Improve Mobile Payment Accessibility for People with Visual Impairment

An Inclusive Design Project with ING

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Master's Thesis

Yongqing Fei
MSc Design for Interaction
Faculty of Industrial Design Engineering
Delft University of Technology

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Overview

This project is the final thesis of Yongqing Fei's master's studies in Design for Interaction at TU Delft. It is a six-months design research project that started on May 21, 2022, and ended on November 28.

Professor Stella Boess and Dr. Niko Vegt from TU Delft supervised this thesis. During the project, I worked as a graduate intern on ING's Global Brand Experience team, mentored by Tom Prakke and Bruna Mendes Correa. The Inclusive Design Lab and TU Delft, Visio, and ING's Global Head of Accessibility, Bianca Prins, are partners in this project.

Preface

Firstly, I want to sincerely thank all the participants in my research. Thank you for generously sharing your experience and insights with me. Without you participation, this project wouldn't have been as complete as it is today.

I want to thank my chair and mentor, Stella Boess and Niko Vegt, for supervising this project. Thank you for providing me with valuable insights from your expertise and support during the last six months. Stella, I am lucky to learn from you about Inclusive Design during my studies, both in this project and the Inclusive Design elective. Thank you for connecting me with this excellent opportunity. Your kindness and patience have encouraged me to power through this project. Niko, thanks for always listening to my thoughts during the coach meetings and directing me in the right direction. My thinking can be chaotic sometimes; thanks for patiently finding valuable things out of this mess and pointing them out to me!

I want to thank my company mentors, Tom Prakke and Bruna Mendes Correa, for supporting this project. Tom, thank you for helping me assemble the dream team to make the concept into a working prototype on CX Day. I enjoyed working on your team! Bruna, thanks for always being so helpful with my graduation and internship. I loved having you as my mentor.

I also want to thank Visio and Bianca Prins, Global Head of Accessibility at ING, for connecting me to this project. All your hard work for the PVI community is truly inspiring to me.

I want to thank my friends from TU Delft, especially those who accompanied me during the lockdown days: Ji Youn, Siqi, Alex, and Yujie. It wasn't easy to complete a master's during COVID, but you have brightened up my days. Thanks, Toon, for helping me translate the interviews and go to all the events with me; your support means a lot to me.
Olivia, thank you for always being there for me. It's nice to wake up to your messages from the other side of this world every morning. I can't wait to see you again.

Most importantly, I want to thank mom, dad, and grandma. Without your support, I wouldn't have gone this far and seen this much of the world.
Dad, thank you for inspiring me to study Inclusive Design. Your positive attitude toward life made me believe working hard for an inclusive future is worth it. Mom, thanks for all your support over the years, I don't know if I can be as successful as you are, but I hope you can be proud of me one day. Grandma, thank you for being the person who tells me everything will be OK. I miss you. I hope to see you all soon!

Lastly, I thank myself for not giving up in difficult times and for choosing inclusive design as my thesis topic. The last two years have been a journey to be memorized.

Sincerely,
Jackie

Abstract

It was an epiphany moment when I heard the statement “disability results from mismatches between a person’s capabilities and the environment.” in the Inclusive Design Elective. Having lived with a family member who uses a wheelchair, it was comforting to understand that the disabled person does not deserve the blame for failing to complete daily tasks independently. Instead, inaccessible environments impede people from participating in everyday activities and jeopardize their independence.

Since then, I have become a proponent of inclusive design and started looking at this world from a new perspective. I realized the world is full of mismatches that can disable people for short and long terms. Therefore, I was motivated to do a master’s thesis project that would allow me to practice inclusive design and make a positive social impact.

This project aims to improve payment service accessibility for people with visual impairment (PVIs) in the Netherlands. In the last few years, an increasing number of Dutch consumers have indicated they prefer paying contactless, either with their debit cards or mobile phones. (De Nederlandsche Bank, 2022) As a result, innovative self-service checkout kiosks are introduced to foster contactless payment and enhance payment efficiency. However, these changes are causing hurdles for PVIs. When payment becomes instant, touch-screen based, and contactless, it mismatches with PVIs’ need for non-visual, tangible cues in an interaction. This project thus explores design opportunities to improve PVIs’ payment experience.

I chose payment as a thesis topic because I make payments daily to buy food, utilities, medicine, train tickets, and many other essential things. Thus, being excluded from payment services can harm PVIs’ access to everything they wish to purchase. Moreover, I decided to focus my

Figure 1:
PayFree self-checkout at IKEA, Delft

research on in-person payment instead of online payment. Following the support card from Microsoft Inclusive Design Toolkit, I envision PVIs are exposed to more privacy risks and social pressure when paying in public (figure 1).

This thesis takes an inclusive design approach to understand the mismatches between PVIs and the current payment infrastructure in the Netherlands. I will apply existing methods for Inclusive Design and general UX design to the context of payment. There are currently multiple toolkits, among them the Inclusive design toolkit (Microsoft, n.d.) by Microsoft. Its Activity Cards and Support Cards on physical and social context help me to envisage the challenges PVIs face during their payment, uncover latent user needs and co-design solutions. Design for Emotion and Interaction Design methods help me envisage and evaluate desirable payment flows. Moreover, while this project aims to improve payment accessibility for PVIs, it also serves as a case study to apply Inclusive Design methods to the context of payment.

The project results in a secure payment transaction design proposal in which PVIs can experience control. The concept aligns with stakeholders' interest and capabilities. The result is positively received by PVIs and their family at Ziezo Beurs, as well as service providers within ING.

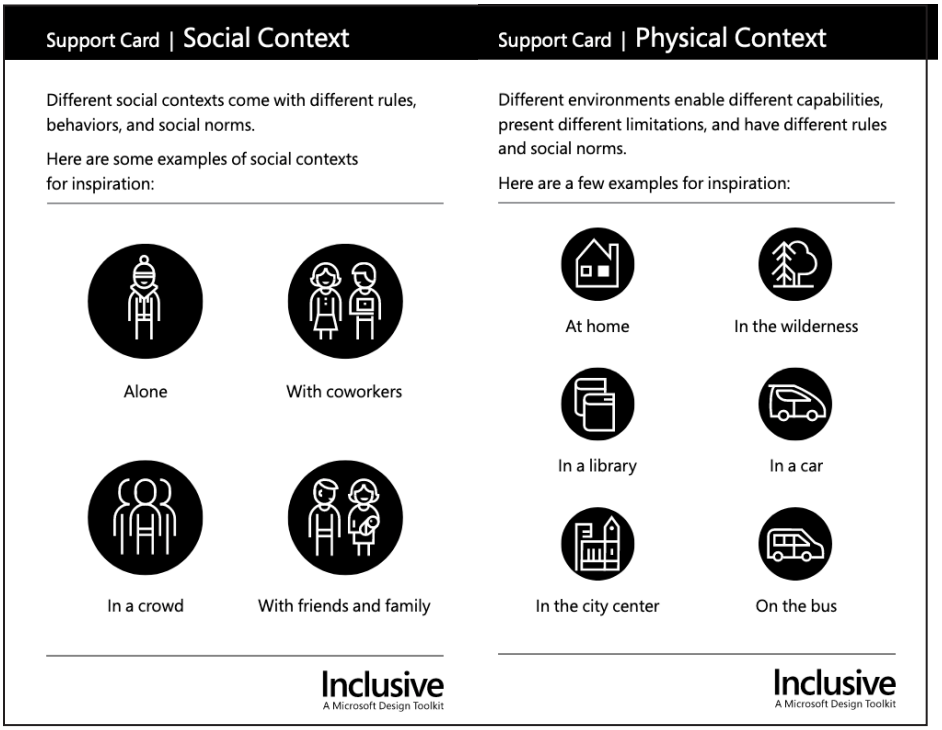


Figure 2: Support Cards from Microsoft Inclusive Design Toolkit ((Microsoft, n.d.)

Introduction


SUPER-VLOOIENSPEL
Time Switch
DEEL 2 / PA
THREE OF
FOUR OF A
FULL HOUS
SMALL STR
LARGE STR
TOP SCORE
CHANCE
TOTAAL / TOTAL / SUMME
STARTER 1-2-3
JUNIOR 1-2-3
EXPERT 2-5-8
MASTER 37-49

1.1 Overview

1.1.1 Project Context

This report presents the research and design process of my graduation project at TU Delft. This project aims to improve payment accessibility for people with visual impairments (PVIs) in the Netherlands. To achieve this goal, I conducted in-depth, iterative research and co-design activities with PVIs. Moreover, the Inclusive Design Lab at TU Delft and ING are the stakeholders of this project. Thus, the research insights were aligned with ING's design interests to ensure the feasibility of the final design. This project also serves as a case study for applying inclusive design methodlogies to the context of payment - a task that involves both human-machine interactions and social interactions with strangers.

As Kat Holms stated in her book Mismatch: People can feel excluded and socially rejected when they cannot interact with their environments at ease. (2020b) As one of the most frequently encountered touchpoints in our daily life, payment should be accessible to as many people as possible, regardless of their physical and mental capabilities. Design for inclusion starts with identifying exclusion. Exclusion happens when a person cannot or has limited access to a service or product. In the context of payment, PVIs often need help following the payment instructions, which is only provided in visual forms. Furthermore, touch-screen system interactions can segregate sighted people and PVIs. of having non-visual information. Communication gaps between sighted and PVIs.

1.1.2 Outcome

The final deliverable of this project is a mobile payment prototype that addresses the three significant pain points in PVIs' payment activities. Each pain point results from mismatched interactions between PVIs' capabilities and the payment infrastructure. The final prototype remedies these mismatches by assisting PVIs to find the POS machine, allowing them to confirm the price on their mobile device and protecting their privacy when they need help.

1.1.3. Chapter overview

Chapter one provides a background overview of this research project. In this chapter, I review the current payment trends in the Netherlands and how it might affect PVIs' payment. The research questions, research scope and stakeholders are then specified. The last section of this chapter explains the research and design approaches.

In Chapter two, I apply inclusive design to "Moneywork" framework to explore mismatches that occur before, during, and after PVIs' payments. I studied PVIs' payment behavior and their context to identify mismatches through interviews, field observations, and literature research. The activities also served as the first step of contacting PVI communities, which laid the foundation for deeper engagement in later research activities. In the end, qualitative data was gathered and processed through these research activities to generate insights for the synthesis stage.

In Chapter three, I combined insights from user interviews, field observations and literature review to understand PVIs' moneywork. Following the moneywork frame - Pre-transaction, at-transaction and post-transaction, I found mismatches in almost all the steps within PVIs' moneywork. They mostly come from two perspectives: PVIs' interaction with the payment system and their social interactions with sighted strangers. Based on the insights, I analyze understand how they currently adapt to these mismatches and what motivates their actions. The conclusions from this chapter will be used in the synthesis phase to generate

Chapter four presents the synthesis phase of this project - how to translating qualitative data into possible design directions. In this chapter, I align mismatch with the service domain of ING. In addition, some mismatches have a more significant impact than others for PVIs. Thus, to answer the third research question: How to use design to remedy the mismatches? I need to understand stakeholders' interests and which mismatch is more at stake for PVIs. Therefore, I used co-creative workshops for acceptance finding and ideation.

Chapter five records the prototyping phase, including the prototyping methods and user test setup. Three rounds of iterations are based on user tests with

PVIs with diverse vision disabilities. In the user tests, an interaction profile model was introduced to evaluate the interaction aesthetics of PVI. The prototype was also presented to design experts at ING for its feasibility. The final prototype is a mobile app that allows PVIs to act easily when interacting with a POS machine.

Chapter six records the final evaluation test of the prototype at Ziezo Beurs 2022. The prototype was tested by six PVIs at the fair. The goal of the final evaluation is to test the prototype's accessibility and desirability among PVIs in the Netherlands. Each test was followed by an interview. Each participants were asked to verbally fill out the interaction profile.

Chapter seven discusses the conclusions, limitations and reflections of this research project.

1.2 Research Background

1.2.1 Payment Trends in the Netherlands

Contactless payment has been gaining popularity in the Netherlands. According to the Dutch Payment Association annual report, about 79.5% of the transactions at a point of sale were made with debit or credit cards, and 87% of these card payments are contactless. (Dutch Payment Association, 2021)

The report also predicts that contactless payment through mobile devices will become more common. Between December 2020 and 2021, the percentage of smartphone and wearable payments has increased from 13.5% to 20.0% among all contactless payments.

The infrastructure around the point of sale also changes. Take supermarkets in Delft as an example: Jumbo in the city center had only a few self-checkout spots before the Summer of 2021. Today, almost half of the store's checkout area has self-checkout kiosks. In contrast, the number of regular checkout counters was reduced by half. On the TU Delft campus, there is a SPAR supermarket where customers can only checkout via self-service kiosks.

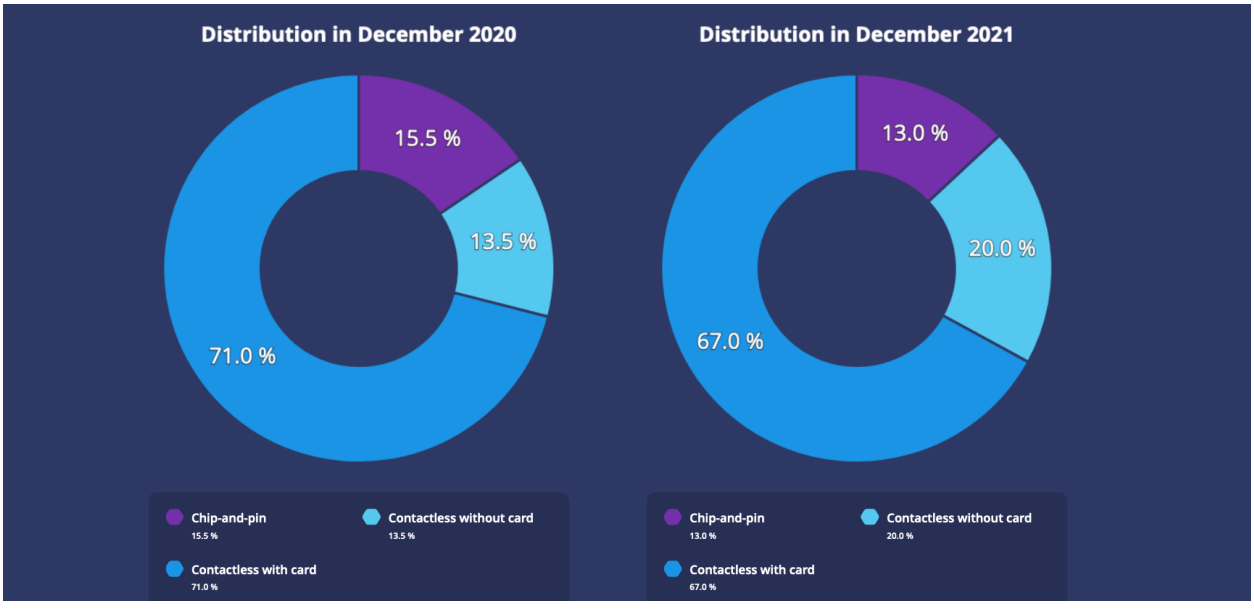


Figure 3: Data visualization of payment method distribution by the Dutch Payment Association

1.2.2 PVIs' interactions with their surroundings

As the infographic "The bandwidth of our senses" conveys (Data Visualization: Processing Images at 1250MB/S, n.d.), vision is the most powerful sense with the broadest bandwidth compared to the other senses. For example, while it takes a sighted person less than 5 seconds to read a web page, it can take a PVI much longer to gain an overview of the page when a screen reader reads it.

Dutch PVI blogger Debby Buis shared her story about once getting over-alerted on the train when she felt someone was moving her bag. (2021) Debby immediately bent down to protect her bag from being stolen. However, she only felt a little girl's tiny hand touching her pink walking cane, which she placed on top of her bag.

The lack of sight can impede PVIs' interpretation of their surroundings, resulting in decreased autonomy. When vision is unavailable, PVIs must use other senses—hearing and touch—to interact with the environment. However, these senses cannot fully compensate for vision accuracy and are often unavailable on touchscreens. Moreover, as touch and hearing are sometimes more time-consuming and cognitively demanding, PVIs can experience panic, fatigue, and other negative emotions during the interaction.

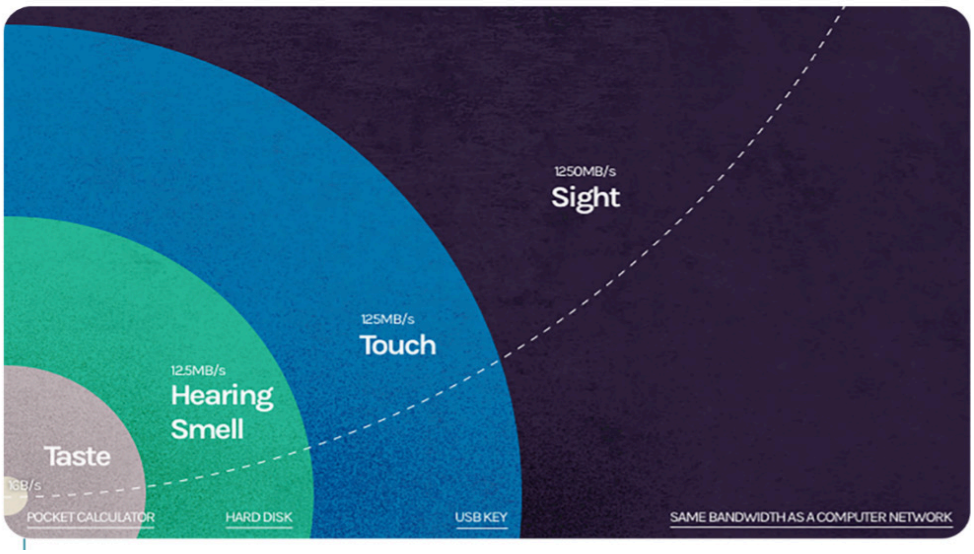


Figure 4: The Bandwidth of our senses by Danish physicist Tor Nørretranders (Data Visualization: Processing Images at 1250MB/S, n.d.),

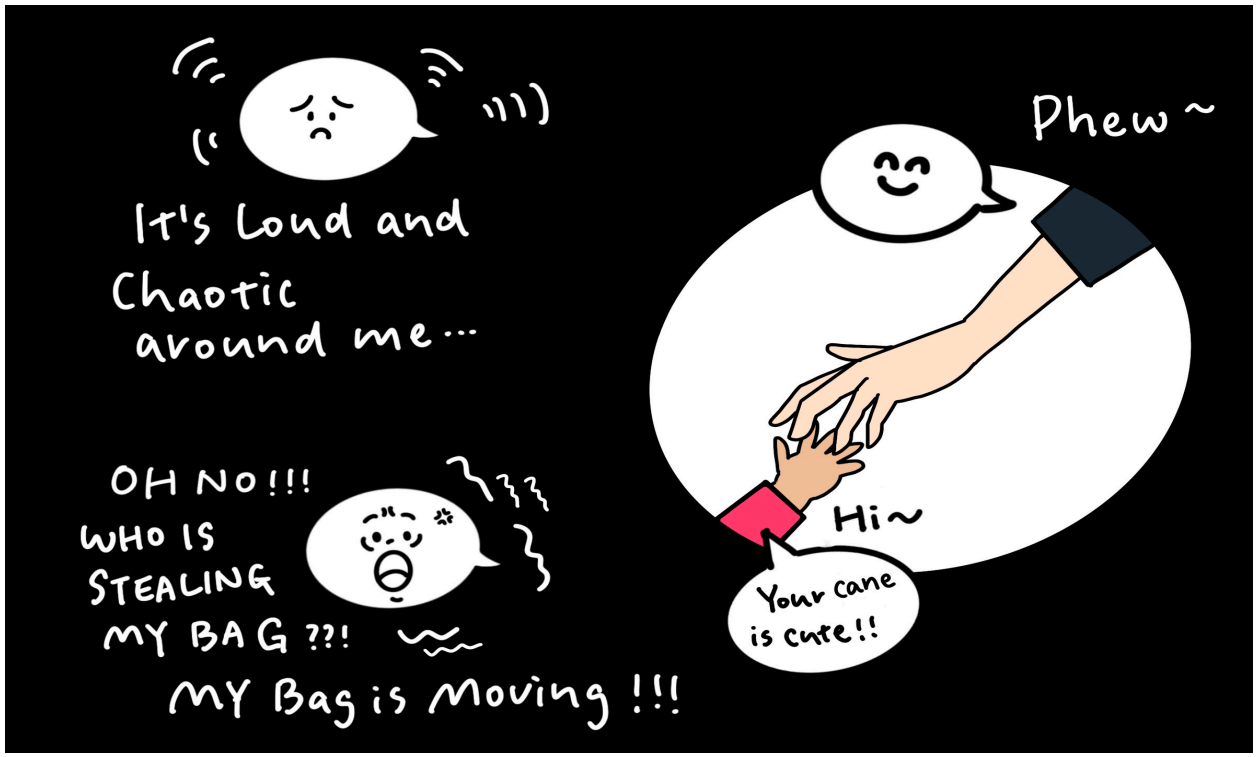


Figure 5: Illustration of Debby's story - PVIs need longer time and senses to understand their surroundings as someof them can't see things from a distancce

1.3 Research Assignment

1.3.1 Research Question

This graduation project aims to **make payment more accessible for PVIs in the Netherlands at Point of Sale (POS).** There are three research questions for this project:

1. **What is it like to pay in public as a PVI in the Netherlands?**
2. **How can design remedy the mismatches between current payment infrastructure and PVIs' capability?**
3. **How can we make PVIs feel socially included during their payment?**

I formulated these research questions to support my design process and to learn from the experience of PVIs. To answer the first two questions, I did interviews, field observations and literature reviews. These activities helped us gain a detailed overview of PVIs' payment. To answer the third question, I did synthesis activities to co-design with PVIs to translate research insights into design concepts. The concepts are prototyped and tested by PVIs to evaluate if they remedy the selected mismatches.

1.3.2 Research Scope

The research focus on payment at point-of-sale only, tasks such as scanning products and shopping for products are not included in the research scope. To start the research, I examined all kinds of payment methods including cash, card and mobile. As research proceeds, I decided to focus on mobile payment for it provides the most design opportunities.

I decided to focus on payment in public . By following the context mapping activities in Figure 2, I found PVIs face more chanllenges when they make payment in person at point of sale. PVIs tend to have less control over the process and result of their payment when they are in a public environment, especially when they are shopping alone

1.4 Stakeholders

1.4.1 PVIs in the Netherlands

In the Netherlands, there are over 320,000 people who are partially sighted or blind. Visual disorders are usually caused by eye disorders or eye diseases, but they can also result from a disorder in the visual processing in the brain. (Koninklijke Visio, n.d.) In recent years, there has been a rise in the number of people worldwide who suffer from visual limitations as a result of diabetes. (Koninklijke Visio, n.d.)

