigation and orientation. Due to the interests in the shopping behaviour the transportation will be discussed only briefly and there will be more focus on the navigation in the store. PVI prefer supermarkets within walking distance unless they are helped by someone that owns a car. Furthermore the entrance can be challenging when there are parking lots

without any guidance and the danger of moving cars. Navigation inside supermarkets heavily depends on the actual visual abilities of individuals and is improved over time. Also some participants mentioned to have a favourite supermarket, and referenced a process of “getting to know” markets and building a sense of orientation. There are barely any systems that help them to navigate through the store. Most of them rely on their senses and complain about rearrangements of the shops. "Rearrangement of shops interior is a big issue because what people normally see, blind need to learn beforehand." (U02) Although many supermarkets have a similar structure that is often learned beforehand or over time. In order to support orientation of impaired people it is required to make information accessible in multiple ways so they address different senses. Another issue is crowded supermarkets that discourage shoppers with impairment. Special open hours or low frequent times can make their shopping more comfortable. Nevertheless it very much depends on the individual abilities. As some have no major problem within a learned environment others need to rely on assistance. Recent tools can improve but not manage to give PVIs real certainty while moving in the market.

Identification of goods is managed either via touch identification, with a bar code scanner or in an assisted way. As touch identification is only applicable for goods that have a certain form factor, bar code scanners can help and give additional information about products. There are more advanced tools available on the market, but these are often hard to afford. While scanners work well for popular products, they don’t for unconventional products. "A lot of products are marked properly but e.g. marmalade with its flourished labeling is really hard to identify. It would be good if designers focus on a clear description." (U02) The use of technical tools is often very time consuming and requires a certain setup (e.g: picking a product from a freezer). Further, the identification result is merely referred to a product that lacks important details, such as form, color, nutrition, and many more. Also the freedom of choosing between different products by comparing them is hardly possible. Therefore most people buy the same products over and over. Regardless if PVI use digital tools or their senses (e.g: braille description), we see a huge potential in improving this particular part of the shopping process. Also a more sensual approach to decide between similar products could improve the shopping experience. When making quick shopping trips or in case of buying something new, where the product is not well known, a personal assistant is the preferred way.

Regarding the payment of purchases participants mostly prefer cash pay "I normally pay cash, just for big sums I use card payment" (U02).Further card checkouts with touchscreens were mentioned as unusable and uncertain for users. While this stage is most probably the easiest part of the whole process, PVI suffer from the stressful situation in front of the cash counter. Subtasks of paying are putting goods on the track, the actual paying process, and packing the products. This gives people less time to count their return money and check if they left any product on the counter. Self-checkouts have a big advantage and could fix many related issues. However, the current state of self-checkouts are not very accessible yet and need further research in order to be usable for visually impaired.

Digital helpers definitely play an important role while shopping. Although the overall capabilities and use of computers and smartphones seem to be relatively low. The correlation can be seen between smartphone usage and age. Assistive devices such as barcode scanner, audio recorder, and augmented glasses are essential for an individual shopping experience. Non technical tools such as braille labels and 3D graphics have a very low adoption rate. The study outlines that most of the tools are trying to solve the identification process. Not all of the digital assistants are comfortable to use and are described in another section. In terms of human assistance the general perception seems to be comfortable and reliant. Although it is not always clear how to request assistance and further information is hard to discover. In our view, shop assistance is very diverse among the different supermarkets and is most efficient compared to using digital tools. There is a big chance to optimize related subtasks and create a standardized approach.

RQ1.2:What senses are mostly involved in the shopping process, and how can these be used for additional feedback?

There is no most important channel, rather a set of multi modal sensing. Nevertheless each sense has its certain strength for a specific situation.

Participants with a rest sight reported this as the fastest and most accurate sensual input, very helpful to recognize sudden actions and spatial conditions. But as for the broad majority of PVI visual perception is not accessible this plays a secondary role for the feedback of devices.

In contrast to the visually based processing of people with sight, PVI construct a very specific representation of a spatial environment. This lays a foundation concept for indoor navigation and correlates with the fact that PVI visit the same market over and over, to learn all details of its spatial environment. Orientation sensing can be intensified by methods such as O&M training or tactile maps. Auditory Sensing comes very much in action when bigger amounts of information are to be conferred. This is while shopping situations, when product information gets read out by a barcode reader, or while online shopping when using screen readers. Also for indoor navigation audio input can give a good representation of surroundings. Multiple participants told us how hearing helps them to orientate in the shop: "Often I can hear the cash machines beeping and I also hear the bottles clashing and know were the section for beverages is" (U01). But also it needs to be said that using auditory assistance in public can be intimidating, as it signifies others that this person relies on assistance."You scan something and then the device shouts with a mechanical voice. That was really uncomfortable for some people." (E01) Transmitting audio information via in-ear headphones is no real solution to that issue, because it results in shut off to the environment.