It is worth mentioning that older adults, though not categorized as PVI, can still suffer from decreased vision. Moreover, tourists, expats and international students can also experience difficulties reading information in Dutch despite having good vision. Thus, what is designed for PVI can be extended to benefit a much larger population.

1.4.2 Inclusive Design Lab

I was connected to ING through the Inclusive Design Lab. The Inclusive Design lab promotes the design of everyday interactions to be inclusive for as many people as possible. It tackles this through design and research. The lab connects societal stakeholders to promote inclusion (Inclusive Design Lab - Inclusive Design Lab Lab, 2020).I n my third semester at TU Delft, I followed Professor Boess' elective: Inclusive Design in my third semester at TU Delft and developed deep interest in this topic.

During the elective, I made use of inclusive design method inspired by the Microsoft Inclusive Design Toolkit to design and research for people with mobility disability. In this project, I will continue use the Microsoft Inclusive Design Toolkit as a major design tool.

1.4.3 ING

This graduation project is in combination with an internship at ING's Global Brand Experience Team in Amsterdam. As one of the largest banking groups in the world, ING embraces inclusion and diversity in its brand identity.

In the past, ING has introduced several product features that were designed to meet the needs of visually impaired customers. One of the most recognizable features is "the Notch" on ING's debit cards, introduced in April 2020. The notch allows visually impaired customers to quickly recognize their Debit Card. In addition, the notch aids in the correct insertion of the debit card into a payment/ATM machine. (ING, 2020)

Figure 6: ING's bank card with a notch, designerd for blind customers

In 2022, as the banking and payment industries are marching forward rapidly to a digital future, ING is motivated to support its customers by providing accessible digital banking services.

1.4 Approach

1.4.1 Diving Approach

In every stage of my research and design, there is one major goal: to discover mismatches and validate my findings with “exclusion experts” - PVIs in the Netherlands and people who work closely around them. Thus, I used diving of a metaphor - I was constantly switching between the role of a designer and a PVI. When I dive into the water, I immense myself in PVIs’ world.

My knowledge and experience with PVI was very limited before this thesis assignment. To put myself into PVIs’ shoes and understand their needs for payment, I closely engaged with the PVI community. Through interviews, shadowing and co-creative workshops, I gather large amount of qualitative data.

When I come out of water, I synthesis, do literature review and prototype. But I constantly dive back into water to validate my research findings and ideas with PVIs.

For example, in the prototyping phase, I itirated my prototype based on feedback from PVIs, dived back and forth for several times.

The final prototype was evaluated with PVIs, their family, friends and caretakers. With the insights they provided, I came out of water with my final conclusions.

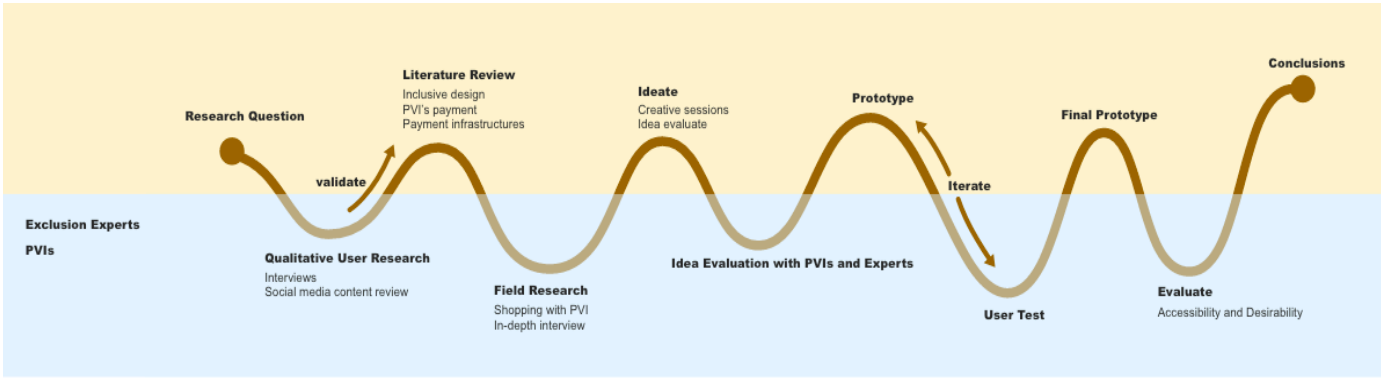
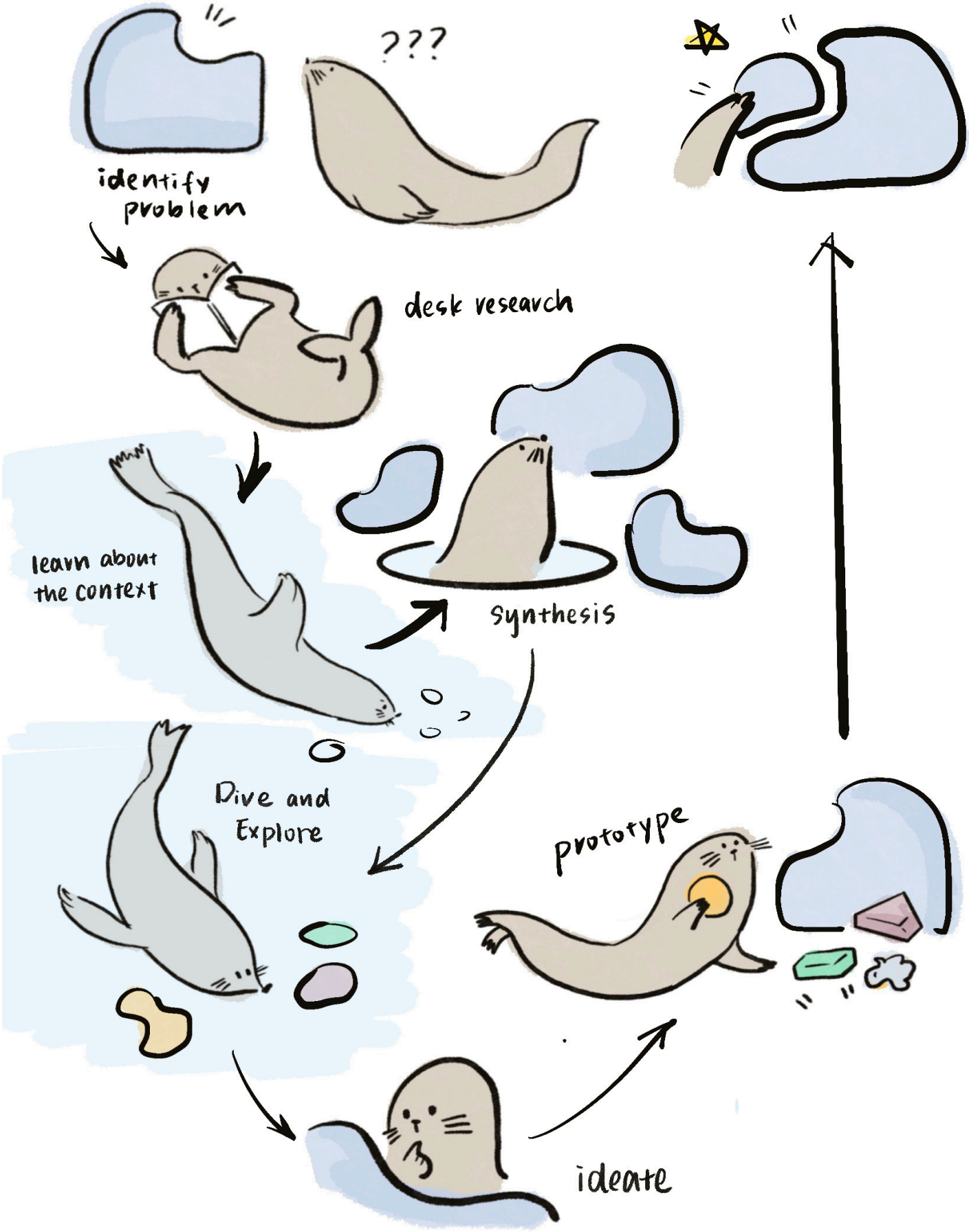


Figure 7: Design Process Overview


???
identify problem
desk research
learn about the context
synthesis
Dive and Explore
prototype
ideate

Inclusive Design and Moneywork

2.1 Inclusive Design in the Context of Payment

2.1.1 Introducing Moneywork

Digital financial technologies are often promoted with the promise of making payments faster and more secure. However, this discourse misses the technological and human infrastructures that enable digital financial transactions. Although a payment transaction happens within seconds, it usually requires considerable work and hidden labor in their maintenance and use (Pritchard et al., 2015). Thus, to uncover mismatches in PVIs' payment, I need to examine the transaction at a point-of-sale and the maintenance work and adaptions made by PVIs to render a smooth transaction.

In this thesis project, I use the moneywork framework in the research of Perry and Ferreira (2017) to examine the exclusions PVIs experience during their payment transactions. Moreover, how the payment system's affordance shapes different forms and patterns of exchange among PVIs and sighted people. The moneywork frame organizes all financial transactions into three phases (Figure x): (1) pre-transaction, (2) at-transaction, and (3) post-transaction. They refer to the activities people undertake before, during, and after transactions to complete a payment (Perry & Ferreira, 2017). Each transaction phase consists of multiple micro-interactions necessary for a successful financial transaction.

We use inclusive design methods to analyze the hurdles PVIs encounter in each transaction step in the moneywork frame. With today's payment infrastructure, transactions take only a few seconds. However, when I look at a transaction from the perspective of moneywork, I can identify many hurdles for PVIs.

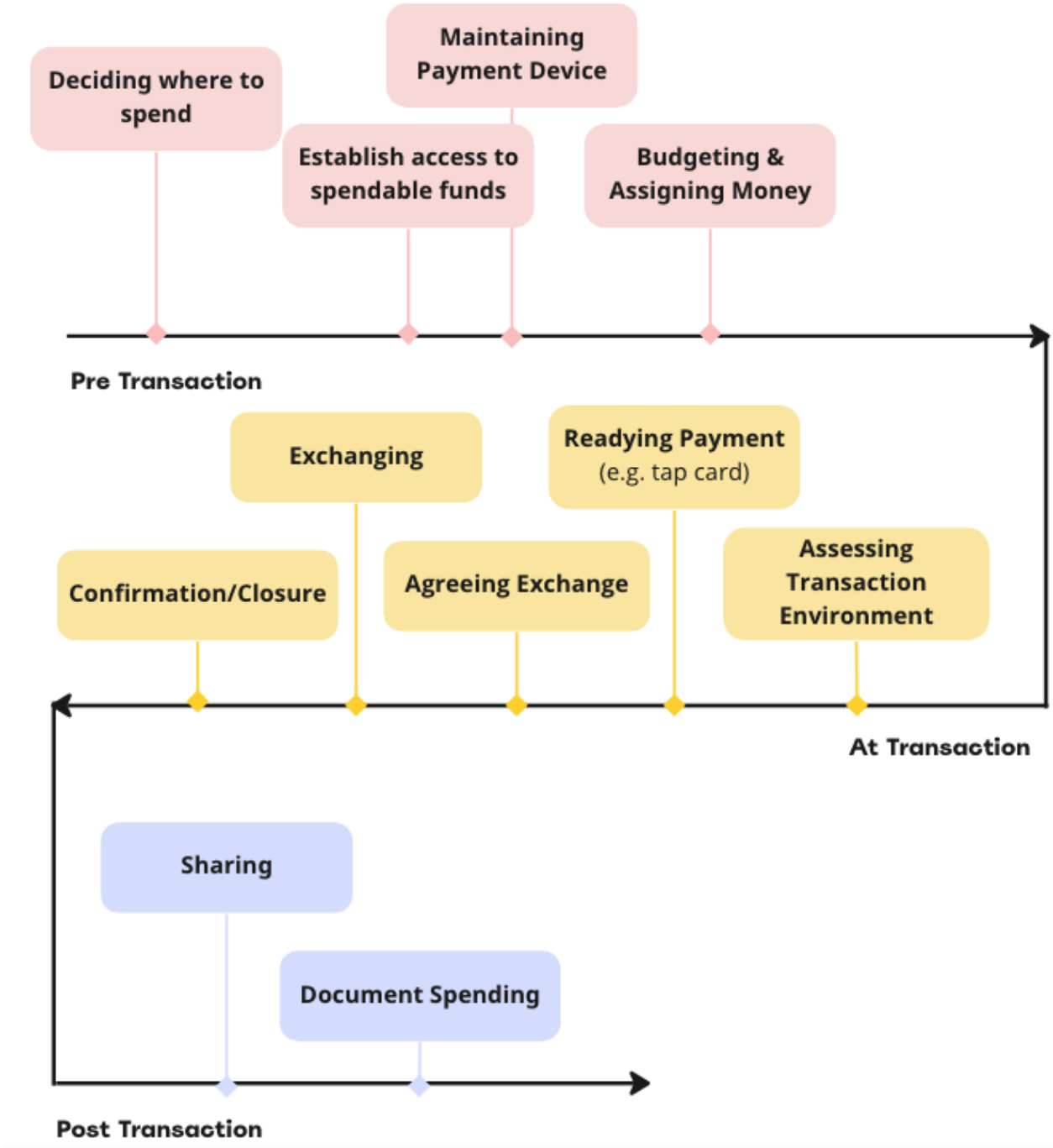


Figure 9: Moneywork frame

2.1.2 Inclusive Design in the Context of Payment

There are two layers of the inclusive design approach in this chapter. The first one is to use activity cards from the Microsoft Inclusive Design Toolkit to understand how PVIs complete their payment. This includes understanding the adaptations they make to ensure a smooth payment experience. The second layer examines the application of inclusive design in the context of payment, which involves both physical and social interactions. Thus, different activities were planned to uncover latent information from both social and physical interactions.

Design for Inclusion starts by recognizing exclusion. An obvious consequence of exclusion in payment interactions is that someone cannot complete a payment independently, and mismatched interactions between PVIs and payment systems cause this. The design of the system did not consider PVIs' capabilities. However, exclusion goes beyond functionality; it has a significant social and psychological impact on users. Our encounters with exclusion and inclusion structure our core identities. (Kat Holms, Mismatch) Inclusion tells us where we belong, while exclusion tells us where we are outsiders. These encounters shape our sense of value and what we believe we can contribute. We are forced to adapt or compromise when we bump into exclusion.

When a designed object rejects a person, it can feel like social rejection. When an object is inaccessible, it sends out a message that it is not designed for the user, thus making the user an outsider of the service it provides. Therefore, providing accessible payment services to people with visual impairment will not only help them to pay with ease but also contributes to their sense of belonging to our society and facilitates their independence.

The fundamental principle of inclusive design is identifying mismatches and exclusions caused by these mismatches. In payment, mismatches come from human-machine interaction and social interaction. Firstly, inaccessible payment systems jeopardize PVIs from independently completing their payments. Secondly, the affordability of these systems provides PVIs and sighted people with different experiences, thus creating communication

gaps between the two. When PVIs need help from a sighted person, the help itself is usually inaccessible.

Moreover, engaging with PVIs on payment is also an essential topic of this research project. As a designer who had no previous experience working with PVIs, how to

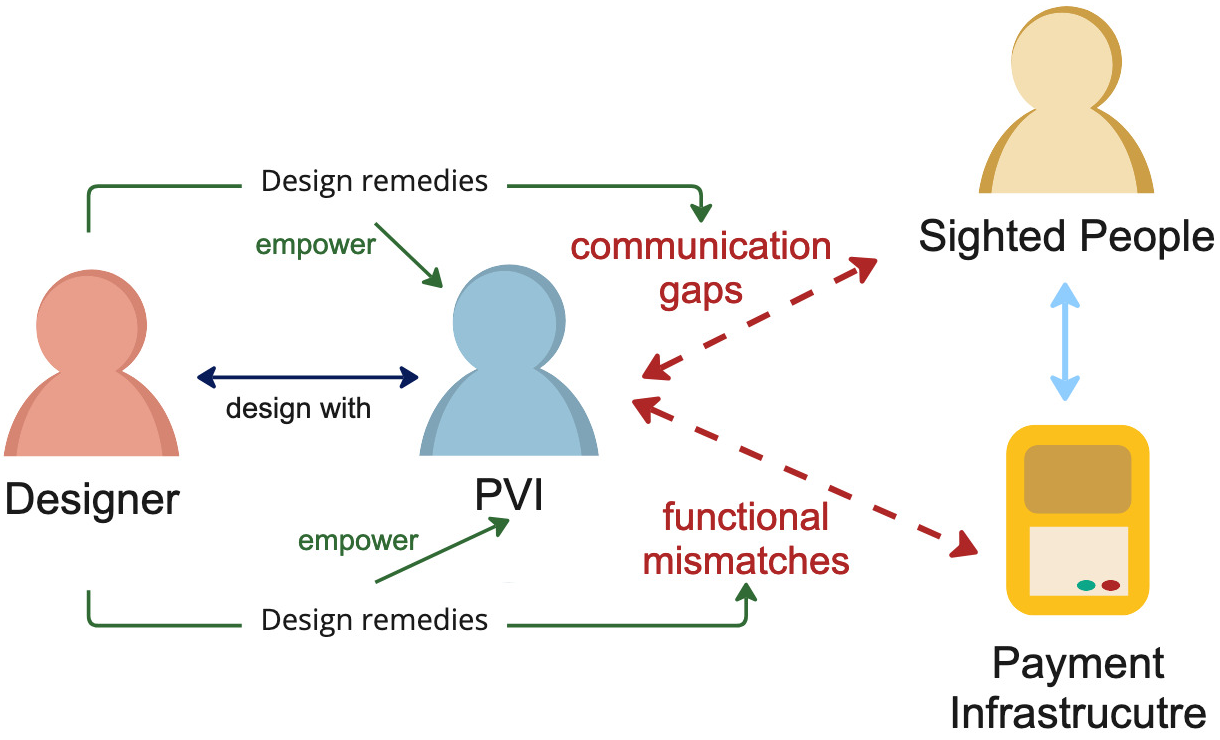


Figure 10: Overview of how inclusive design is applied to Moneywork

2.1.3 Applying inclusive design principals

Seek out points of exclusion

Following the Moneywork framework, we identify exclusions from two perspectives: (1) how the system itself rejects PVI due to inaccessible design and (2) the social exclusions caused by inaccessible payment systems.

Learn from human diversity

The PVI community is extremely diverse. Firstly, there is a spectrum of visual disabilities - people have different sight and therefore prefer different payment interactions. Secondly, people's payment experience largely depends on their past experience, where they shop and whom they are paying to. We use the activities from Microsoft Inclusive Design Toolkit to learn PVIs' diverse needs.

Provide equivalent experiences

When information is only provided in visual forms, PVIs are getting less cues and feedback than sighted people in the payment interaction. During the research.

Recognize personal biases

Visual impairment is difficult for sighted people to relate to. By conducting expert interviews and experiencing simulated disability, we try to put ourselves into the shoes of PVIs. This helps designers find common ground with PVIs during research activities. Moreover, the insights from these experience contribute to the synthesis phase, when designer communicates the insights to sighted stakeholders from ING.

Offer different ways to engage

This principal of inclusive design is applied to both the research process and the final design. The goal of the final design is to situate diverse needs of PVI and sighted people. The design process should also allow accessible participation of PVIs.

Extend the solution to everyone

The final design does not focus on one type of visual impairment, it should be accessible to PVIs of different capabilities. Moreover, it should not be an added feature on the side of the "normal" payment flow. The goal is to create a design solution that is accessible to both PVIs and sighted users.

A person’s environment has a huge effect on the experience and extent of disability. Inaccessible environments create barriers that often hinder the full and effective participation of persons with disabilities in society on an equal basis with others.

- **The World Health Organization**

2.2 Preparation Work

2.2.1 Engaging with PVI communities

The best way to understand exclusion is to learn from people who experienced it the most (Kat Holms, Mismatch). Inclusive design accentuates a participatory design approach - to design with people instead of for people. Thus, an important starting point for an inclusive design project is to engage with exclusion experts - people who experienced mismatches or who are the most negatively affected by these mismatches. (Kat Holms, Mismatch)

Their experience of adapting themselves around the mismatched interaction can inspire inclusive research and design.
In this project, any PVI who has made payments at a point of sale can be an exclusion expert for this project. Thus, the context research assembled a group of "exclusion experts". PVIs were contacted via channels shown in figure (fix me)

The engagement with PVI communities also improved as the research proceeded. After each interview, PVIs were invited to share their experience of being contacted and interviewed. Edits were made to the invitation message accordingly. For instance, one participant admitted he was concerned about his banking information being asked before he joined the interview. Thus, later invitations included disclaimers that the research only focuses on the payment experience and will not involve any sensitive questions. The research activities do not collect any personal data or payment information.

Interviews are also good opportunities for designers to introduce themselves to PVIs participants who are contacted by social media. The participants are usually more willing to to participate in more research activities and meet in person after the first round of online interviews.

I met most of my participants from online PVI communities mentioned in 2.2. Two participants later offered to meet with me in person after they heard more about my

research through email exchanges and phone calls. I met three participants in person from an off-line event organized by the Eye Cafe in Rotterdam.

For accessibility reasons, I asked for verbal consent from my participants that their response will be documented only for research purposes. During the interviews, questions only focus on how they experience payment in the Netherlands. No personal questions related to their identities were asked. However, sometimes participants voluntarily mention personal data during the conversations. Thus, the interview transcripts were only used for research activities and will not be included in this report to protect PVIs' privacy. During the field observation and user test, all photos were taken from angles that exclude PVIs faces and participants are aware of this.

I met most of my participants from online PVI communities in Figure 11. Two participants who live close to Delft offered to meet with me in person after they learned more about my research . I met three participants in person from an off-line event organized by the Eye Cafe in Rotterdam.

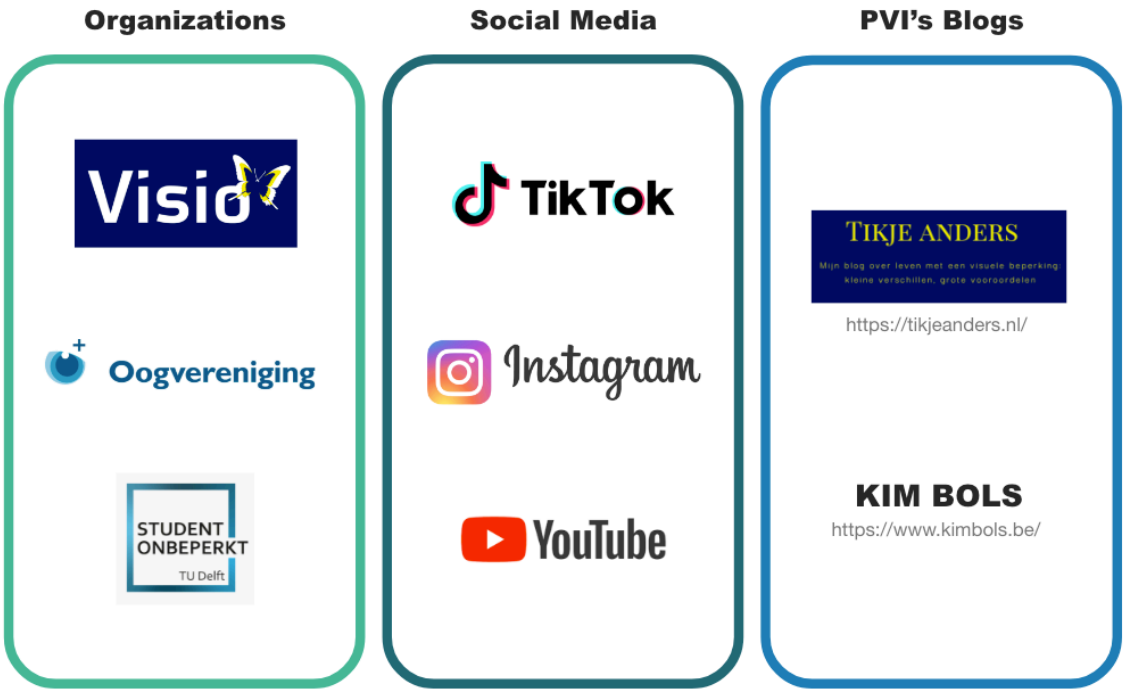


Figure 11: Organizations, Social Media and PVIs' blogs that helped to contact PVI participants for this research

2.2.2. Expert interview

Before diving into research activities with PVIs, I wanted to give myself some accessibility sensitivity training. Since I had no contact with people with visual impairments in the past, I decided to do an expert interview with Rachel Lourens - founder and designer of **SeeFeel**, a Dutch fashion brand dedicated to designing accessible fashion for women with visual impairments. Rachel had extensive experience shopping with PVI women. I paid a visit to Rachel's studio to get tips on how to work and interact with PVIs.

Rachel uses fashion design to situate PVIs' needs for low-maintenance, easy-to wear outfits. For example, rachel uses braille on her tags and labels so that PVIs can easily recognize the items. She replaces buttons and belts with elastic bands. For colors and patterns, she describes them in straightforward terms like "dark blue" instead of "Midnight Paris". She also uses textured fabric instead of printed so that PVIs can feel the patters they are wearing.

Rachel also shared with me stories of her costomers to convey one key message: despite of their visual disabilities, PVIs can still do a lot of things independently and they are very willing to try and learn new things. Independence and autonomy are both very important to PVIs

Tips from Rachel:

Always ask what they are comfortable with, there's no need to be overly helpful. Give them options if they need help and let them decide what to do.

The feeling of independence is very important for PVIs.

No need to let their disability get into the way of knowing them as a person.

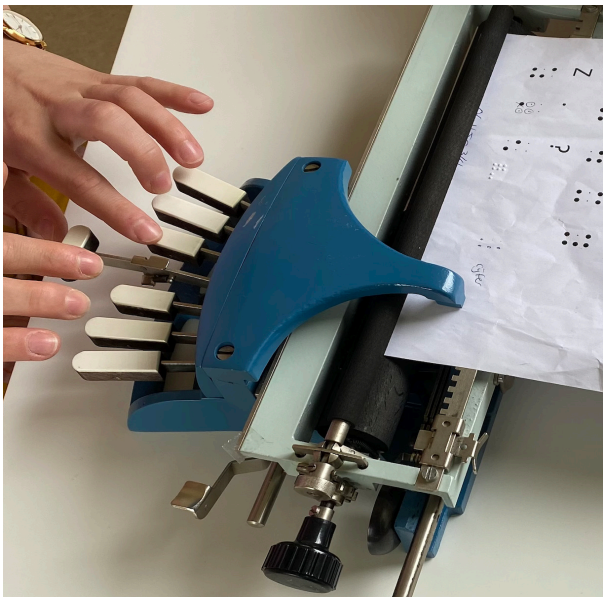


Figure 12: Experiencing braille typewriter at SeeFeel studio

Figure 13: PVI friendly fashion designed by Rachel: tags with braille, elastic bands on dress, elastic dress with special texture instead of prints so that PVIs can feel the patterns what they are wearing

2.2.3 Activities from the Microsoft Inclusive Design Toolkit

My research activities are inspired by the Microsoft Inclusive Design Toolkit. This toolkit includes activity cards that help designers engage and empathize with their target users. The activities can be performed at different stages of the research process (i.e., data collection, interviews, or usability testing). The toolkit aims to engage participants in various activities and dialogues that lead to in-depth knowledge of their values and dreams.

The cards are organized to support 5 phases of design research (figure xx), which does not entirely align with my research plan. Therefore, I used the activity cards more flexibly to fit my research goal. Activities assigned to a particular phase in the toolkit may be integrated into a different stage of my research.

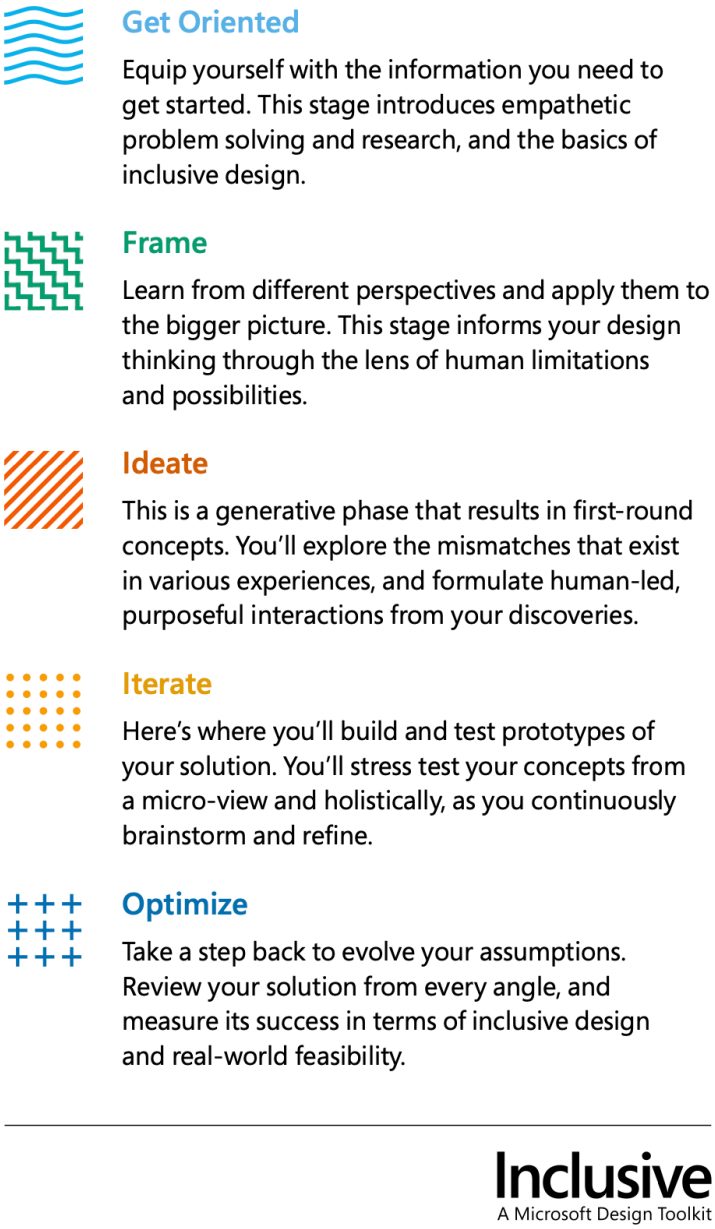


Figure 14: five inclusive design phases from Microsoft Inclusive Design Toolkit (Microsoft, n.d.)

Mismatches in PVIs' Moneywork

3.1 Research Activities

3.1.1. Interviews

Interview is the first step to understand what PVIs need, feel and dream during their payments. The interview questions were designed to guide user to form a personal narrative of their payment experience, and to share that experience with the designer. Eventually, users reflect on their experience to uncover their dreams and deepest needs that motivate them to make payments in person.

Semi-structured Interviews were completed via email exchange and video calls. After sending out messages on the channels in 2.1.2, ten PVIs responded and expressed their willingness to participate in the research interview. Each interview lasted for 45-60 minutes. Interview questions are shown in 2.2.2.

After each interview, participants were encouraged to share their opinions and doubts about the interview. After gaining a better understanding of the project, some invited me to meet in person and observe how they make payments in a store.

Each interview was documented and transcribed. The interview notes were later pasted to a Miro board to find recurring themes in PVIs' payment journeys. Moreover, I aim to answer questions from the Microsoft Inclusive Design Toolkit with the interview insights. The interview results are discussed in 3.2 to 3.5.

	Age	Assistive Device	Location	Payment Method	Activities
P1	60-65	Screen reader, guide dog, cane	Netherlands	Contactless card	Online Interview
P2	25-30	Sun glasses	Netherlands	Contactless card	Field Observation Interview
P3	40-45	Screen reader, guide dog, cane	Netherlands	Apple Pay on iPhone	Online Interview
P4	40-45	Screen reader, guide dog, cane	Netherlands	Card with PIN	Online Interview
P5	25-30	Sun Glasses	Netherlands	Contact-less Card	Field Observation Interview
P6	50-55	Screen reader, guide dog, cane	Netherlands	Apple Watch, Contactless Card	Online Interview
P7	50-55	Screen reader, guide dog, cane	Netherlands	Apple Watch	Field Observation Interview
P8	50-55	Screen reader, guide dog, cane	Netherlands	Card with PIN	Online Interview
P9	30-35	Screen reader, cane	Netherlands, Denmark	Contact-less Card	Field Observation Interview
P10	35-40	Screen reader, cane	China	WeChat Pay (QR Code Scan)	Online Interview
P11	45-50	Screen reader, cane	USA	Swipe card and sign Apple Pay	Online Interview

Figure 15: List of PVI participants

3.1.2 Blind folded shopping

In the early stage of this research, I did not find PVIs to meet in person for research activites. With the absence of PVIs in the design process, it is common for design researchers to apply user simulation methods during usability and accessibility assessments (Cardoso & Clarkson, 2012). To answer research question 1 and 2, we decided to wear sunglasses with covered lenses to find answers for the first two research questions:

What is it like to pay publicly as a PVI in the Netherlands?

How do PVIs experience exclusions when they make payments at a POS?

We covered the lenses of a pair of sunglasses and wore them to a self-service store in Delft to feel the effects of sight loss during payment. This activities can help sighted designers to emphasize with PVIs and overcome their personal bias.

I invited one sighted participant to join the blind folded shopping. We each picked a few items and tried to checkout while wearing the glasses. One of us paid with card and the other with Apple Pay, our daily payment method. Both payments failed due to different reasons. The results are discussed in 3.3.5. to validate hurdles in PVIs' at-transaction phase.

Participants: Two sighted students from TU Delft, wearing sunglasses with covered lenses

Location: SPAR self-service supermarket on TUD campus. Customers must check out via the store's kiosks

Figure 16: Blind folded shopping at self-service SPAR shop on TU Delft campus

3.1.3 Field Observation

Disability is not something people can put on and take off. Simulated disability are usually not accurate replication of what people may experience. Most PVIs have been experiencing vision loss for a very long time. As a result, they have learnt to compensate for it in their daily life. (Cardoso & Clarkson, 2012) Fortunately, three PVIs agreed to invite us to go shopping with them after meeting in person at an Eye Cafe event in Rotterdam. The participants are P2, P7 and P9 from Figure 15.

Participant 7 pays with his Apple watch. It was described as “fast and easy”. He expressed his preference for digital payment: “ I don’t need to carry my wallet with me anymore. This frees my hands for other tasks. The payment is safe since it does not leave my hand. I trust Apple because it is a big company.”

Participant 2 pays with a contact-less card. She can tell whether the payment is successful or not from the beeping sound of the card reader. However, not every card reader makes a sound, when we shopped together in a department store in Rotterdam, the POS machine makes no sound, forcing the participant to ask for help. At self-check out spots, such as the OV chipcard topup machine, the participant cannot complete the topup by herself because it takes her too long to feel the layout of the machine. Although there is braille on the card scan areas, the participant said it is useless for her because she cannot read the instructions from the touch screen.

Participant 9 pays with contactless card. As this participant has relatively good vision (does not walk with a cane), he can locate the POS machine when the screen lights up. However, he cannot precisely tap on the buttons when it is a touch screen. This participant also needs help with reading small texts on the POS machine.

The insights from field observation is discussed in section 3.3: At-transaction

Figure 17: Participant demonstrating how she makes payment during field observation

3.2 Pre-Transaction

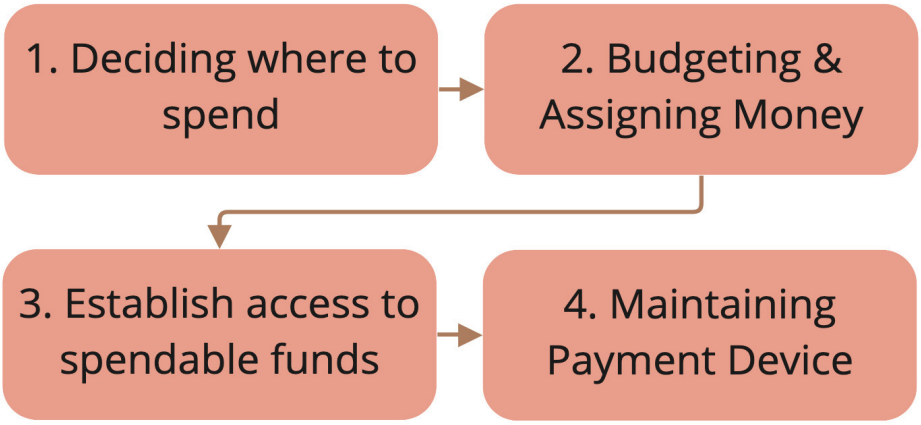


Figure 18: Steps from pre-transaction phase of Moneywork

Summary

In the pre-transaction phase, card and mobile payment show less mismatched interaction than cash payment. The introduction of online banking accounts allows PVIs to manage their money at home, which is considered safer and more convenient. However, with digital systems, PVIs usually do not receive the same description level as sighted people, mostly because information is only available in visual forms. (Szpiro et al., 2016).

Cards have the advantatge of easy to carry, light, small and low in cost. With the introduction of accessible bank cards with "notch". PVIs can differentiate their bank cards from other cards at payment. With mobile payment, PVIs need to link their account to their mobile device, some people find challenging. Fortunately, it only has do be done once.

Smartphone payment is more expensive and requires more maintenance compared to card payment. For example, smartphones need to have data subscription and be charged daily. However, these do not hinder PVIs from using smartphones because they need the device for other daily tasks.

3.2.1. Deciding where to spend

PVIs can shop at many different places, both individually and accompanied. However, they do not always have full autonomy in deciding where to shop. Travel time, store accessibility and the type of shopping influence their decisions on where to spend their money. *Moreover, PVIs need different assistance in different scenarios.* For example, for PVIs who have a guide dog, the dog must come along when they go shopping alone. When they are accompanied, they only bring the cane and the dog can stay home. However, when they need to be accompanied, where to shop sometimes depends on their accompany's preference and availability. *When accompanied by a trusted family member or friend, PVIs are more relaxed* with their payment because the sighted person can assist them during payme.

The setting in which transactions took place have impact on PVIs payment method. Most of the time, PVIs must yield to the stores' settings. *When possible, some PVIs ask the merchant to allow them to pay in a more personalized style (e.g. sending tikkie).*

"When the dog is with me, sometimes we can't both fit into the counter area, I have to stay a little far from the counter which is inconvenient " - P7

"I live in a small town for over 10 years, it's quite nice, everyone knows each other. I sometimes just tell the cashier my password, I don't think he's gonna take advantage of me " - P11

"When I shop with my mom, she helps me to check if everything is correct. But she's not available all the time " - P8

Figure 19: the counter area is quite narrow for P7 and his dog, with the presence of other shoppers and their carts

3.2.2. Budgeting and assigning money

All participants praised digital and card payment for helping them overcome the difficulties of managing cash. Before card payment was widely introduced, many PVIs struggle to arrange cash, especially in Europe - design of the Euro bills received a lot of complaints for its inaccessibility. One PVI explained to me he missed the Dutch guilder bills for they have better contrast in color, fonts and sizes. Although it took some PVIs to get used to card and mobile payment, they are happy that they no longer have to ask a sighted family member to help them sort cash everyday.

Some PVIs still have concerns about the safety of their accounts. Some chose to use an account that only has a small amount of funds in it. Thanks to banking Apps, budgeting has become easier for PVIs and their family members.

"I was taught how to sort my cash from an early age, I use a special wallet with lots of different sections. With card I don't need to worry about this." - P6

"WeChat Pay gave me more freedom in my spending than cash" - P10

3.2.3. Establishing access to spendable funds

With cash, this step in the pre-transaction phase means PVIs have to get cash, for example, from ATMs. Getting cash from ATM raises mobility concerns, for they need to first go to the machine. Then they have to be able to operate the ATM to withdraw money, which requires PVIs to learn the interface while being very alerted about their surroundings to protect their privacy.

"I used to ask my family to go to an ATM with me and teach me how to use it, I try my best to remember all the buttons and the steps" - P9

Compared to cash withdraw, digital bank accounts give PVIs more flexibility to manage their money. Most of the account management can be done online. Although there is still issues with the App and web accessibility, especially the UI design. PVIs can do this at home and ask for help from a family member if needed.

"My wife helps me a lot with my account settings. It takes a while but we only have to do this once in a while." - P3

3.2.4. Maintaining Payment Device

Compared to cash, the maintenance of card payment and mobile payment is much less demanding. Cards are small, light and easy to carry. Some PVIs find it difficult to recognize their bank cards, thus the notch on ING cards is a very helpful feature. However, when they have multiple cards from ING, finding cards can be a problem. Some PVIs use stickers or cuts to mark their cards.

In terms of mobile payment, all PVI participants have a smartphone that they carry everywhere. This is because they need the phone for other important tasks like navigation and texting. However, mobile payment is not available when the phone is out of battery. PVIs also need to setup their mobile device and learn how to use it, usually helped by a sighted person.

Some PVIs use Apple Watch to pay. Like mobile payment, PVIs need some help to set up Apple Pay on their watch. Some organizations like Visio also give step by step instructions to PVIs on how to set up their watch. *Compare to smartphones, an Apple Watch is an expensive purchase with limited functionality, thus it is not widely used among PVIs yet.*

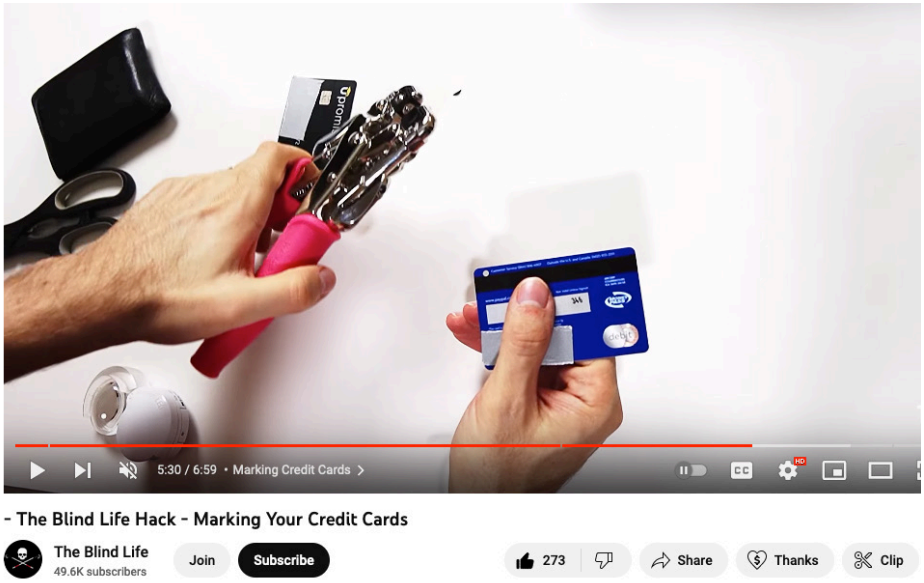


Figure 20: YouTuber Sam made a video tutorial on how to mark bank cards for PVI on his channel: The Blind LIfe (2019)

3.3 At-Transaction

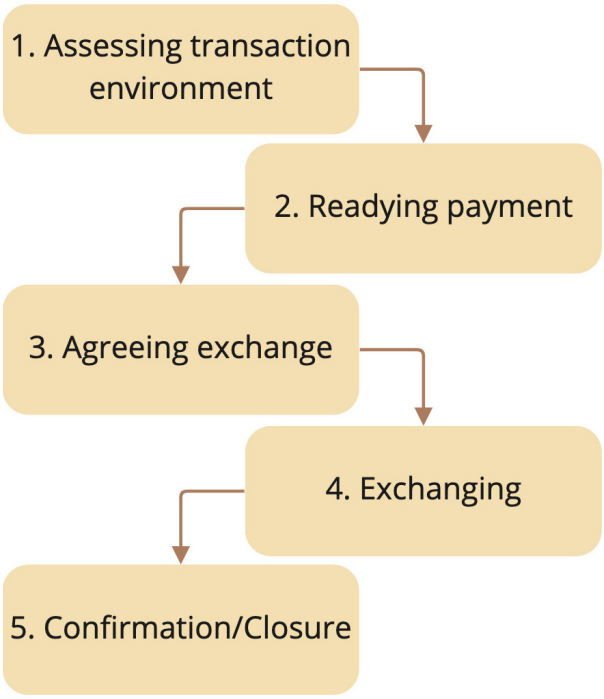


Figure 21: Steps in the At-transaction phase

The at-transaction phase reveals the most mismatches. With the current payment infrastructure in the Netherlands, this phase requires customers to engage all their senses in payment interactions, especially sight. During the research of this project, I see increasing trends in self-checkout systems. These systems were introduced to offer customers a faster, easier, and seamless payment experience. However, these all stand on one premise - the customer must be able to see the kiosk layout and read all the visual displays.

Figure 22 shows some of the Netherlands' most common types of POS machines. Each affords a different payment interaction. Figure 24 and 25 shows how customers interact with these POS machines when they make payments with card and mobile device. In Figures 26-30, the user flows show all the steps users must take to make a successful payment.

Figure 22: Common POS machines in the Netherlands. Each machine has different sizes, keyboard layout and screens.

3.3.1. Overview - Payment infrastructure

Before introducing digital POS systems, cashiers would constantly give verbal instructions to customers during the checkout process. This verbal communication is carried out by card readers and kiosks today in the form of text and images on a touchscreen, sometimes accompanied by beeping tones that convey minimal information. Customers are supposed to operate most or all parts of the POS system, usually on a touch screen. However, this idea only assumes that all customers have good vision.