Touch sensing is broadly involved in the shopping process, and serves for different purposes. It is involved in the shape identification of products and contributes to building a lasting mental

representation of items. It serves as a medium for Braille and other tactile labels. Especially for shopping clothes, where textiles “need to feel good” this is also part of the decision making process while shopping. Although participants told us that touch may result in “awkward situations”.

Surprisingly many participants mentioned olfactory sensing as deeply involved in indoor navigation and decision making. It seems this has a great influence on the experience as one participant also told us of her “smelling through markets and fairs” (U03), like a great pleasure. There is still a big potential in making shopping a more olfactory and gustatory experience for PVI. Especially because visually impaired people are used to buying the same items over and over. Participants claimed to not have access to the complete product range or special offers.

RQ1.3: What kind of alternatives are there for PVI (e.g. Online shopping)?

Grocery shopping might be challenging and time consuming due to multiple circumstances. Depending on the assistant’s availability it may lead to postponing the shopping or waiting for a long time. Service delays are not the only problem. Some assistants can’t speak English and properly read the product’s ingredients. In this situation customers have to select another product, that they did not want to buy or settle with distant substitutes.[15]

Therefore, we decided to explore other options and alternatives of grocery shopping and answer the question, whether there are some and if so, could they replace the our current form of shopping.

One of the options is an online-shopping with home delivery service. For instance, American internet-based service PeaPod. In Austria customers can also order products from supermarket pages, like Billa. In some cases shopping lists can be provided over the phone, but most often through the website. However, there are few main disadvantages of delivery services. Firstly, they require precise scheduling, planning and waiting for the delivery. Due to responses from our interviews, participants are concerned whether products would not take too long to be delivered. "There is a online market called Picknick but I wouldn’t want to wait days for my order to arrive" (U02). Secondly, these processes reduce personal independence and spontaneous shopping becomes not possible in this situation. The main benefit of real shopping in comparison to online is a sensory perception, which is very important to visually impaired people. Also such things as immediate gratification and social interaction is not possible. Another issue is that PVI don’t know which products were delivered and there are some occasions when customers notice that the order is not exactly what was asked for. However, the main problem is that websites are not entirely accessible for visually impaired people, especially for older ones. The content on the websites need to be more adapted for people’s needs.

As for the phone order, some participants preferred this option. However, delivery still is not a universal solution. Another alternative is pickup stations, this way customers are able to check the products before checkout.

DESIGN

The Design process started after we conducted the study and thereby were highly informed by our previously gained results. Due to the fact that the project took place while the COVID-19 pandemic the design process was partially split to individual focus. This made sure researchers had clear responsibilities as well as encouraged the individual design process.

As a first step in the process the team of researchers conducted affinity mapping, where we collected interesting insights as well as possible fields of application. These were clustered and discussed about in a remote form. Followed up by an individual brainstorming and a final concept decision for the whole team.

The central idea of the design concept is to encourage people assisted shopping via an application for organized social interaction. Further the app is meant to be expanded with a wearable device in order to reduce accessibility issues between PVI and the smartphone but still encourage regular users to use the application on a smartphone side. The concept is called "Shopping Friend"(3).

Roles were split into three main areas, foundational design process, application design and wearable design.

Design Process Foundation

We developed three personas representing major different parties involved to the process of shopping groceries. Study data was used do built the persona representing the visually impaired person. Further we conducted fictive personas for the shopper and shop employee. These personas later informed the design process of the app and wearable. We executed a user journey of the visually impaired persona "Hannah" to better visualize an emotional curve. Also this pretty much helped to distill opportunities and specific features for our prototypes. In respect to the present situation this was also a measure to keep the team up on track despite to the remote form of the project.

Phone Application

The phone application was developed to connect with the wearable device and build a better interaction between store’s customers or employees and visually impaired people who need shopping assistance. The main function of the application "Shopping friend" is to arrange meetings with visually impaired people and proceed shopping together with volunteers. Based on the digital ethnography data, we have found that people in most cases don’t know how to provide better assistance, therefore on the main screen of application we included tips for volunteers. Volunteer can receive shopping list in advance and check the estimated time for shopping. The rating system is designed for the both sides (volunteer and visually impaired person) and maintain an important measure of quality in the application, which helps to keep the experience comfortable and enjoyable. By receiving GPS/location data, "Shopping Friend" shows all meeting participants and destination spot on the interactive map.