The introduction of self-checkout kiosks also impacts the relationship between customers and cashiers. Generally, cashiers are supposed to instruct the customers during the entire payment process. In today's world, however, the change from a human cashier to a self-checkout kiosk is rapidly increasing. Thus the responsibility is put upon the customers by default. Consequently, cashiers are not expected to give additional verbal instructions or read the screen display to customers unless asked explicitly to (Pritchard et al., 2015b). PVIs face the dilemma of either admitting they are incapable of operating an "easy" system by asking for additional help or avoiding using the machine.

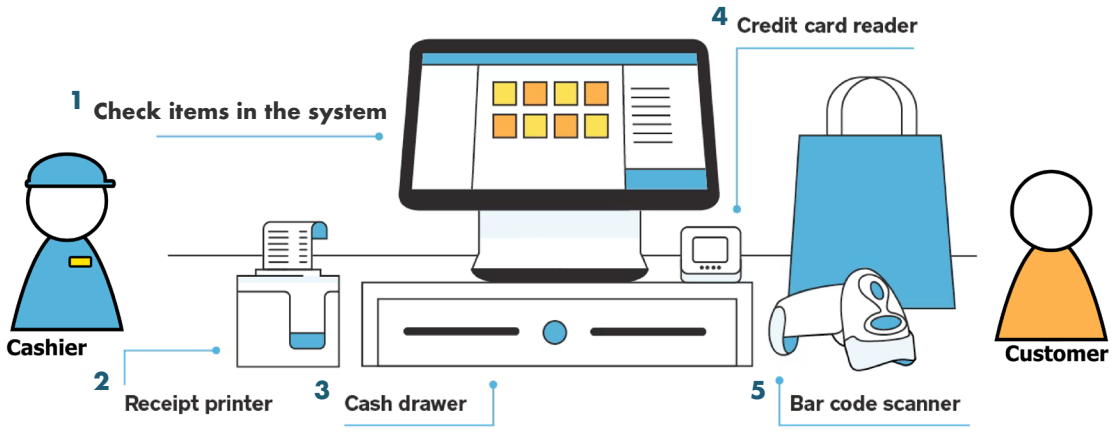


Figure 23: It used to be the cashier's job to handle 1, 2, 3, 4 and 5. Nowadays, these responsibilities have shifted towards the customers' side. Though some items are digitized, like the cash drawer, customers are still in charge of most part of the payment system.

3.3.2. Payment user flows

In Figures 26 to 30, I map out all the user flows for five different types of payment based on the user interviews. I used color dots to indicate which cues are available in each step. There are three: visual (text, graphs, colors), audio (beep sounds, notification sounds, conversational instructions, screen reader), and touch (lifted buttons, textures, different shapes, braille). I also use the shape of the dots to indicate the availability of each kind of cue. For example, not all POS machines make beep sounds.

The POS machine only gives visual display on a small screen with some light signals. Sometimes the machine plays a beep, sometimes it doesn't. The beep is only played once and is hard to hear. Some machines have lifted buttons, but PVIs can't see the numbers

PVIs cannot see the layout of the checkout area, thus they have to hover their hands to find where the POS machine is. Sometimes the payment session already expires when they figure out where to tap their cards.

The final amount is only displayed in small fonts on a low-contrast screen. PVI cannot read how much they are about to pay.

When there is an error message, PVIs can only hear a buzz noise, they know something is wrong but can't read the error message from the POS machine

Figures 24 and 25 are screenshots from Klein Media's YouTube video that shows how to make payments in the Netherlands with card and mobile (2013). Even with the presence of a cashier, the payment interaction is solely between the customer and the POS machine.

Figure 26 to 30 shows the user flow of five types of payment and the cues available in these flows. The ideal situations is that each step offers multiple ways to ensure equal access to payment information

Figure 24: a successful contactless card payment in the Netherlands

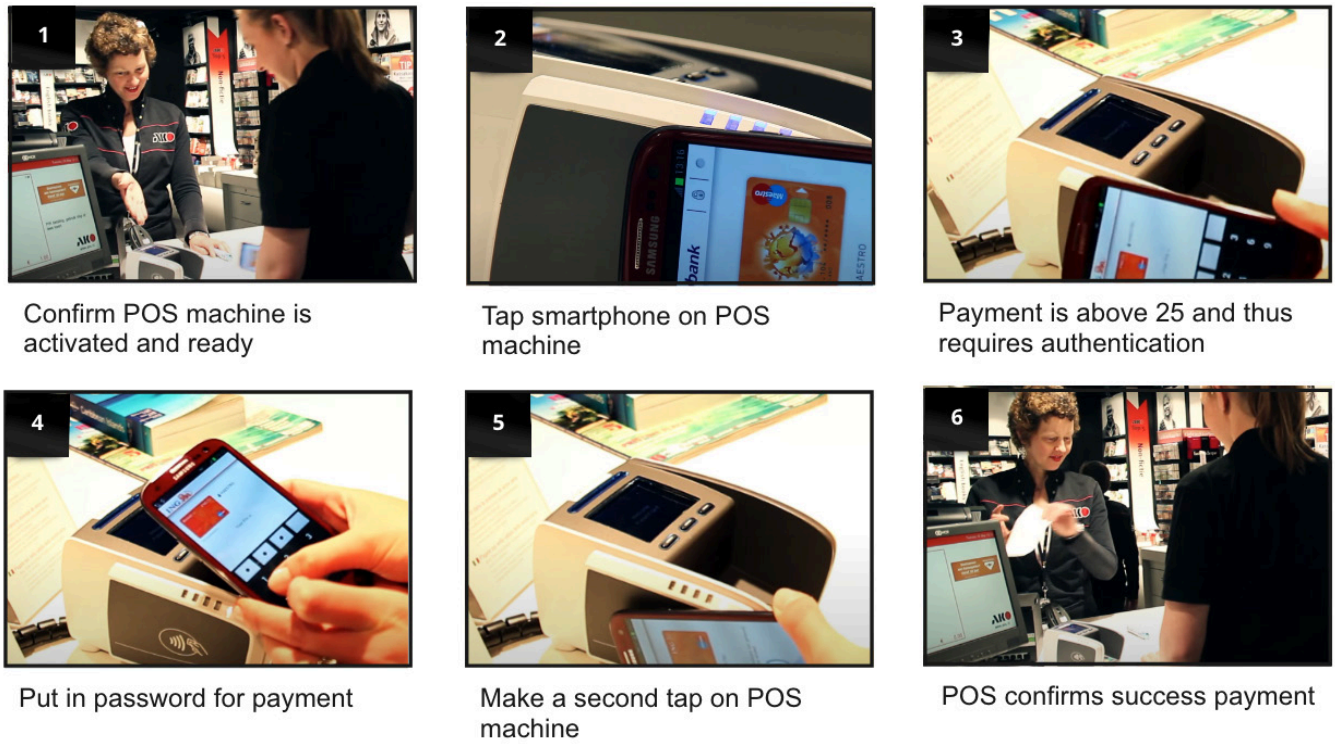


Figure 25: a successful mobile payment with authentication in the Netherlands

Card payment with pin code

When PVIs choose to pay with card in the old fashioned way (inserting card and put in pin code). They must interact with the POS machine. This is a challenging and frustrating task - the inconsistency in size, shape and keyboard layout of POS machines cause more effort for PVIs to understand the interaction. Moreover, PVIs face more security risks when they put in pin code in public.

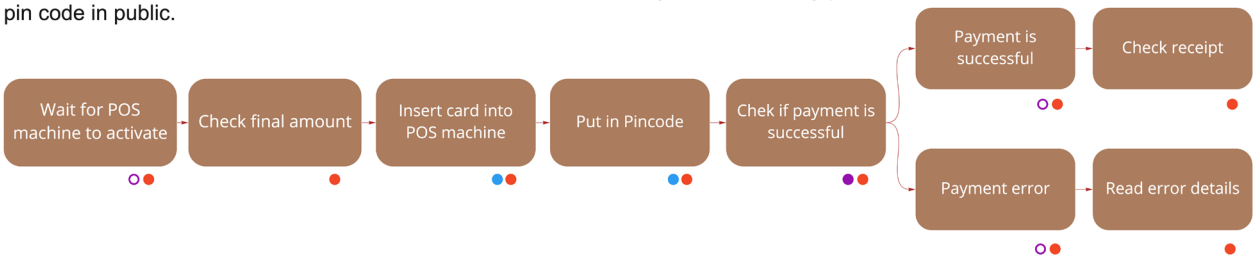


Figure 26

Contact-less card payment without pin code

In this user flow, PVIs can rely on limited audio feedback to complete some of the steps. For example, some PVIs can memorize the beep tones from the POS machine and follow the instructions. This usually takes them a few tries to learn, usually with the help from a sighted person. However, not every POS machine plays an audio sound. In busy shops, some PVIs also find it difficult to follow the audio instructions. Most machines only beep once.
Locating the POS machine is also challenging. Each store has a different counter layout. In some cases, the payment session is already expired before PVIs can find the POS machine.
For some steps, there is only visual information available. In all scenarios, the final amount is only displayed on the POS machine screen in small fonts, which makes it very difficult for PVIs to read. When there is an error message, PVIs have to rely on a sighted person to access this information.

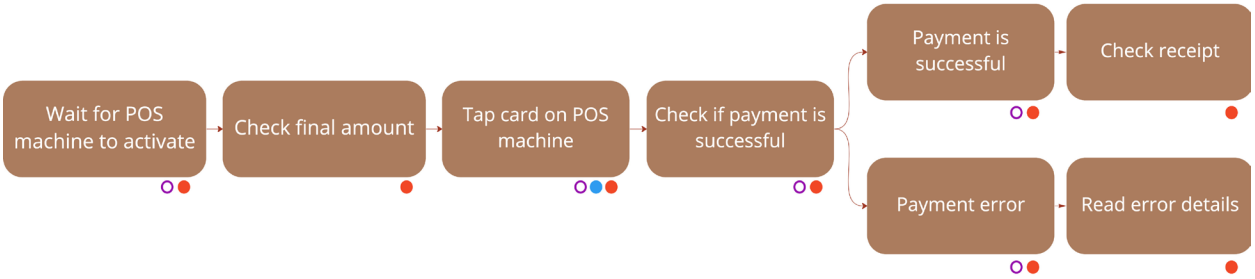


Figure 27

Contact-less Mobile Payment with Authentication

When PVIs do a mobile payment with authentication (which many people prefer), they struggle to coordinate the mobile phone and the POS. For example, it takes PVIs longer time to input their password. With face ID, it's also a struggle because many PVIs wear sunglasses indoors to protect their eyes from strong light. The best way to authenticate is with finger print, sadly not all device have it. When they are done with authentication, the payment session usually expires already.

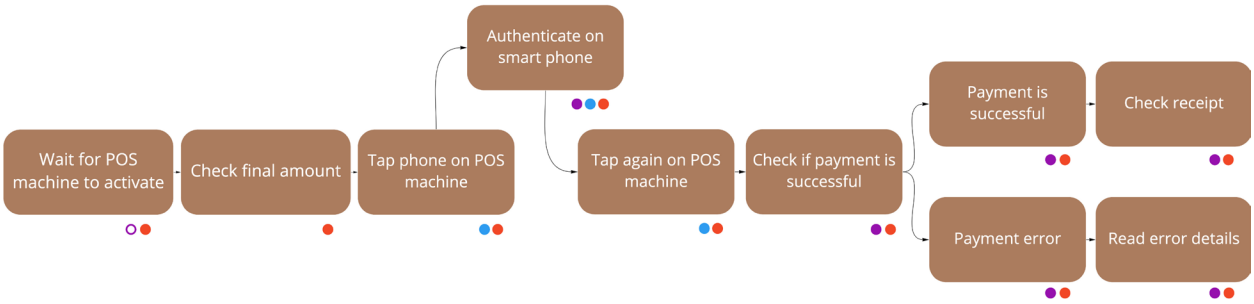


Figure 28

Contact-less mobile payment without authentication

Thanks to the mobile device, PVIs can have better control over their payment in some steps when they pay with their smart phone or watch. For example, PVIs can immediately know whether the payment is successful because the mobile device will send notifications. When there is an error message, they can also access this information by checking on their mobile device.

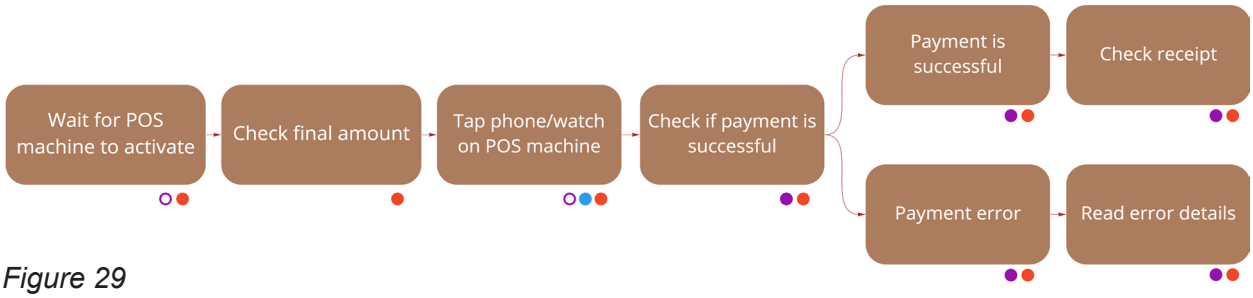


Figure 29

Apple Pay with Apple Watch

Apple Pay on Apple Watch is a very popular payment method among PVIs. However, not everyone can afford and Apple Watch.
Compare to mobile payment, users don't need to authenticate between the tap and transaction, which help them to avoid the hurdle of putting in pin code. PVIs who choose to pay with Apple Watch believe it's relatively secure because they can wear the device on their wrist.

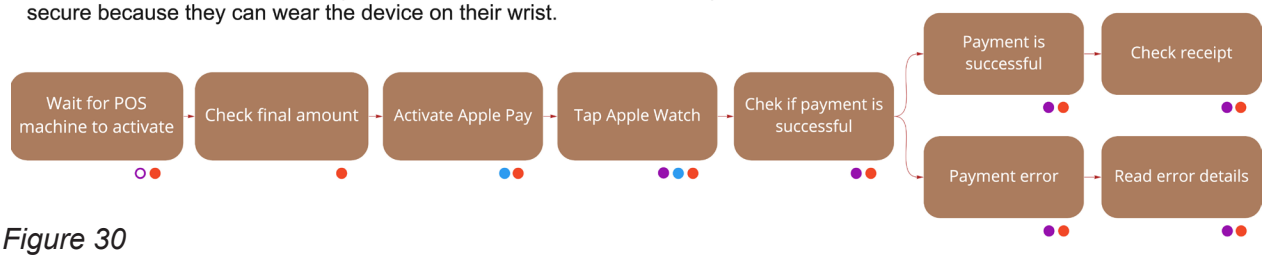


Figure 30

3.3.3. Assessing transaction environments

Participants reported that they sometimes could not assess the safety of their payment environment. Many PVIs are concerned about visual eavesdropping. If they need to put in a password, they must be cautious and always cover the keypad. Some PVIs ask the merchant to send them a tikkie if possible; this switches the interaction to their smartphones, which they trust.

Moreover, POS machine accessibility also affects PVIs' payment choices. Not every POS machine has a keypad with raised buttons. For PVIs who like to pay with PIN, an inaccessible keypad means they either have to give up their payment or give their password to another person to complete the payment.

Handling PIN and cash can also cause delays during PVIs' payment and thus make them feel embarrassed for causing others to wait. (Szpiro et al., 2016a) PVIs sometimes have to try multiple times to successfully enter their PINs and count the right bills, which can cause anxiety during their payment. *Thus, some people like to pay with a contactless card, for it frees them from interacting with inaccessible POS machines.*

"Can someone explain to me, why are there so many different POS machines???!" - P4

3.3.4. Readying payment

From the interviews and literature reviews, both PVIs and sighted people want their payment to be smooth and fast. Payment delays can be considered time-wasting and cause social embarassment. (Mainwaring et al., 2008). From the interviews, PVIs expressed that they often have to extend this step because they have difficulties readying their payment on a POS machine due to inaccessible designs:

- **Minimal audio feedback**
- **Low contrast, blurry screen**
- **Inconsistent keypad layout**
- **Touch screen**

The hurdles in readying payment is especially difficult for people with low-vision. When people see a blind person who has a cane or a dog, they tend to be more patient. However, for PVIs whose visual disability is not that obvious, they sometimes encounter very unfriendly reactions from

Figure 31: a very inaccessible POS machine in IO

cashiers and other customers. *In some situations, they are forced to reveal their disability to strangers to get proper help.*

The design of the POS machines affords very different experience to sighted people and PVIs. A seamless and intuitive design for sighted people can be mission impossible for PVIs. These different interaction qualities create communication gaps between PVIs and sighted people. As a result, when PVIs ask for help, the help they receive is often unreliable and inaccessible (Williams et al., 2014).

"It seems like people assume we have magic to solve everything by ourselves. I am just a normal person..." - P7

"When I ask how much do I need to pay, the cashier just flips the screen" - P5

Most of the time, people are willing to help if they are aware of a person's disability. From field observation with P2, the cashier adjusted the POS machine to an easier angle for the participant to tap his watch. She also silently pushed purchased items to participant's hand to make sure he doesn't leave anything behind. She later told us she sees our participant quite often and understands what he needs. However, not everyone is as aware of this cashier.

Most people's impression of PVIs come from mass media - a person who walks with a cane and a dog. Most of the time, people fail to respond adquately to PVIs' needs. Films tend to portray PVIs as characters with unordinary personalities in dramatic events. It is infrequent for the general audience to find PVI characters represented as ordinary people who do housework, go shopping, or travel; that is, coping with the mundane everyday tasks like common sighted people. (The Impact of the Popular Media on Public Perception of People With Disabilities, n.d.-b)

"People can't really recognize my visual impairment, they just thought I don't know how to use the machine. They walk away and tell me they don't work here. Then I really have to reveal my visual disability... it is very awkward. " - P5

"Telling me: "Oh! It's right there! and point at a direction" doesn't mean anything to me" - P5

Figure 32: P2 paying for his groceries during field observation

3.3.5. Agreeing payment

Currently, there is no way for PVIs to directly confirm the final amount from the POS machine before agreeing the transaction. PVIs are forced to agree their payment without assessing the final amount. Most POS machines have a low-contrast screen that is unreadable for PVIs.

Prior to the introduction of digital POS systems, cashiers would constantly give verbal instructions to customers during the checkout process. This verbal communication is carried out by card readers and kiosks today, in the form of text and images on a touchscreen, sometimes accompanied by beeping tones that conveys minimal information.

"I always keep my receipt and ask my husband or caretaker to double-check everything for me as soon as I get home."

To assess the final amount, PVIs are forced to trust sighted strangers if they are shopping alone. In the meanwhile, they have to bear the risk of being taken advantage of by dishonest merchants or overcharged by careless cashiers.

Some PVIs respond to this issue by doing extra "homework" in their pre-transaction and post-transaction phases to render a smooth at-transaction experience. For example, some make a shopping list and pre-check the price of everything before they go to the store. Others take the receipt home and ask a trusted family member to check for them. (Kameswaran and Hulikal Muralidhar 2019)

"I pre-check the price on the store website and make a shopping list beforeI go shopping. This way I have an idea of how much I should pay."

When people decide to pay, the gesture of tapping or inserting their card is a sign of agreeing the exchange. However, this interaction is chanllenging for PVIs. *For people who cannot see the layout of the checkout area, it uaully takes them a while to find the POS machine.* When they feel the machine, they need time to feel the buttons and card slot. I validated these hurdles from both blind-folded shopping and field observation.

Figure 33: P2 wears backpack and folds away his cane inside the store to free his hand for the basket

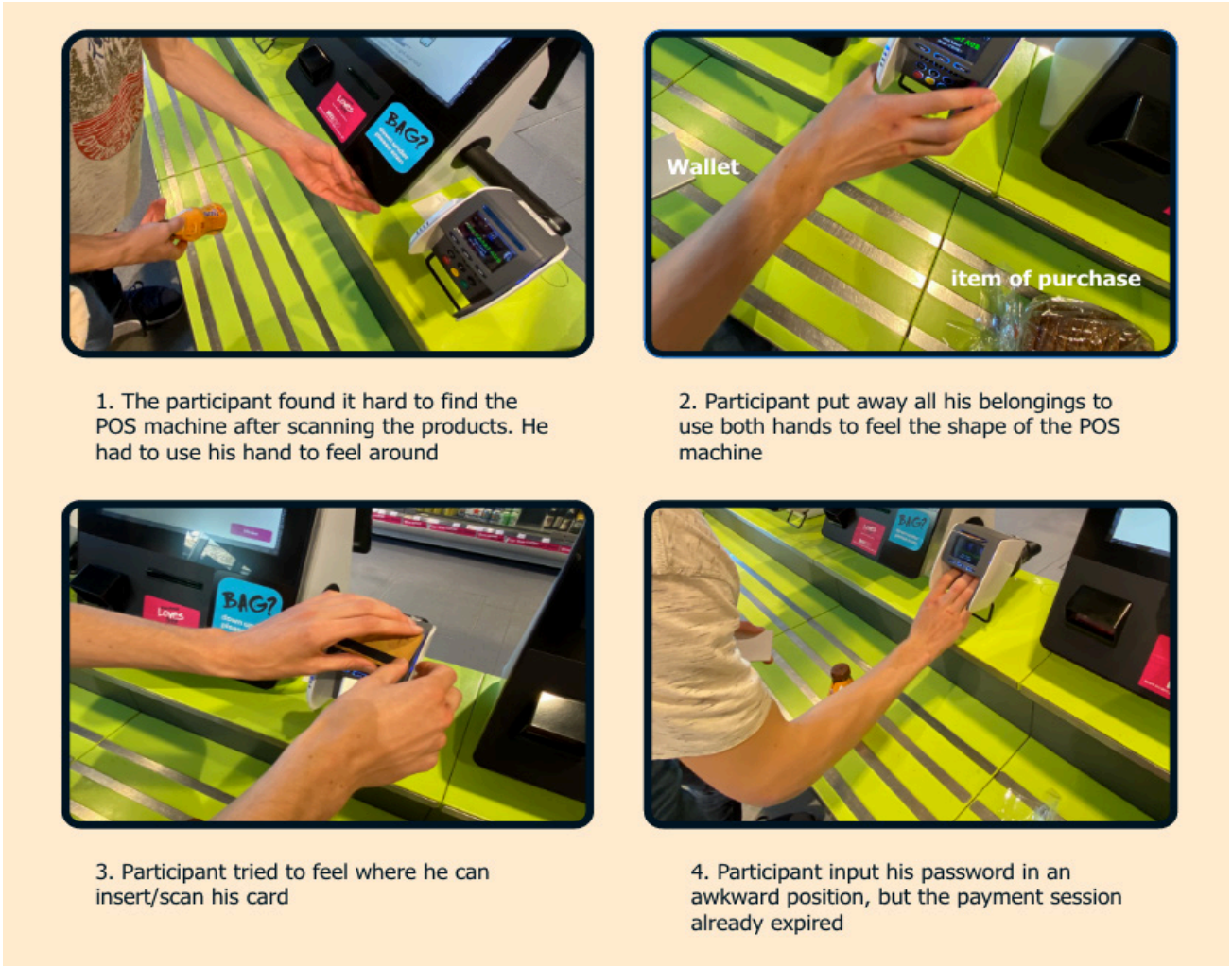


Figure 34: Blind folded shopping at SPAR: card payment with PIN

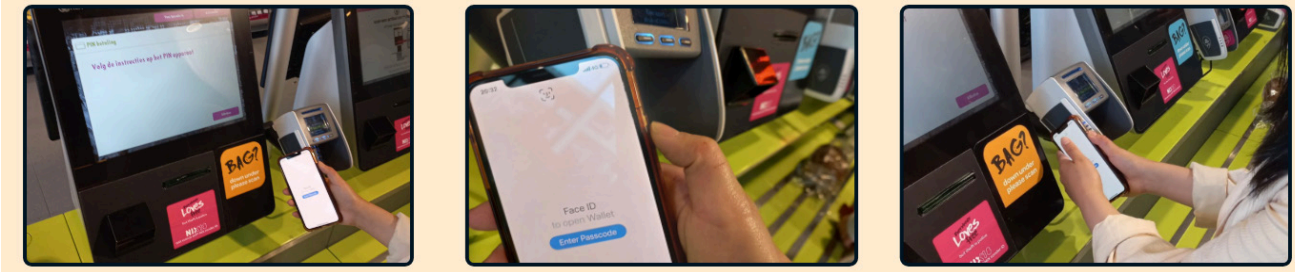


Figure 35: Blind folded shopping at SPAR: card payment with PIN

Audio feedback is an important source of information for PVIs, even though it only conveys minimal information. Many people memorize the tones of the POS machines to tell if the POS is activated. However, some machines play a very weak sound, or no sound at all, leaving PVIs feel clueless about the upcoming events.

The "agreeing exchange" step to "exchange" step happens within seconds, but PVIs need more time than sighted people to agree their payment and send back this confirmation. If PVIs are not familiar with the counter layout, the payment session might expire before they tap their card/phone for confirmation. Thus, contact-less payment become a popular choice - exchange happens with only one tap. However, contactless payment is a double-edged sword. It provides some convenience yet creates new challenges. PVIs shared mixed feelings about contact-less card payment.

In fact, contactless payment doesn't solve the problem of POS machines and inaccessible keyboards - it gives VIPs an opportunity to avoid POS machines. In the meanwhile, the agreeing exchange step is also skipped - the boundary between readying payment and agreeing payment is blurred. Thus give PVIs a sense of insecurity.

3.3.6. Exchanging

With the current payment infrastructure, exchange happens in a blink, especially with contactless payment. However, as discussed in 3.3.5. this fast transaction can seem scary when the agreeing exchange step is skipped. **Some PVIs do not trust contactless payment** because their money was accidentally taken when they stood too close to the card reader - PVIs feel that their money was deducted without their consent.

Hurdles in the exchanging step also come from PVIs' encounter with errors. *While they can tell something is going wrong from a notification sound, they do not always know how to respond to the error.* For example, during field observation, participant experienced some delay in her exchange. The POS screen says "connecting", but our participant couldn't read this message. Therefore, she lifted her card, which caused the payment to fail.

"I tried it once, but decided to turn it off immediately - I accidentally went too close to the counter and I heard a beeping sound - it is already paid! It took money from my account without my consent" - p8

At a different store, the participant recognized the notification sound asking for her PIN and successfully completed the transaction

3.3.7. Confirming and closing the exchange

Customer need to know whether the payment is successful before they close the transaction. With digital payment, the movement of the money is invisible, thus, customers can only be informed in in-direct ways. *For PVIs, they have to rely on audio feedback or a sighted person to confirm this step.* Some PVIs with less severe vision loss can decide whether the payment is complete from the color of the light or the brightlness of the screen.

If the payment is unsuccessful, PVIs usually need to seek for help from a sighted person. Thus the same concerns of receiving inaccessible and unreliable help might occur. Resulting in PVIs' indenpendence being jeopardized

One interesting adaptation made by PVIs is that some people ask the merchant to send them a payment request via text.

This way they can complete and assess the payment on their personal device. The device settings are often equipped with accessibility features and tailored to PVIs' personal preferences. This way they can have better control over their payment

3.4 Post-transaction

In the research by Perry & Ferreira, post-transaction activities include "house-keeping" or document their spending and "sharing". The original work studied the interaction around the Bristol Pound. A local digital currency that often enables sharing on social media by its users to showcase their support for local business. However, this sharing activity does not apply to PVIs' moneywork.

Another step in the post-transaction phase is "House keeping", which refers to the activity of additional transactional work after making a payment to prevent fraudulent use of their account if their phone were to be stolen. For PVIs, post-transaction work is very common. This is because *some steps in the at-transaction phase is only possible when they return home.*

One of the most frequently mentioned activity is to ask a sighted family member to check their receipt and make sure they have paid the right amount. Since PVIs cannot read the final amount from the POS machiene when they are paying.

Some PVIs also immediately check their account balance after they return home to make sure no fradulent transactions were done to their mobile device. Or if they experienced a suspicious payment when they were at the store.

3.5. Conclusions

This chapter answers the first two research questions by doing interview, field observations and literature review. I use the framework of moneywork (Figure 9) to break PVIs' payment interactions into a series of micro-interactions to uncover the mismatches they encounter during payment

What is it like to pay in public as a PVI in the Netherlands?

During interviews, the most frequently occured comment from PVIs is: *"I feel I don't have full control over my payment."*. This comment addresses several issues. Firstly, the moneywork interaction afforded by the current payment system does not fully match with PVIs' capabilities. The current payment interaction is supposed to be fast and frictionless. However, PVIs need more time and feedback during some steps of their moneywork. Moreover, PVIs do not receive the same level of instructions for their payment as sighted people do. When information is only available in visual forms, PVis cannot access these information without the help of a sighted person.

PVIs sometimes do not have full autonomy in choosing where to spend their money. Therefore, they are forced to adapt to the payment infrastructure by relying on sighted strangers, or doing extra work before or after they go shopping.

An analogy of this out of control feeling in PVIs' payment is a dancer who is used to slow dance movements is suddenly forced to dance to very fast jazz music. To follow the rhythms, their steps become hasty and fragmented. They feel embarassed and insecure about their performance. To provide PVIs with a more accessible payment experience, we need to recompose the chreography so that it better fits PVIs' capabilities.

When a designed artefact, especially one that is supposed to be accessible to everyone, rejects its users. The person can feel embarassed, excluded and disrespected. Touch screens are becoming increasingly popular in the Dutch payment infrastrucuture, leveraging visual perception in people's payment interactions.

These payment systems afford very different experience to PVIs and sighted

people. Thus, when a PVIs ask strangers for help with their payment, the help they receive is usually unreliable and inaccessible. Most people are unaware of the power of vision in their interactions with their surroundings. It's very ieasy for sighted people to give visual based descriptions to PVIs that is barely helpful.

In conclusion. PVIs need more sense of control in their payment. The design intervention needs to address two aspects: Firstly, the design should remedy the mismatched interactions between PVIs and the current payment system. Secondly, PVIs should receive the same level of instructions during their payment as sighted people.

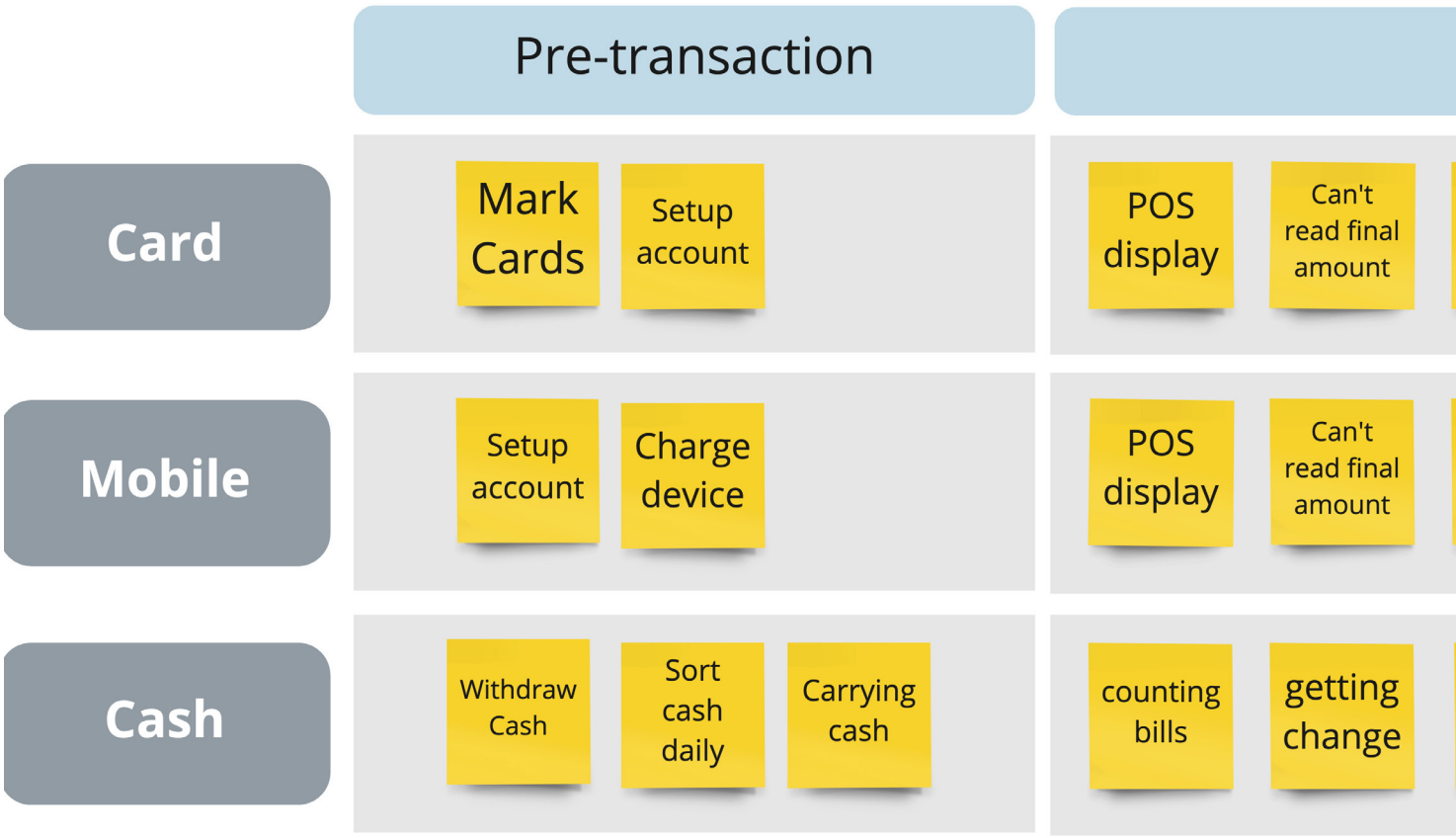
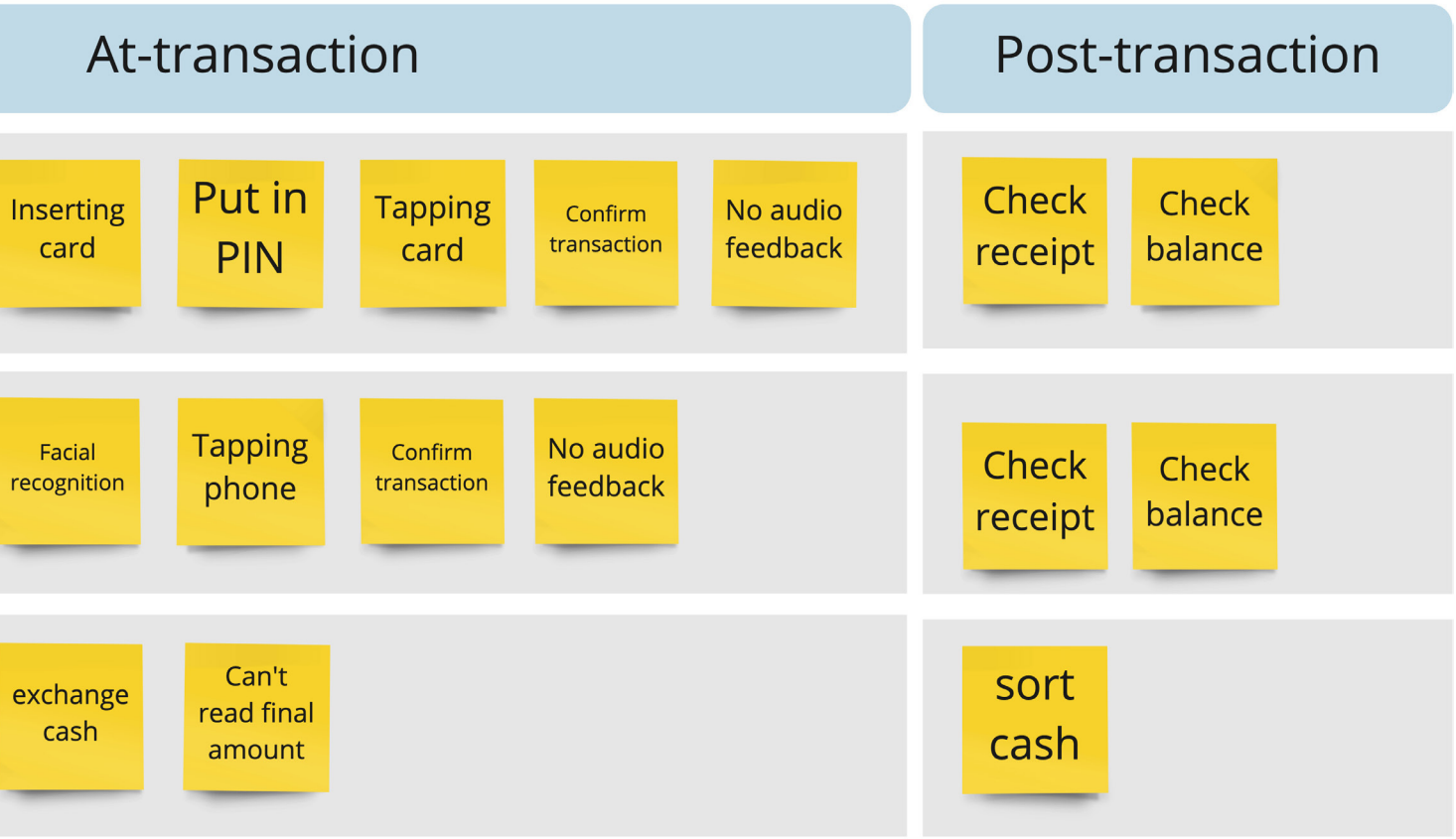
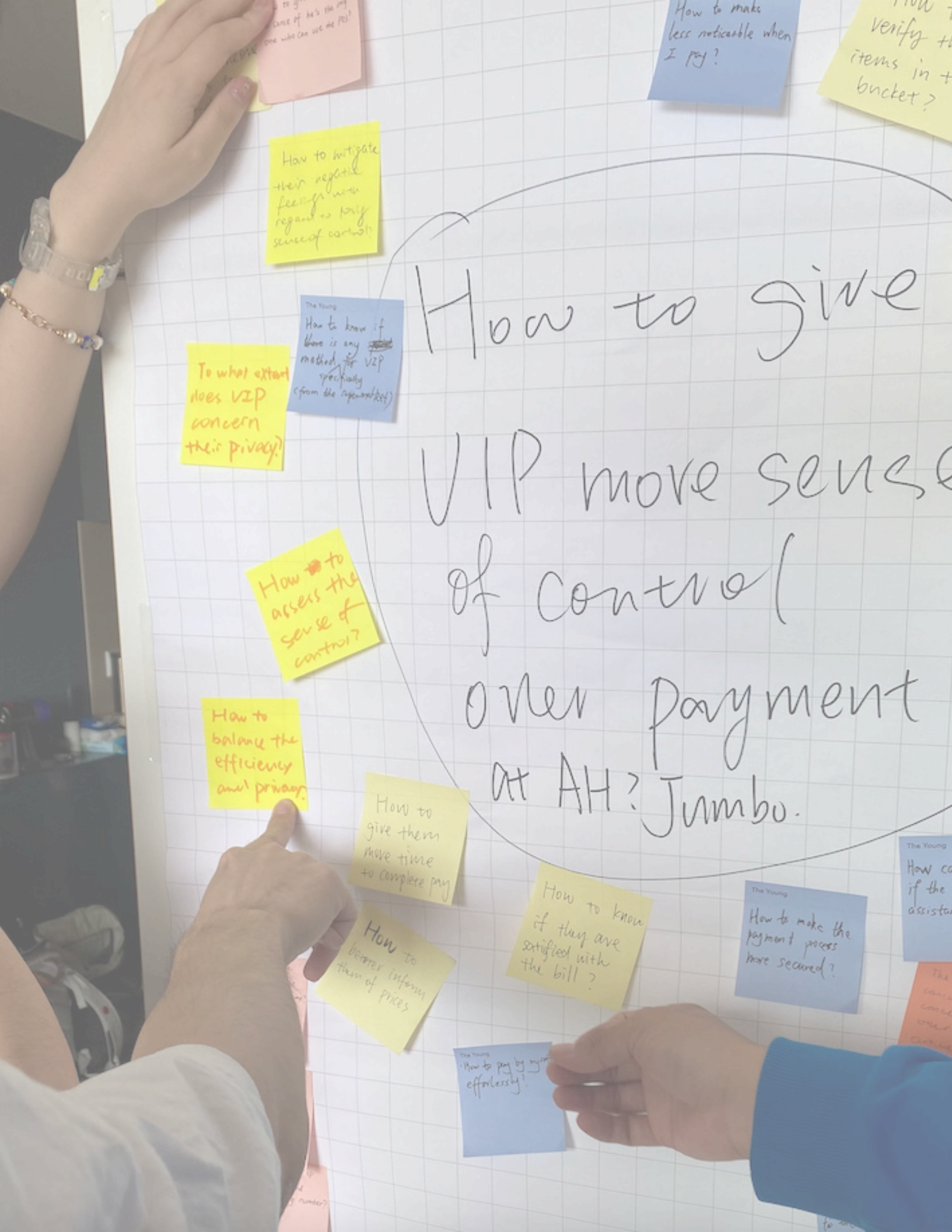


Figure 36: Overview of mismatches in PVIs' moneywork


At-transaction
Post-transaction
Inserting card
Put in PIN
Tapping card
Confirm transaction
No audio feedback
Check receipt
Check balance
Facial recognition
Tapping phone
Confirm transaction
No audio feedback
Check receipt
Check balance
exchange cash
Can't read final amount
sort cash

Synthesis


How to give
VIP more sense
of control
over payment
at AH? Jumbo.
How to mitigate their negative feelings with regard to lack sense of control?
How to know if there is any method for VIP specifically (from the supermarket)
To what extent does VIP concern their privacy?
How to assess the sense of control?
How to balance the efficiency and privacy?
How to give them more time to complete pay
How to know if they are satisfied with the bill?
How to make the payment process more secured?
How to make less noticeable when I pay?
How to verify items in bucket?

4.1 Synthesis and Ideation

4.1.1. Synthesis Goal

In Chapter three, I used the moneywork framework to answer the first research question in 1.3.1.

1. What is it like to pay in public as a PVI in the Netherlands?

From interviews, field observation and literature reviews, I conclude that PVIs experience mismatches in their moneywork in two major aspects: *both from their interactions with the current payment infrastructure and their communications with sighted people*. When an inaccessible system rejects PVIs, they are forced to rely on sighted people for their payment. However, the help they receive is not always reliable and accessible.

To answer the second and third research questions: ***How can design remedy the mismatches between current payment infrastructure and PVIs' capability?*** and ***How to make PVIs feel socially included during their payment?*** I need to answer the following questions: *(a) What kind of service can ING provide to help remedy the mismatches?* For example, the layout of the kiosk and inconsistent design of the POS machine caused a series of mismatches, but ING as a bank cannot directly influence these design decisions, and *(b) What kind of interaction qualities should the design contain to empower PVIs and ensure a smooth payment experience?*

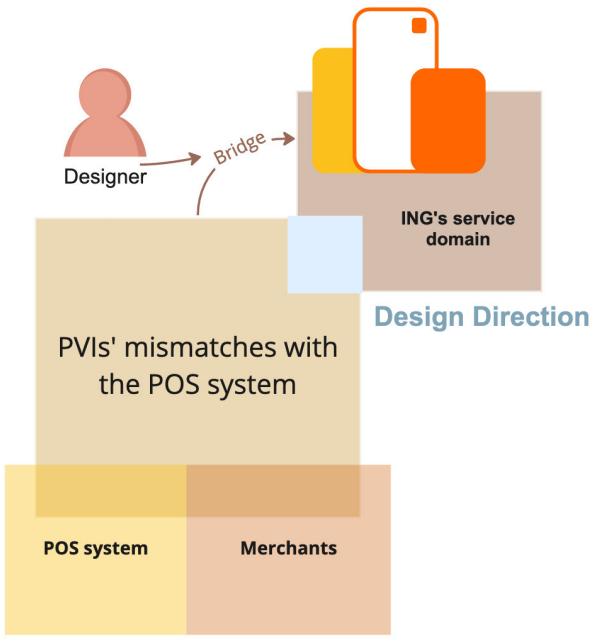


Figure 37: Finding design directions

To answer question a, I decided to facilitate a co-creative session with ING. One PVI colleague joined our session. The goal of the session is to *brainstorm for design directions that align with ING's service domain*. In other words, the workshop helps us to decide on a phase in PVIs' moneywork that creates the most design opportunities for ING. Participants were briefed with the findings from Chapter three, then we started the session with the question: ***How to give PVIs more controls over their payment.*** After the sessions, *we concluded we can improve the at-transaction phase by allowing PVIs to connect their divice to the POS machine and access information directly from their smartphone*. The design directions were discussed and validated by technology experts within ING.