The visual design (1) should be simple and intuitive, to ensure quick access to any function in one-two clicks, therefore menu

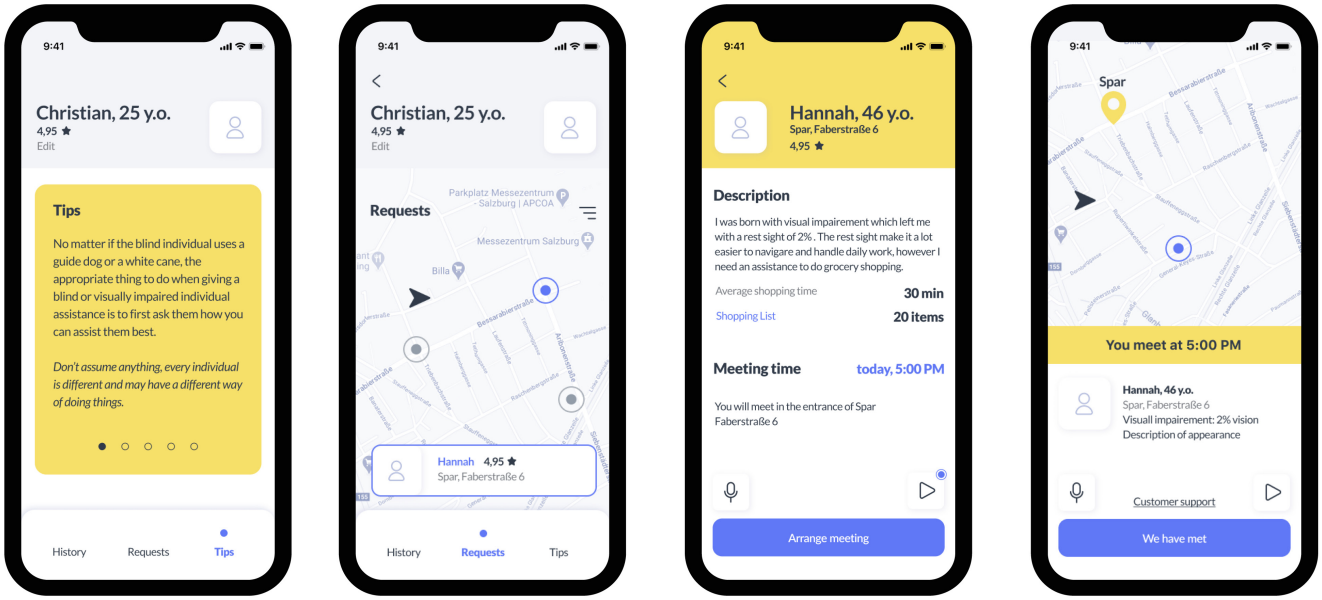

Figure 1: Screen Designs of the application

was designed in the bottom of all screens to show user all possible actions. There are 2 bright and distinguished colors in addition to black and white : bright cornflower blue for CTA button and yellow, as in the wearable device.

Wearable Design

During the ideation phase we discovered the need of a physical device to request assistant. Low smartphone usage because of age or cost consolidate this decision. The design process focus on features, mounting, appearance, and interaction with the wearable. Several methods and diagram helped us to translate study results into a profound design. A mood-board of mentioned technologies for PVI got the process started. Further mood-boards were constructive to discover ways of mounting and to develop the visual appearance of the device. A detailed user journey was made to identify tasks, negative and positive impacts that were then clustered to find solutions for very specific problems. Further methods including a user flow diagram supported our decisions and were relevant to make our design process contextual.

The presented wearable (2) can be easily mounted on various body parts and objects. It uses a flexible band that snaps automatically when slapped softly against an obstacle. On the backside there is a micro velcro material, so the device can also be sticked to different fabrics, for example a shopping bag.

The main action a user can perform is to call for help. The user can do so by pressing the one and only button on the device. This will notify close by "Shopping Friend" fellows on their smartphone application. Once a request is accepted the volunteer can see the location of the PVI's device to make the encounter fast and easy. In addition both of them can send and receive voice messages in order to communicated while meeting. This feature is only available when the device is in this very specific state. The yellow band and the black button symbolize the well known sign for visual impairment which helps the assistant when approaching a PVI. Simultaneously it has great contrast that benefits the interaction.

Figure 2: Prototype of the wearable shopping friend device.

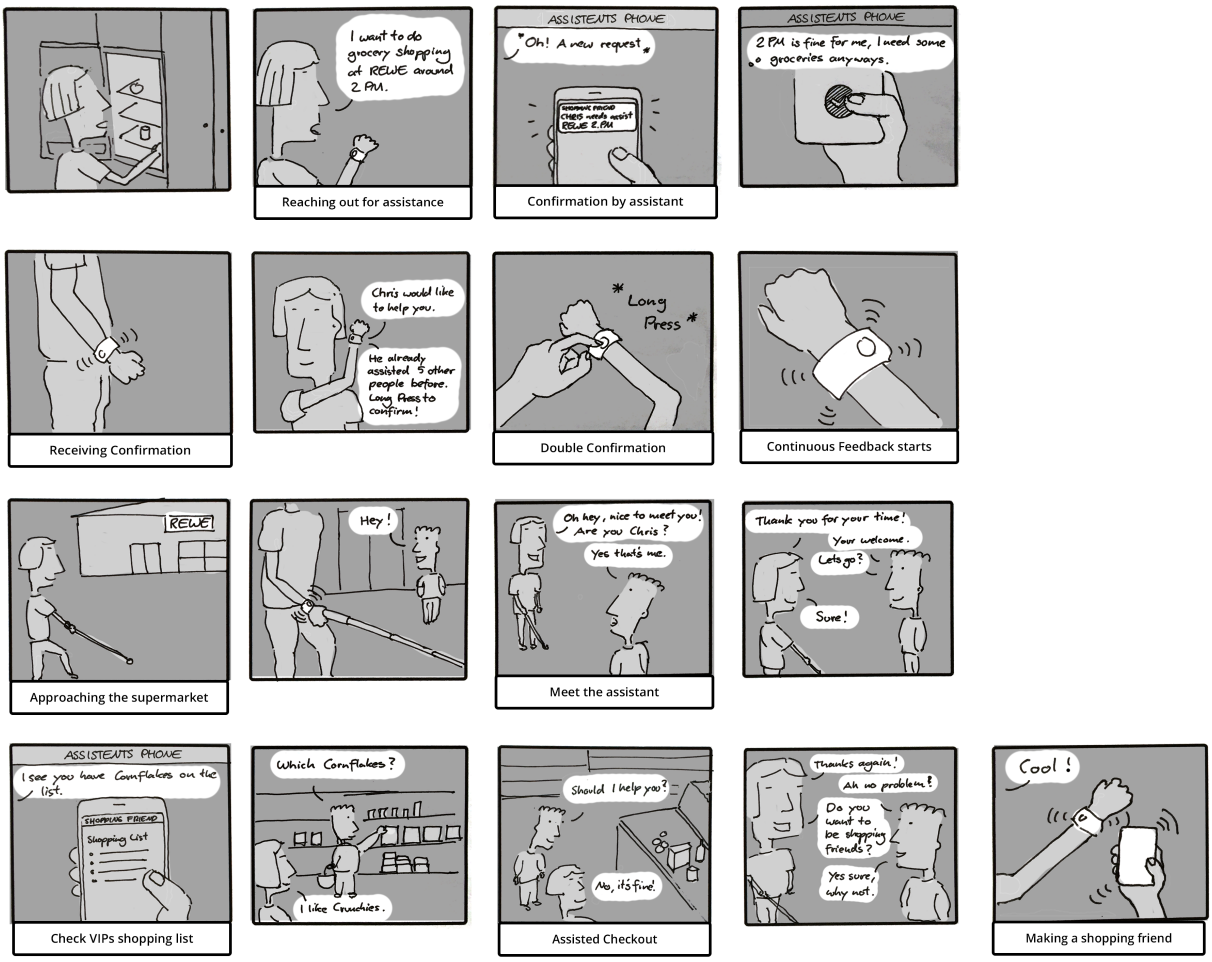

Figure 3: Storyboard of the design prototype "Shopping Friend"

During the shopping the assistant has access to a shopping list that can be prepared via voice recording in advanced. The device is designed to be cheap and has all necessary sensors included. The wireless device has a SIM-card slot and can run independently. A big investment that was made during the design process is the exploration of haptic feedback. Vibration is the main feedback and tells a user the current state of the device and gives instant feedback to executed actions. For illustration, if an assistant is approaching a person the vibration feedback will get more frequent and stronger to not scare the person.

CONCLUSION

To conclude our work, we made the attempt to answer the main research question: How to make grocery shopping more accessible for PVI?

The study showed that there is still a big wish for improvement of accessibility in supermarkets. Although there is a variety of assistants in the field of technology, we realized that technology can just be part of the solution but not the whole. Tools like the barcode scanner, audio recorders or augmented glasses can highly improve individual shopping. But with different abilities of PVI shoppers, there is also a big hurdle for a rather large amount of people in properly using these applications. This is why a lot of PVI rely on assisted living concepts as well as daily assistance by people.

As for our design prototypes there was applied an approach of social interaction and bonding with others. We belief that true value for PVI comes from proper assistance by people and the reduction of uncertainty and anxiety in approaching others. With current design concept "Shopping Friend" we propose a solution for reaching out to shoppers and shop employees. Further the device is aimed to reduce time spent and help to socially interact while doing grocery shopping. As a positive effect it is aimed to build lasting bonds between PVI and assistants and thereby better integrate people to the society. Further we think that this proposal has also high potential to help people with other disabilities and elderly people.

Due to time restrictions we did not do any further evaluations on the design process. To further expand the capabilities of "Shopping friend" and make the product flow more solid, we will have to match the wearable and application on behave of a user test.

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