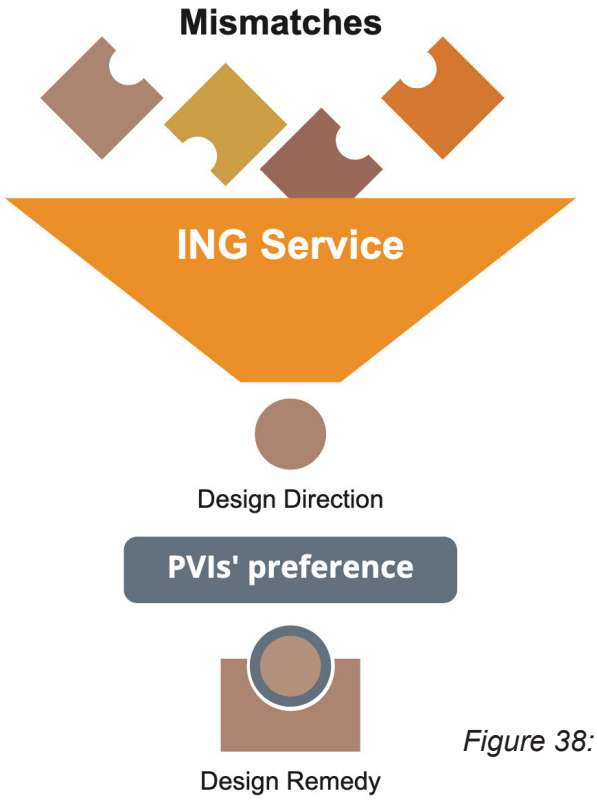


Figure 38: Synthesis with ING and PVIs

After agreeing on a design direction, I need to ideate for the interaction qualities. Specifically, to ideate with PVIs on how to create a more accessible experience in the chosen phase of their moneywork. Thus, I picked the "role play" activity from the Microsoft Inclusive Design Toolkit to ideate together with PVIs. These activities help us to understand that the user flow must be improved in three aspects: *1. Help PVIs to connect their smartphone to the POS machine. 2. Allow them to read the final amount. and 3. Give them more time to get ready and agree their payment.*

The generated design ideas were discussed with other PVIs for validation, the results will be taken into account for the next research phase: Prototyping.

4.2 Co-creation Workshop

4.2.1. Workshop Planning

Workshop Goals:

1. To brief ING colleagues with research findings from Chapter three.

2. To find acceptance within ING for de-sign opportunities in PVIs' moneywork

3. To generate design directions that fit both PVIs' interest and ING's service domain.

Participants:

Pilot session: IDE Alumni
Brand Experience Team at ING
Global Head of Accessibility (PVI)

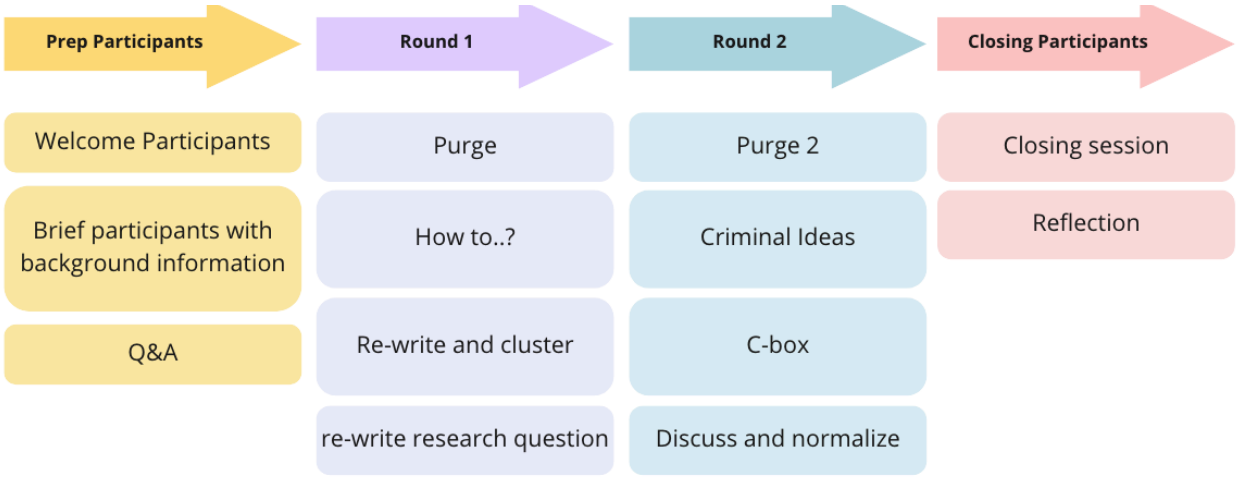


Figure 39: Co-creative workshop plan

4.2.2. Research Question

Research Question

How to give PVIs better sense of control over their payment?

This research question was formed in response to the most frequently occured comment during our interviews with PVIs: “I feel that I don’t have control over my payment”.

After briefing ING participants with the findings from Chapter three, we used two rounds of activities (figure xx) to generate design directions. The workshop contains two rounds of brainstorming sessions.

Prior to the workshop with ING, a pilot session was conducted with IDE alumni. The goal of the pilot session is to re-hearse the session planning and ensure the selected activities can fully engage participants. In addition, to generate ideas from the perspective of regular consumers in the Netherlands.

4.2.3. Tools and Methods

Round 1 Activities

1. Guided Fantacy

Before the workshop, I invited participants to close their eyes and imagine they are paying at a supermarket. After scanning their items, they need to start interacting with the POS machine to complete their payment.

Figure 40: I prepared 3D printed POS machine with a plain layout and goggles to help participant experience visual disability

2. Purge

This is a quick activity. Participants are invited to give their most intuitive answers to the research questions within a short time. There is no right or wrong answer. The more ideas the better.

3. Cluster

After purging, participants clustered the ideas according to the issues they address. The goal is to find recurring themes in their responses.

4. How-2

This activity helps participants to start thinking how to respond to the themes we found in clustering. They are invited to rewrite each cluster themes into questions that start with “How to ...” or “How can we as ING ...”

4. Vote for new question

From all the How 2 questions, we vote for our favorite one as the new research question of the second round.

Round 2

1. Criminal Mindset

This activity aims to help participants, especially in an office setting, to think out of the box. Participants were encouraged to think of criminal solutions to the new research question. Participants are ensured that the result of this activity will not be published or recorded.
After we got enough responds, we voted for three best criminal ideas and reflected on how these criminal ideas inform our research question. This step helps us to normalize the ideas into feasible design directions.

2. C-Box

The final ideas are placed to a C-box. Each participant were asked to vote for the most feasible and creative ideas. The end result is the new design direction.

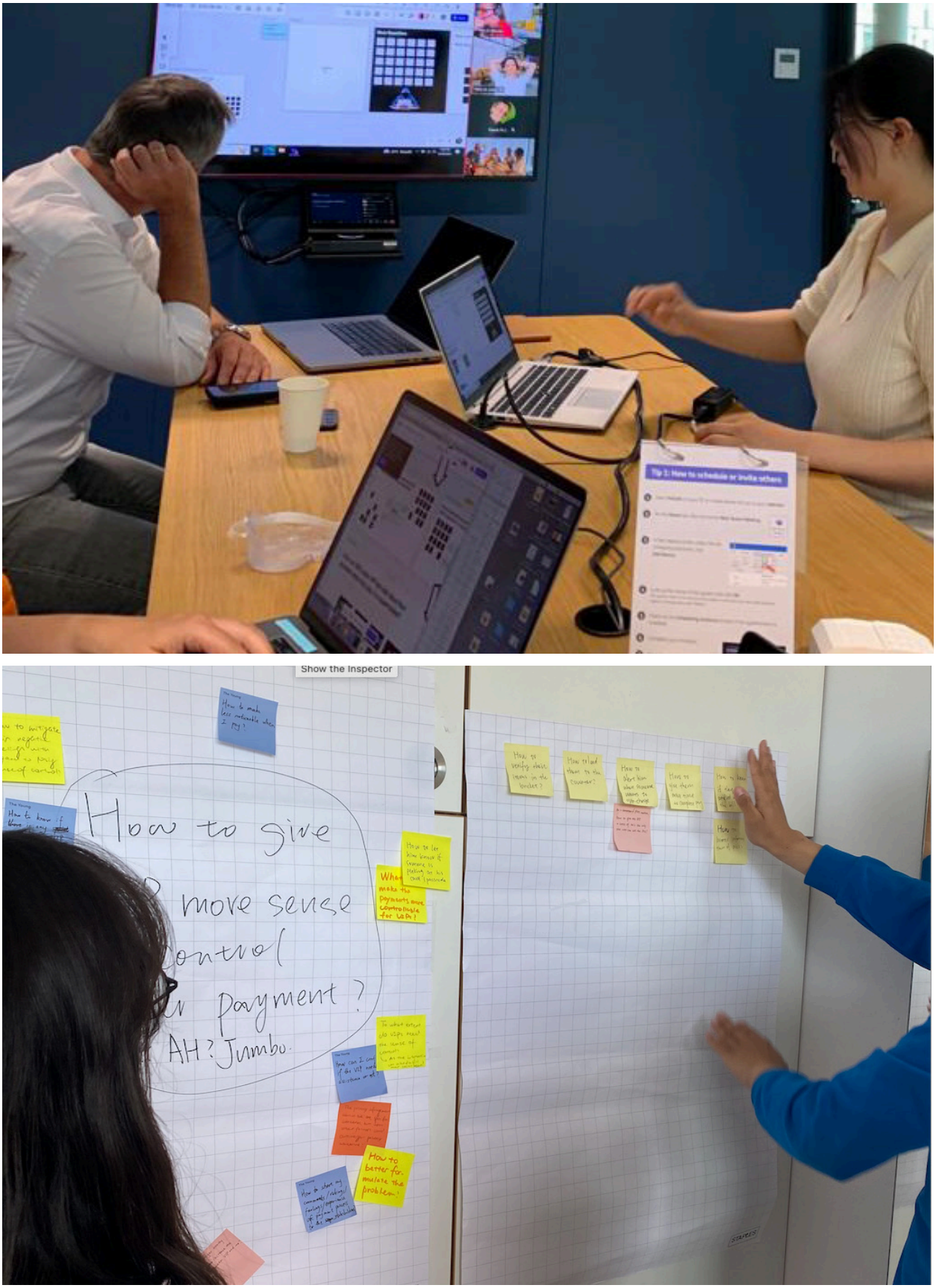


Figure 41: Pilot test and co-creative workshop at ING

4.2.4. Summary of results

1. Clustered themes

In Round one, participants generated the following themes from their purged ideas

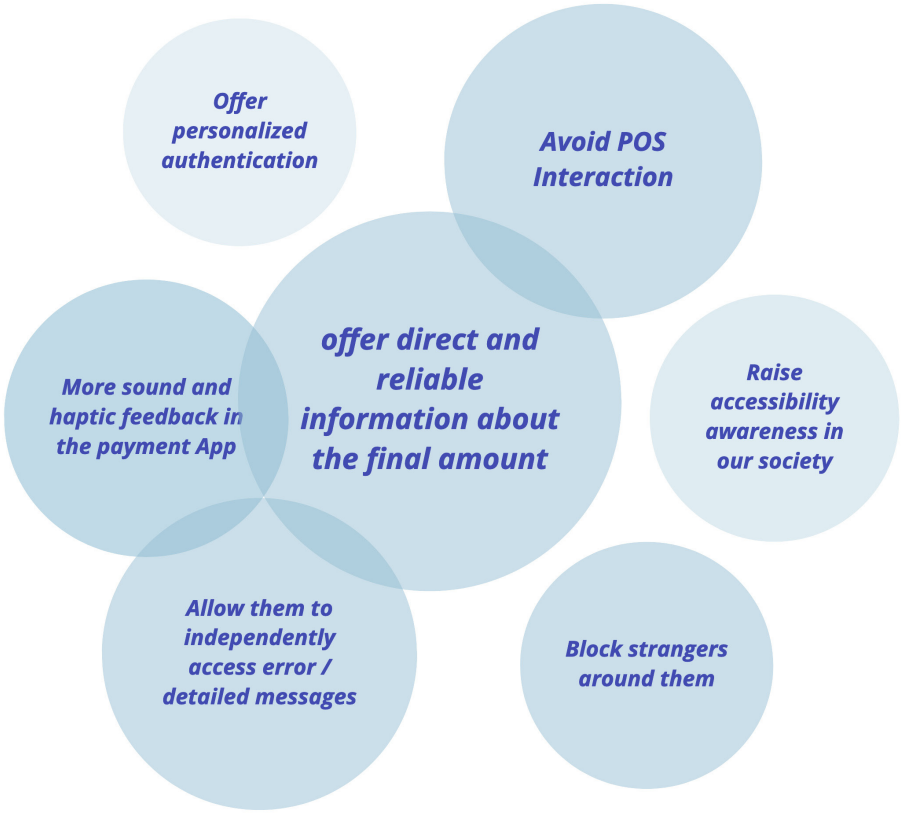


Figure 42: Clustered design themes

2. How to and vote

For each cluster, we rewrote them into "how to" questions. We then selected five how to questions that best fit the research question and voted for a new research question for the next round.

3. The new research question

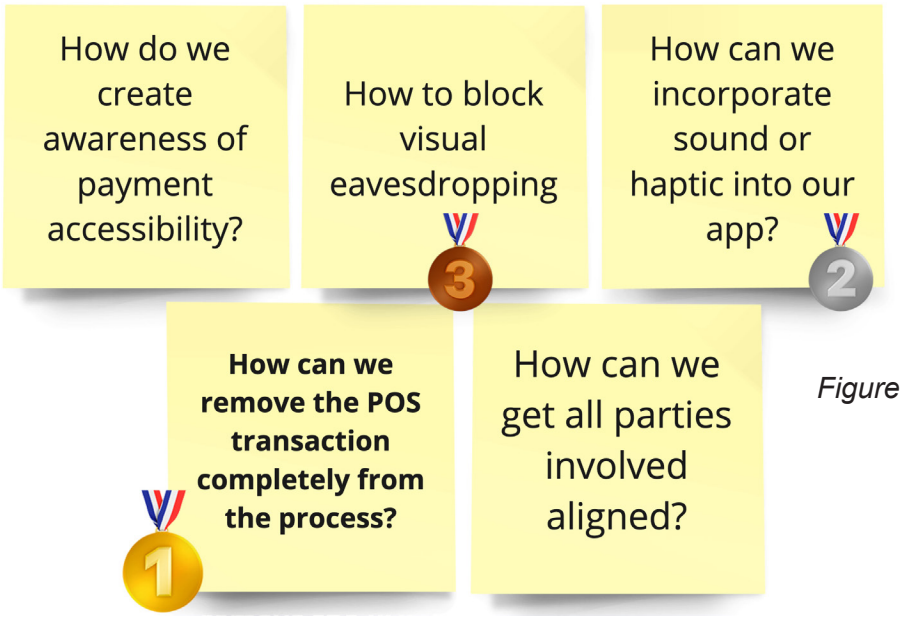


Figure 43: Vote for how-to ideas

The goal of this session is to vote for one question to be the new research question. However, participants voted for three questions because they all play an important role in giving PVIs more sense of control over their payment.

How can we remove the POS transaction completely from the process?

This How to question is selected because participants believe it creates the most design opportunities and removes the biggest frictions from PVIs' payment experience. During the session, participants mentioned the Amazon self-service store. The store allows customers to grab their items and walk out of the shop directly, the Amazon Payment App can automatically detect the items purchased and deduct money from customer's account.

How can we incorporate sound or haptic into our App?

This question is voted because participants think it is an obvious issue we need to take care of. It is clear that PVIs are not receiving enough information about their payment, thus we need to make sure they access these important information in non-visual forms.

How to block visual eavesdropping?

This question is voted because we think it is nice to offer PVIs a safe space in public. To make them feel protected and feel more relaxed with their payment

4. Criminal Mindset

Due to privacy agreement, the criminal ideas are not presented in this report. Only the interaction qualities reflected in the criminal ideas are documented.

The qualities of the criminal ideas reflected three themes, all related to directly connecting PVIs' smartphones to the POS machine.

Firstly, we agreed to allow PVIs to access the final amount of their payment directly on their smartphone, without relying on a third-party.

Secondly, we agreed PVIs should be able to agree or disagree with their payment directly from their smartphone instead of confiming on the POS machine.

Lastly, we agreed there should be plenty of none-visual information for PVIs to access, via voice over, chatbot or haptic feedback. The results were moved into a C-box to vote for the most feasible and innovative ideas.

Then we re-wrote these interaction qualities into design directions for C-Box session.

Figure 44: Interaction qualities from criminal ideas

5. C-box

At the end of the workshop, all design directions were moved to a C-box according to their feasibility and desirability . Workshop participants were each given one red sticker and two green stickers to vote for the design directions that are most feasible and innovative for ING

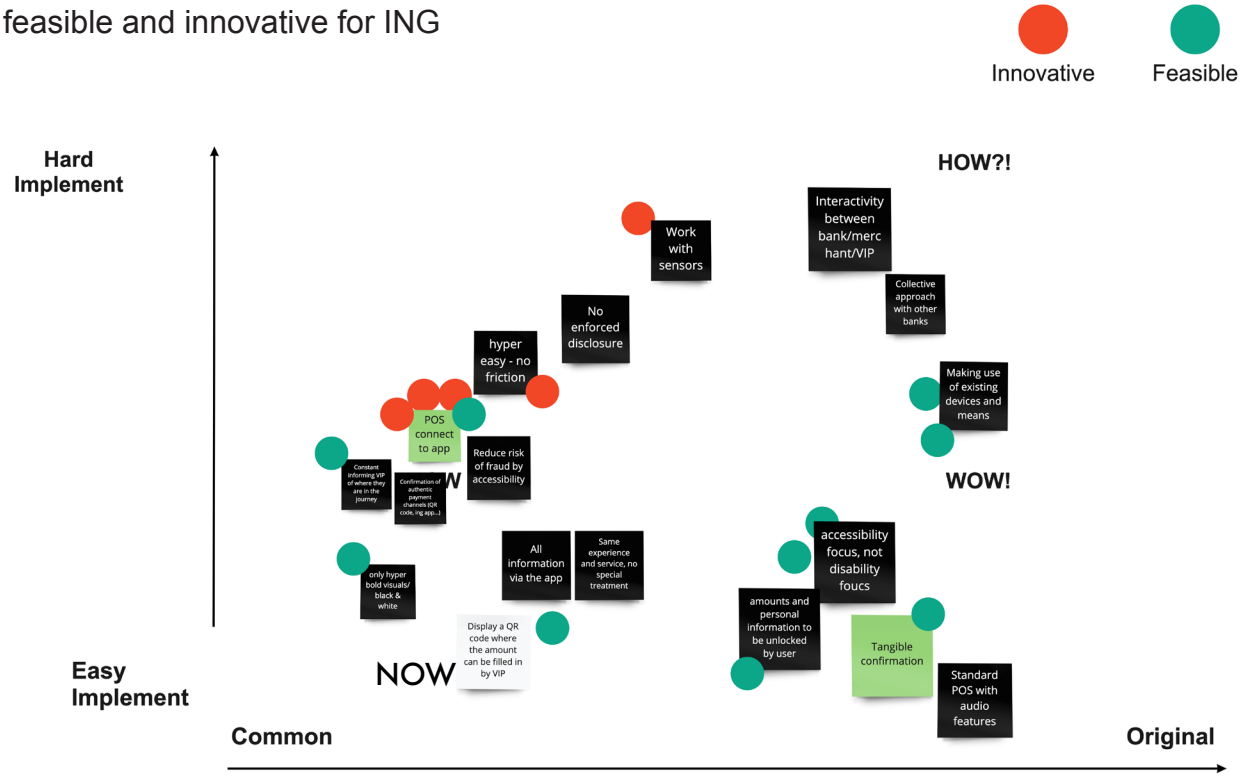
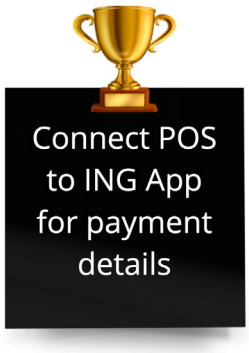


Figure 45: C-Box

6. Session winner

In the end, we voted for “Connect POS to ING App for payment details”. This one was voted for it reflects the qualities from criminal mindset. As a in-house App, we have full control over its design and thus can create a lot of design opportunities. It also aligns with the trend of increased popularity of mobile payment.



4.3 Technology Feasibility

At ING Factory, we spoke with innovation director Thijs. He demonstrated a latest payment prototype which allows customers to send money to each other via NFC chips from up to 50 meters. Two friends can point their smartphones at each other and send transactions to each other. The project was introduced on de Volkskrant reported by Haas. (2022)

This visit to the ING Factory confirms that smartphone - POS connection can happen at a distance. This means PVI do not have to squeeze themselves into a narrow isle to make a payment. This feature also creates opportunities for PVIs to receive the final amount directly on their smartphone and confirm their payment without interacting with the POS machine.

Moreover, the smartphone - POS connection can potentially guide PVIs to the POS machine like a radar.

deVolkskrant

NEWS

Contactless payment up to fifty meters away is within reach, according to ING

Send a little bit, create a QR code or, if it still exists, withdraw cash from your wallet. If it is up to ING and chip manufacturer NXP, it will all be superfluous in the future. With the latest, contactless payment method, users only need to point the smartphones at each other to pay.

Anna de Haas 6 July 2022 , 22:45

Figure 46: News article from de Volkskrant about Innovative payment concept by ING

4.4 Co-design User Flows with PVIs

4.4.1. Workshop Planning

During the session, the PVI participant and designer discussed the ideal payment scenario for a PVI customer. Following the Human Analogy activity card from Microsoft Inclusive Design Toolkit (Figure 47), *We agreed that the role of the payment App should be a kind-hearted cashier who is willing to give detailed instructions step by step.* In addition, the App should provide PVIs with adquate information and sufficient time to get ready and confirm their payment.

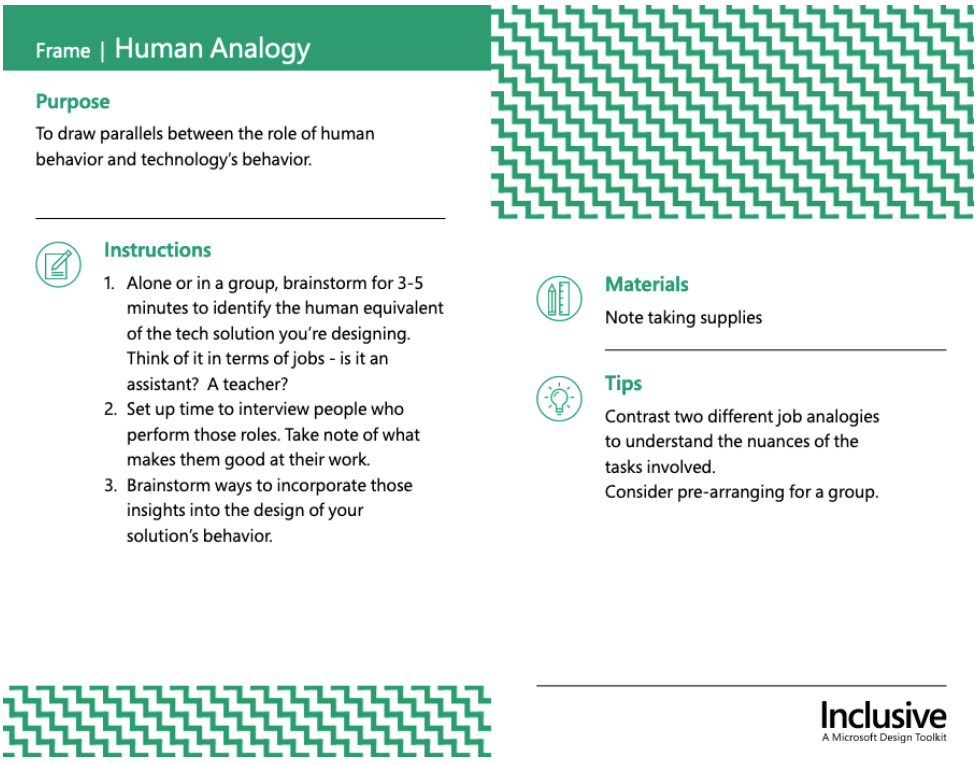


Figure 47: Activity card from the Microsoft Inclusive Toolkit (Microsoft n.d.)

4.4.2. Role playing human-technology interaction with PVIs

Figure 49: Human analogy and Role-play research with PVI

1. In this co-creative session, PVI participant plays the role of a payment console and I play the role as a visually impaired customer.

2. I showed the participant my room and he selected a spot in my room as the payment console.

3. I put a blinder over my eyes to mimic visual impairment. The participant is responsible for guiding the designer towards the payment console.

4. The participant is responsible for giving none-visual instructions to help the designer complete the payment.

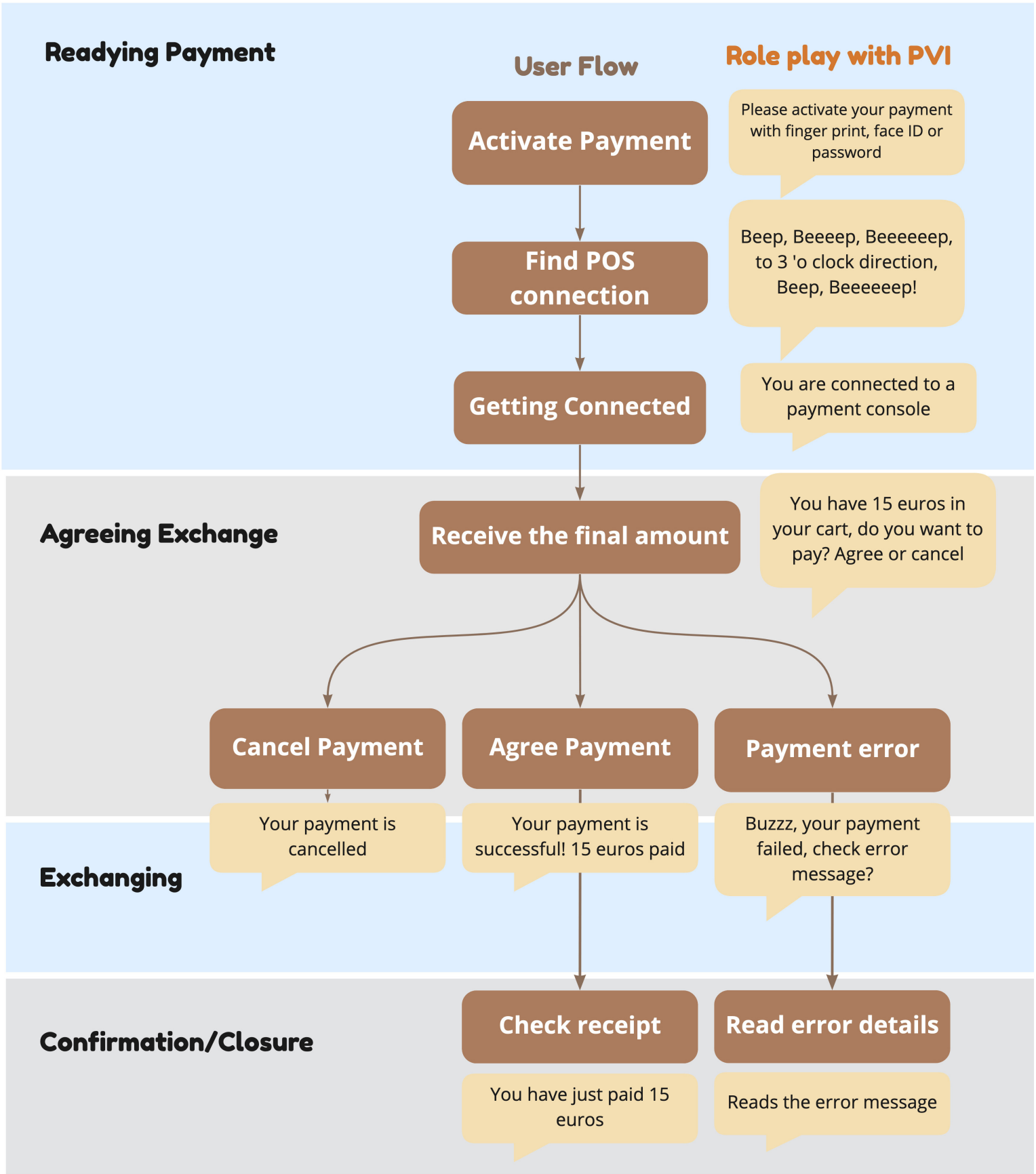


Figure 48: User flow of human analogy results with PVI

4.4.3. Validating with PVIs

To validate the results before prototyping, I narrated the user flow to two other PVIs with different levels of vision loss to validate the results of the co-creative session:

Han, 40 years old, male, blind:

“No App can solve all problems. Everyone has diverse needs.”

“It’s nice that I can check the final amount before I pay, on my own. Then I don’t have to trust a stranger to read the details for me and risk my privacy”

D, 50 years old, female, blind:

That is a great idea. Both: for the POS and for the ov-scanner. The sound is helpful for the blind people. The light can help the visually impaired who are not totally blind. Some of them do not like to attract attention. Sound will attract attention from other travelers. I do not mind if others notice me, so for me the sound would be extremely helpful. And if you mind the sound you can choose to use your headphones (like AirPods). Vibration would also be nice.

If I must give my top 3 of your options, it would be: 1. Sound 2. Vibrations 3. Light

This is because I do not see light anymore. I would prefer sound above vibrations, because you must hold your phone in your hand to feel the vibrations. I like to have one hand free while walking. On one hand I have my white cane or the harness of my guide dog. With my free hand I can use my ov-card or use it for feeling around me. When I walk with my guide dog, in my second hand I have my small white cane. You can hear the sound when your phone is in your pocket or purse.”

4.5 Design for a Positive Payment Experience

4.5.1. Capture positive emotions

Disability is a social and emotional experience. Previous sections in this chapter discussed how to remedy utilitarian mismatches between PVIs' capability and the payment system. However, it needs to go beyond the functional level of exclusion. The design remedy should also enhance PVIs' life experience and societal resilience beyond physical adaptation (Boess, 2018).

The Microsoft Inclusive Design Toolkit (2015) also encourages designers to understand the emotional context of people with disability. To learn from their experience of joyful and frustrating moments.

In this section, I use the "positive emotion capture card" by Desmet (2022) to understand what brings PVIs positive feelings in their daily life. I invited some PVI participants to share with us moments in their life when they feel "confident and in control of their tasks". Together we fill out the positive emotion capture cards.

For each emotion captured, I first ask "what" question to understand the event. Secondly, I ask a "how" question to learn how they feel about the event. Lastly, I use a "why" question to reflect on why this event makes them feel empowered.

Figure 50: Positive emotion capture card from course manual of Pieter Desmet (2022)

Emotion	What	How
Assured Welcomed Respected	 STOP button on a bus with braille	*"I feel assured, I know this is something I can trust even though I don't know braille"* **Why** *"The designer took into consideration of PVIs' needs. It is something specifically designed help PVIs access information. I know I am welcomed on this bus"*

Emotion	What	How
Competent Safe Respected	*"I like it when people give me detailed, step by step explanations and leave the choice to me. Before my visual impairment, I probably would think they are treating me like a kid, but now I am happy that I can hear all the detailed information."*	*"I feel respected, I know they are not judging me for my disability, try to help me understand the context instead of do things for me"* **Why** *"I want to be independent in my decision making, I don't want others to do it for me"*

Emotion	What	How
Confident Safe Assured	*"I feel relaxed when I go to the stores in my neighborhood. I've been going there for 10 years. The people there know what kind of help I need and they are willing to help me."*	*"I feel confident. I know I am safe there. It's almost a personalized experience because we know each other well?"* **Why** *"I want to be relaxed in my daily tasks like grocery shopping."*

Figure 51: Positive emotion capture results

4.5.2. How do positive emotions inform design

From the interview, I summarized three themes from PVIs' experience that makes them feel safe, in control and confident.

From the positive emotion capture activity with PVIs, we agreed that the design intervention should reflect the following qualities to empower PVIs in their payment experience.

Safe: PVIs feel safe and reassured when they are at familiar places or accompanied by people whom they trust: family, friends and caretakers. Knowing that they are in a risk-free context, or understand they can depend on someone if things go wrong makes PVIs fee reassured.

PVIs also feel they are less likely to be judged by their disability when they are with people who understands their needs.

Respected: When accessible cues are provided, it will not help PVIs with their tasks, but also make them feel respected and welcomed because they realized their needs were taken into consideration. They feel that the object or place is designed for them.

Competent: When PVIs ask a sighted person for help, what they are asked for is to be given guidance and information, instead of having someone making the decision for them. The help should engage PVI in the decision making process and treat them equally. Therefore, it's important to provide them with adquate information and guidance instead of making decisions for them.

4.7 Assistive Tools for PVIs

This section discusses some of the popular assistive mobile devices designed for PVIs. By learning about their pros and cons from users, I aim to reflect these preferences in the prototype. There are three types:

(1) Help PVIs recognize the environment around them: Envision Glasses, AI Reader

(2) Help PVIs to interact with touch screens: Hable One and headphones

(3) Built-in smartphone accessibility features

AI Readers

One PVI complained about the sound quality of the AI reader: “It does not feel very natural. Sometimes it’s embarassing to use such assistive device in public” Moreover, the scanning feature require users to point at the scanned object or text at certain angles. Bad lighting can also result in recognition error. These precise interactions can be challenging for PVIs.

Figure 52: AI scanner and reader App for PVI

Portable Braille Keyboard

Hable One is a small sized handheld keyboard to help PVI navigate and type on their smartphones. It has six tactile buttons with two additional function keys for typing.

PVIs can connect Hable One with smartphones via Bluetooth. Together with a pair of headphones, PVIs can type while keeping their smartphones in the pocket. The downside of this device is that PVIs have to carry it along with their smartphone. It also takes users a little time to get used to.

Figure 53: Hable One

Be My Eyes App

Bemyeyes is an App that supports anonymous help call for PVIs. The App helps PVis by allowing them to call a sighted stranger registered on the App when they need help. However, this does not apply to the context of payment, because PVIs do not want a stranger from the Internet to look over their bank details. The concern here is not that they cannot find help, when it comes to payment, a sighted stranger from the store is probably more reachable than people from the internet.

From the App Store reviews, most people reported to have helped PVIs with reading labels and picking clothes, which are tasks that do not involve personal information

Figure 54: Be My Eyes App

Accessibility features on smartphones

Many PVIs use their smartphones' built-in accessibility features to access website, Apps, texts and other digital services. Smartphone accessibility features have greatly improved PVIs' digital experience and allowed them to access a lot of online services. PVIs use smartphone frequently to read news, text people and look up directions like sighted people do. As mainstream devices, smarphones can also enhance PVIs' independence without the social stigma of specialized devices (Shinohara & Wobbrock, 2011). Smartphones' operating systems have accessibility features that can help PVIs. Both ios and Android allow users to turn on screen readers and enlarge screen displays. During the interviews, most the PVIs are very positive about smartphones.

Figure 55: Screen Curtain
With voice-over, PVIs can black out their screen to protect their privacy.

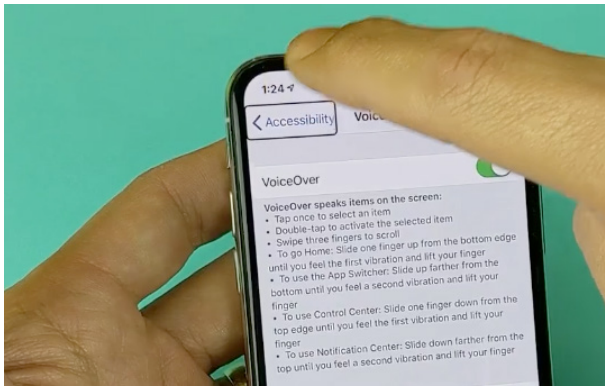


Figure 56: Voice-over
Voice over is the most popular accessiblity feature for PVIs. When turned on, users can hover their fingers over the scree and the voice reader will read each item. User can double tap anywhere to confirm select the button they want to tap.

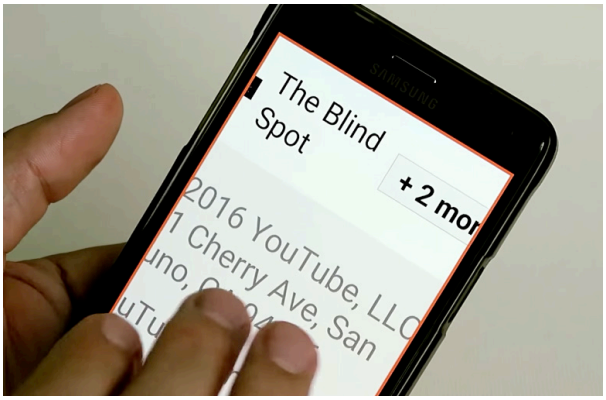


Figure 57: Screen Magnifier
PVIs can tap with three fingers to zoom in on their screen to increase readability.

4.8 Conclusions

In this chapter, I used co-creative workshops with ING colleagues to find a sweet spot between mismatches in PVIs' moneywork and ING's service domain. From the workshop, we decided to use mobile payment to improve the at-transaction phase in PVIs' moneywork with three design goals:

1. Give PVIs more time and directions for readying and agreeing payment

2. Access the final amount before exchanging

3. Create same level of experience for both sighted people and PVIs

After confirming these three design goals, I used the "human analogy" activity from the Microsoft Inclusive Design Toolkit to co-design with PVIs for a new user flow. Here are some results from the co-creative sessions:

1. Use the smart phone as a radar and guide PVIs to establish connection to the POS machine with audio and haptic.

2. Allow them to use screen reader and screen magnifier to access the final amount on their smartphone.

3. Allow them to access detailed information like error message on their phone

Inclusivity does not only stay on the functional level, but also address social interactions and emotion aspects of an experience. To have a sense of control over their paymentnmnn, PVIs need to feel **safe, respected** and **competent** to pay. To achieve this goal, the design intervention need to afford familar interactions, accessible cues, and allow PVIs to have full autonomy during their payment.

In the next phase,Iwill make prototypes and test with PVIs to evaluate whether the design intervention achieves the design goals and affords the desired interaction attributes.

Prototyping

5.1 Prototype Goals

This chapter presents the prototyping goals, process and results. In Chapter three, I identify the mismatches in PVIs moneywork, and learned how these mismatches cause exclusion during PVIs' payment. In Chapter four, I organized co-creative sessions with PVIs and payment experts from ING to decide a design direction. I decided to improve the mobile payment experience for PVIs, because it creates the most design opportunities for both ING and PVIs. Then I brainstormed with PVIs for the interaction flow of a mobile payment with the followign goals:

1. Give PVIs more time and directions for readying and agreeing payment

The current interaction leaves PVIs very little time to ready and agree their payment. We need to provide PVIs with more time and information for them to get ready for their payment

2. Access the final amount before exchanging

The current interaction leaves PVIs very little time to ready and agree their payment. We need to provide PVIs with more time and information for them to get ready for their payment

3. Create same level of experience for both sighted people and PVIs

Allow PVIs to have equal access to payment and information as sighted people. Bridge the communication gaps by offering both groups the same payment expe-rience.

Moreover, we want the participant to feel **safe, respected and competent** with their payment when completing simulated payment tasks with the prototype.

5.1.1. Evaluation tool

The Interaction Profile

In this chapter, I use prototypes to evaluate and test the **accessibility and desirability** of the design concepts.

To evaluate the accessibility, I observe if PVI participants get adequate information in each step to complete their payment task. I examine if the App provides PVIs with accessible cues and feedback in forms of visual display, sound and vibration.

For desirability, I use the **interaction profile** from research of Lenz et al. (2013) to analyze how participants perceive the afforded interaction qualities. PVIs' interaction with the payment system is not only about user interfaces, but also embodiement interactions. Our physical bodies play a central role in shaping human experience in the world, understanding of the world, and interactions in the world. (Klemmer et al., 2006). I want the positive emotions discussed in section 4.5 to be reflected in our design interventions. Thus, I use the interaction profile to evaluate the interaction aesthetics perceived by PVIs.

The interaction profile contains a set of 11 interaction vocabularies to help participants describe their experience. Participants are invited to reflect on the interaction quality of each prototype and use the interaction profile to identify desirable and undesirable interaction attributes.

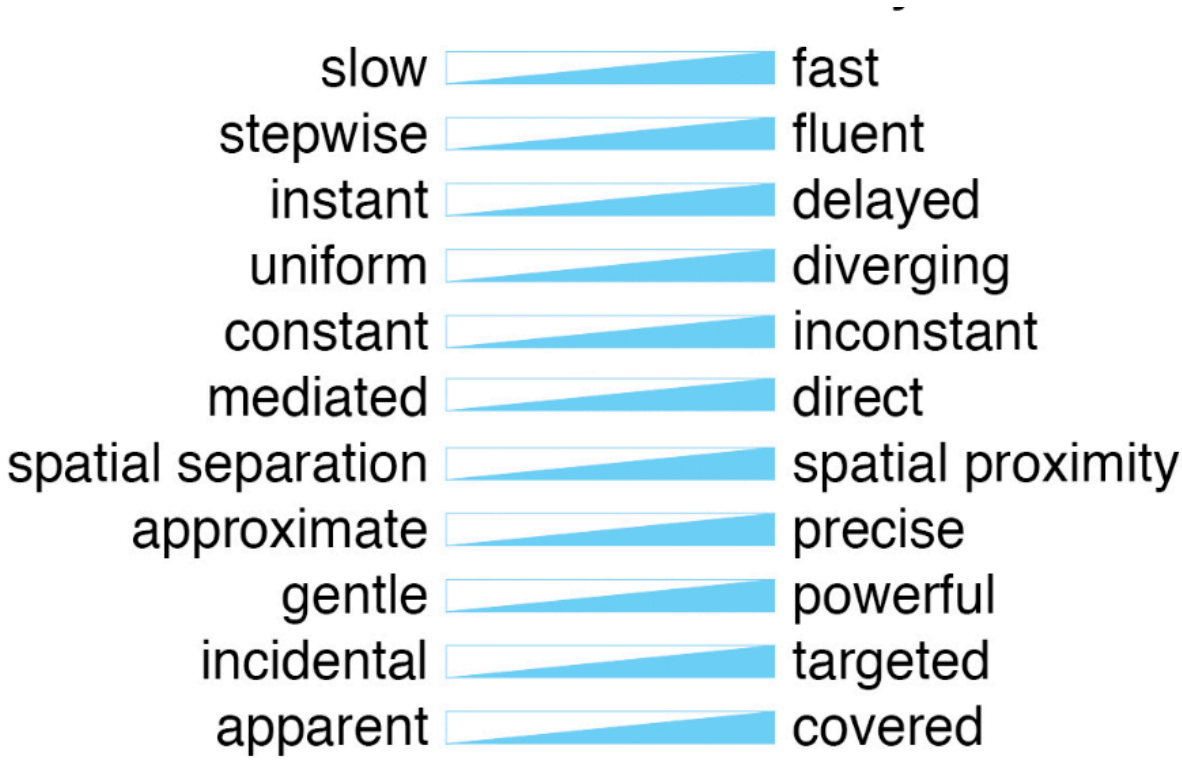


Figure 58: The Interaction Profile

5.1.2 Ideal interaction profile

After the user test, participants were invited to share their experience with the prototype by verbally filling out the interaction profile. In addition, they were also invited to reflect on their other payment experience and create an interaction profile for it. Together we reflect on the difference between the two interaction profiles and learn about participants' preference on payment interactions.

In figure 68, I created an ideal interaction profile with PVIs. I use this ideal interaction profile to compare with the interaction profile of each prototype. During itiration, I try to fix the attributes that do not fit with the ideal interaction profile.

Slow - Fast:

Participants prefer to have the payment to be fast. They do not want to spend too much time on paying.

Stepwise - Fluent:

The payment should feel fluent. Too many steps will make the process lengthy and complicated.

Instant - Delayed

The interaction should be instant, "feels like joining forces with the device." "the phone understands the user" (Lenz et al., 2013)

Uniform - Diverging

Uniform interaction is intuitive and provides a feeling of being in control. Diverging makes people feel uncertain about the consequence of their actions.

Constant - Inconstant

Uniform interaction is intuitive and provides a feeling of being in control. Diverging makes people feel uncertain about the consequence of their actions.

Mediated - Direct

The interaction should feel directed. Participants want to feel a direct connection with the POS machine when they pay

Separation - Spatial Proximity

Spatial proximate interaction creates an awareness of the ongoing process and details. It creates a feeling of security. (Lenz et al., 2013) These are preferred feelings for PVIs' payment.

Approximate - Precise

The interaction should be approximate because precise gestures can be challenging for PVIs during a quick payment. (e.g. input PIN or tap buttons)

Incident - Targeted

The payment interaction should feel targeted instead of incident. Targeted interactions are considered more trust worthy and worth attention

Gentle - Powerful

Gentle interaction express caring and appreciation, PVIs want to feel these attributes during their interaction with the POS

Apparent - Covered

Payment should feel apparent. Apparent interactions make users feel competent to figure out the functionality of a system. (Lenz et al., 2013)

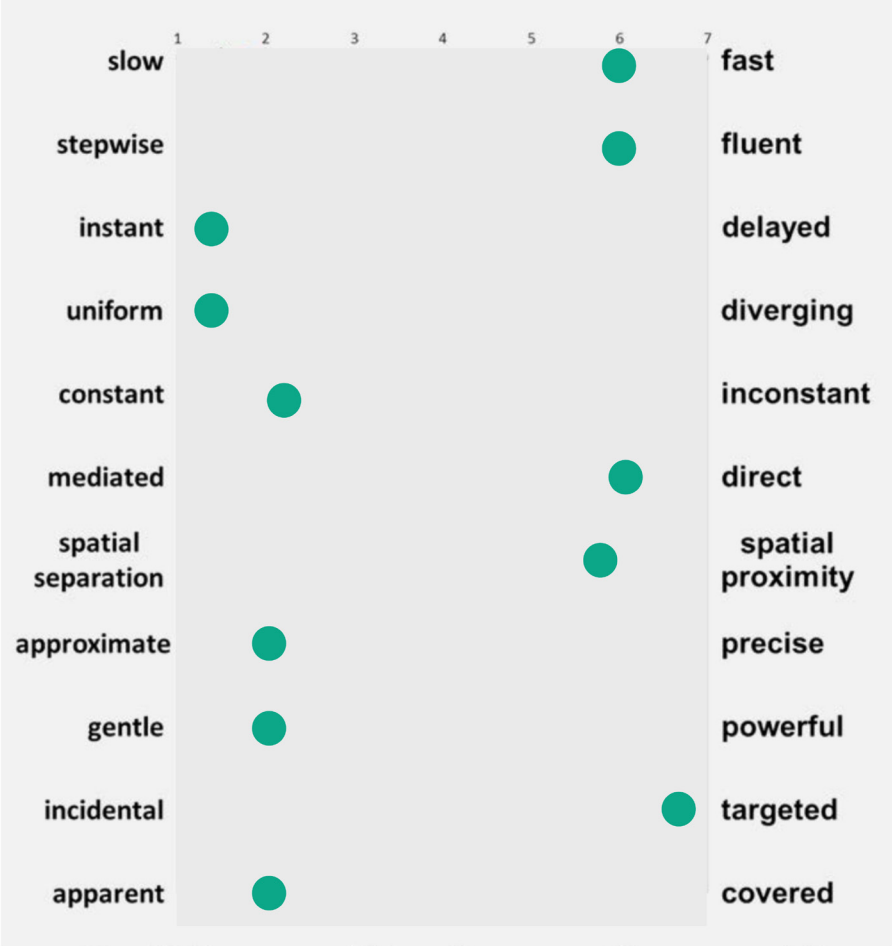


Figure 68: Ideal interaction profile

5.2 Prototyping

5.2.1. Prototype 1

The first prototype consists two parts: An arduino distance sensor and buzzer for detecting the POS and a UI prototype in Protopie that supports voice interactions. When the arduino detects an object within five meters, it triggers the UI prototype and give voice instructions to the user. The arduino board is glued to the back of a smartphone for testing.

This prototype aims to rendor a “blue-tooth” payment exprience that allows user to pay from a distance. When connected to the POS, PVIs can send the payment directly from their smartphone. To simulate the event, I use an arduino distance sensor and a UI prototype with voice interactions built with Figma and Protopie. The voice interaction in this prototype is based on the outcomes of 4.2.2. - Human analogy role play with PVI

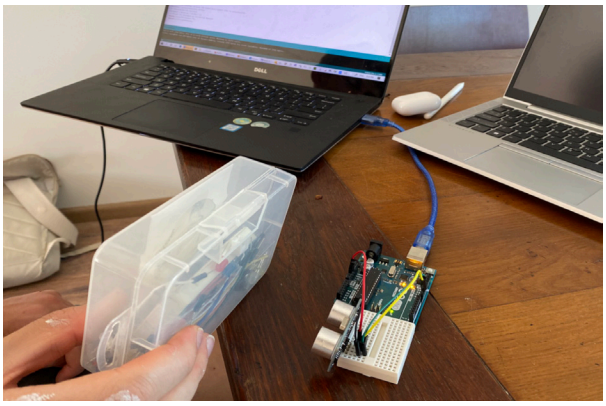


Figure 59: Arduino Prototype

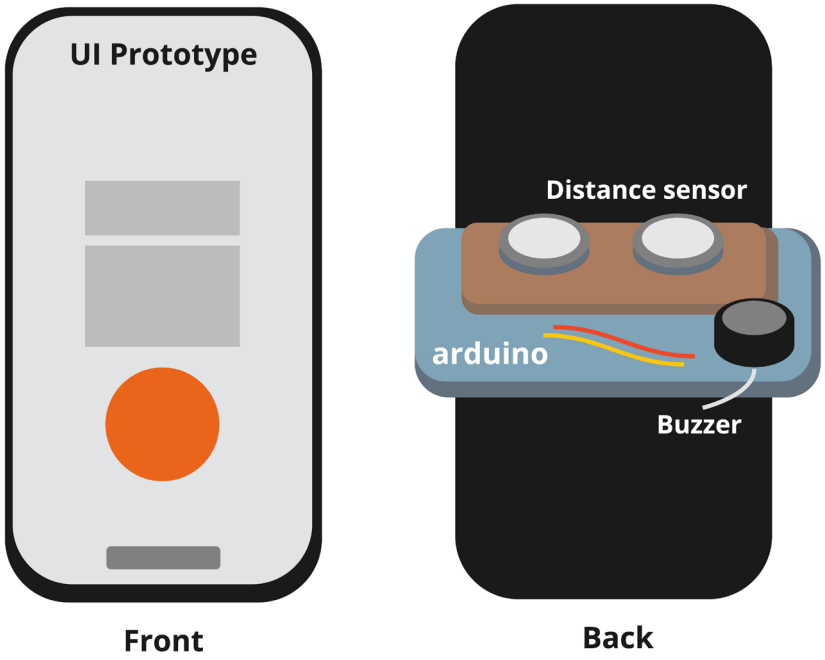
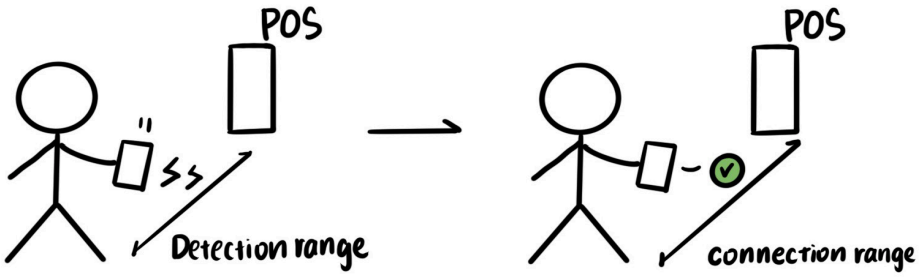


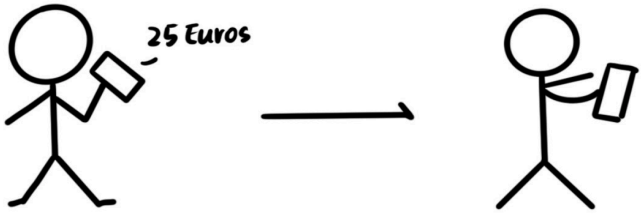
Figure 60: Prototype

5.2.2 Prototype user flow

Guide user to the POS machine

Confirm connection once user is within the connection range

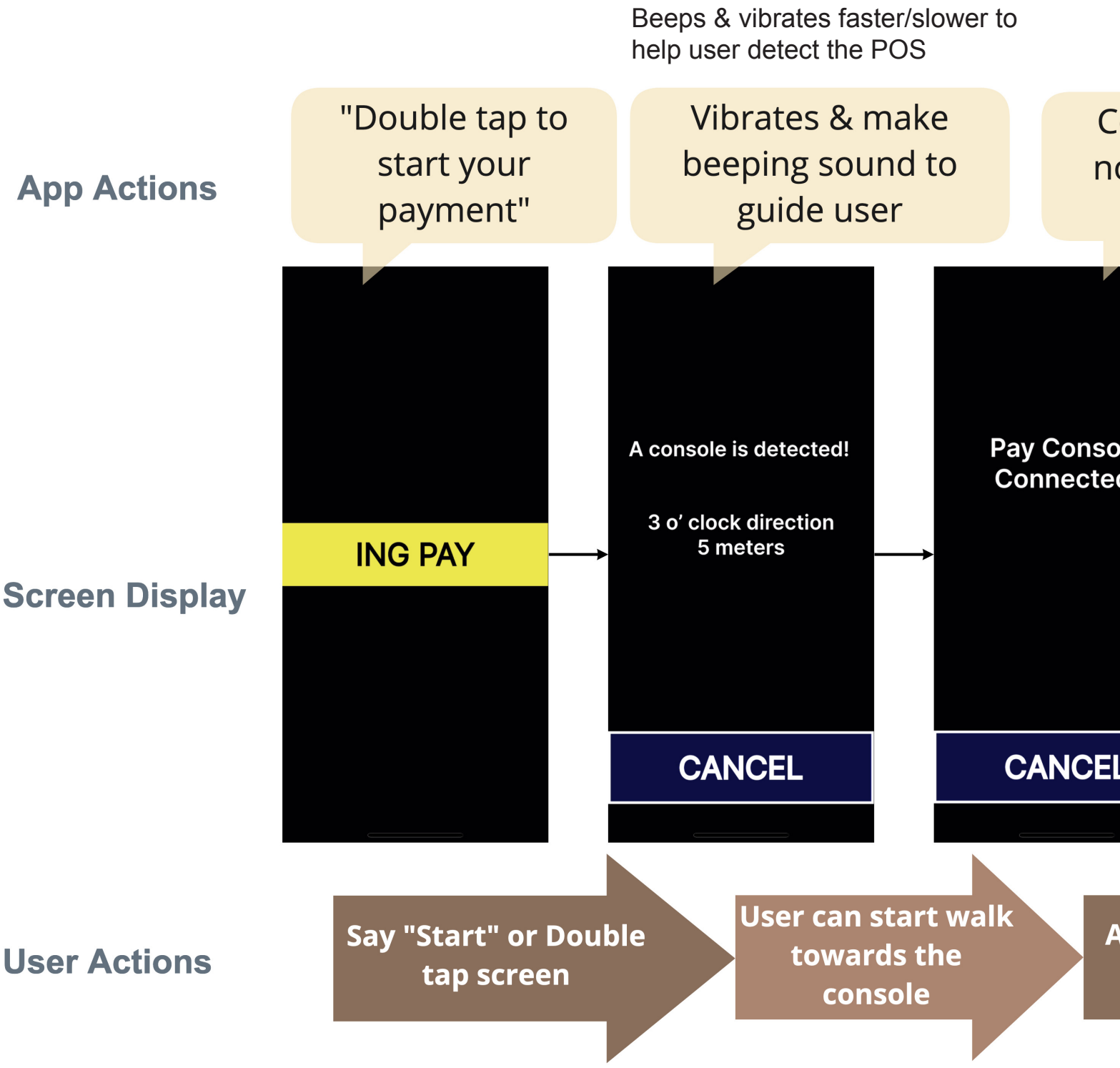




Allow users to hear or read payment details on their phones

User confirms payment or read more details on their phones

Figure 61: Pilot test settings


Beeps & vibrates faster/slower to help user detect the POS
App Actions
"Double tap to start your payment"
Vibrates & make beeping sound to guide user
Screen Display
ING PAY
A console is detected!
3 o' clock direction
5 meters
CANCEL
Pay Conso
Connecte
CANCEL
User Actions
Say "Start" or Double tap screen
User can start walk towards the console

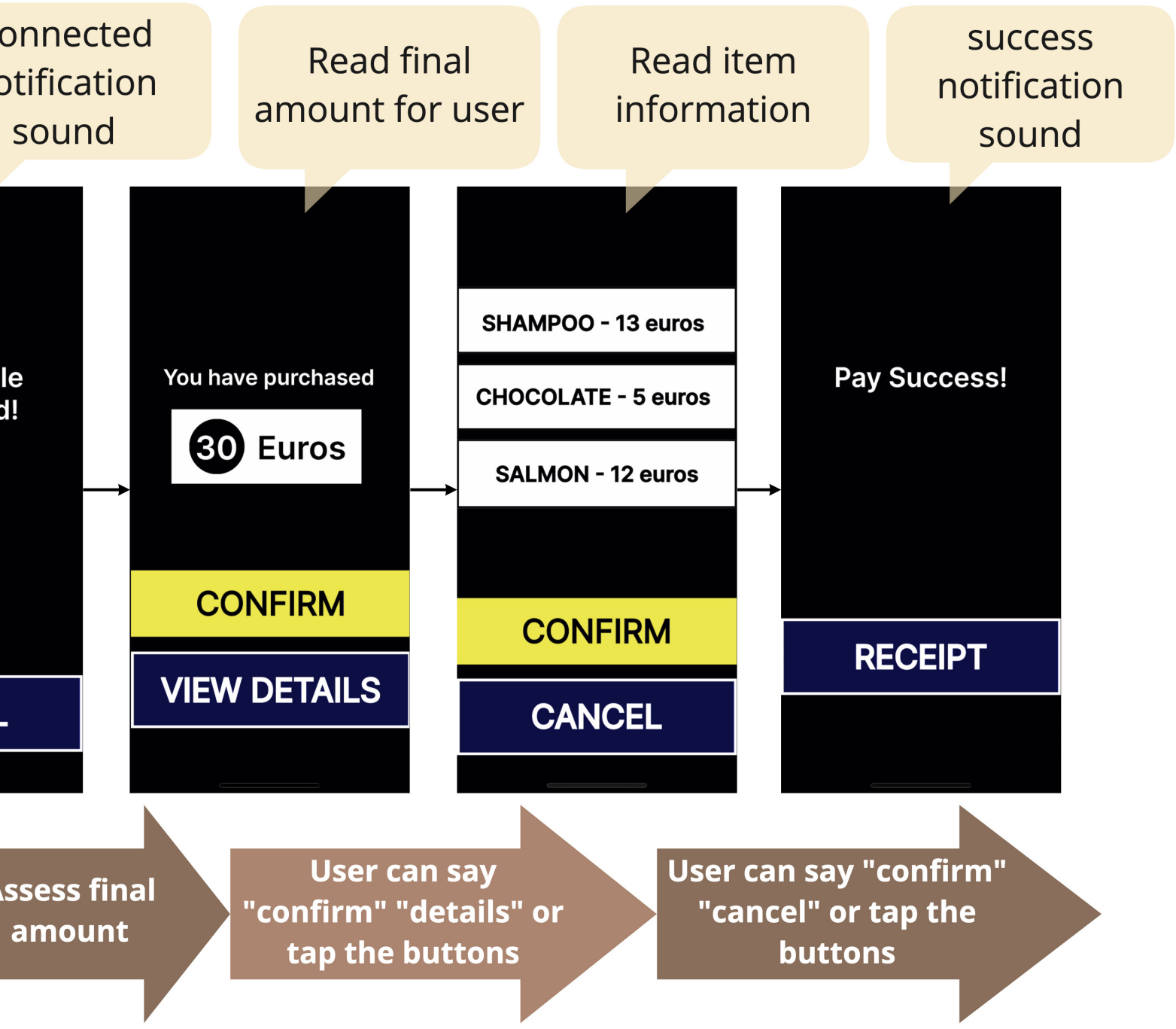


Figure 62: User flow and UI interface of the first prototype

5.2.3 Pilot test

Before the user test, two pilot tests were conducted to test if the prototype can convey the intended interaction experience to users. Two IDE students were invited to join the pilot test with their eyes covered. They were briefed about the context and asked to complete a payment task with the given prototype.

Figure 63: Pilot test

Comments from Pilot Test

“I am not sure what I am holding - the electronics are quite distracting. I am afraid to break it.”

“The beeping sound from the buzzer is very loud, it makes me feel alert.

it makes me think I did something wrong or I was about to bump into something. ”

“The voice interaction is pretty straightforward, but I am not sure if I want to talk to my phone in public”

Adjustments after Pilot Test

After the Pilot test, I decided the arduino parts are too distracting. In addition, the buzzer makes such an alerting sound that confuses the user.

After consulting prototyping experts from the StudioLab of IDE. I decided to get rid of the Arduino parts. Instead, I built a prototype using Protopie that can be remotely controlled with a bluetooth keyboard. (Fig. 64)

5.3 First User Test

5.3.1. Test settings

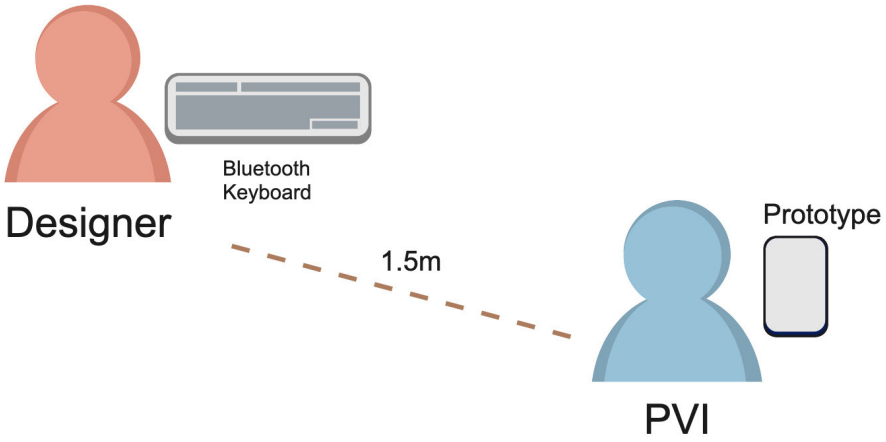


Figure 64: New test settings

Three participants with different visual disabilities joined our user test. All tests were done at a public space with background noise and passerbys to best simulate a store setting.

The UI prototype is controlled remotely with a bluetooth keyboard. Before test started, PVIs were briefed about their tasks. I stood away from the PVI and let them complete the task independently

	Age	Gender	Vision	Timing	Aid	Device	Pay with
P1	30-35	Female	Blind	Birth	White cane, voice-over	iPhone	Contactless card
P2	25-30	Female	Low vision	Childhood	Screen magnifier, sunglasses, high contrast display	Android	Contactless Card
P3	55-60	Male	Low vision	unknown	White cane, guide dog, voice-over	iPhone	Apple pay on Apple Watch

Figure 65: Participant overview

5.3.2 First prototype evaluation results

During the user tests, two interaction profiles were filled. By comparing the interaction profiles with the ideal profile, I see some mismatched attributes.

Stepwise - Fluent:

The voice instruction is too slow for participants, they would like to speed up the payment

Instant - Delayed

In the first prototype, PVIs must follow the voice instructions. While this is accessible, participants think there are too many steps

Uniform - Diverging

participants find it too lengthy and unpredictable to wait for the voice instructions.

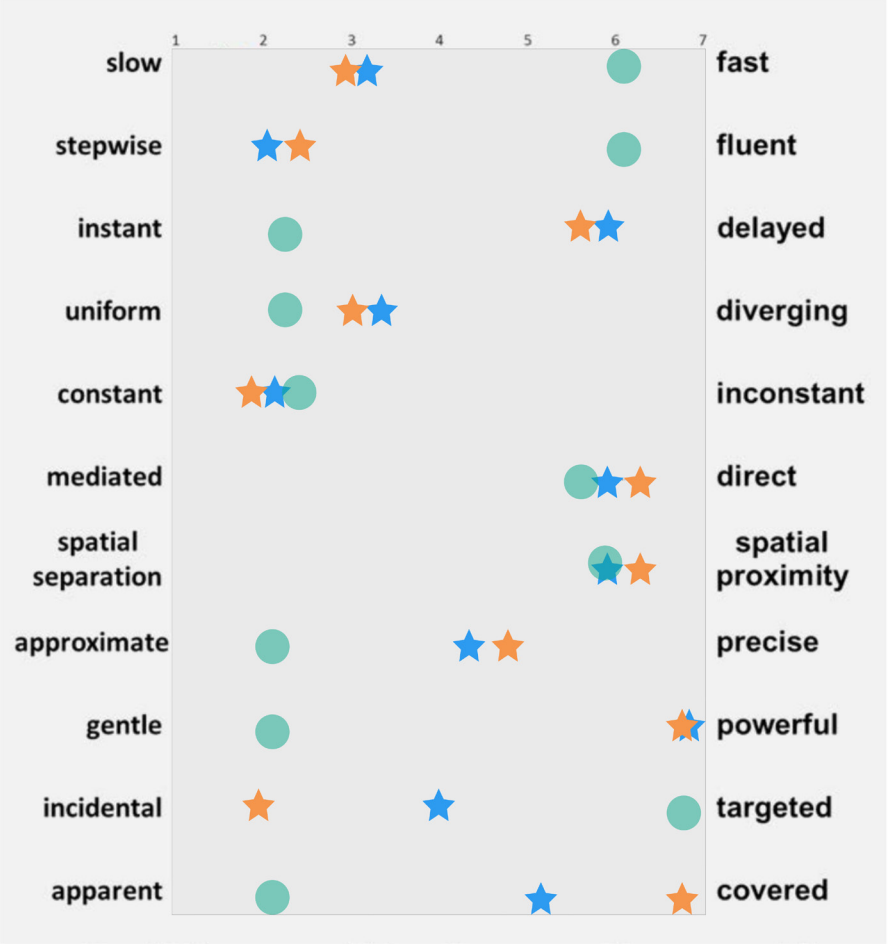


Figure 69: First prototype vs. Ideal interaction profile

Approximate - Precise

PVis like the fact they don't need to do precise interactions with the POS machine. But following voice instruction requires a lot of attention

Powerful - Gentle:

One participant find it too lengthy to wait for voice instructions, but overall

Incidental - Targeted:

PVIs relect the goal of payment is quite targed, but the voice instructions sometimes glitched or played too slow. Making Participants feel unpredictable.

Apparent - Covered:

With step-by-step voice instructions, PVIs cannot get an overview of the payment flow

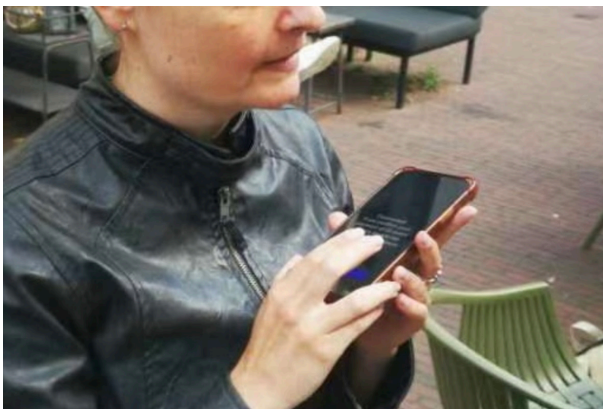


Figure 66: Participant hovering her finger over the screen for an overview of the interface. When the prototype did not trigger the screen reader, she was confused.

5.3.3. Insights

Participants questioned the usefulness of the navigation feature. Although it sucessful leads PVIs to the POS machine, it doesn't help them to avoid obstacles. However, participants think this feature will be helpful when they are already at the counter.

The voice directions are accessible. PVIs are able to follow the instructions and complete the payment. However, it did not afford participants with the positive emotions as intended. The voice interaction was not familiar for participants, which makes them feel less safe and competent with the interactions.

Figure 67: Participant expressed skeptical attitude towards the "pay from a distance" feature

5.3.4. Comments from ING

I presented the first prototype to payment experts from ING. From the discussion, I learnt that although smartphones are equipped with chips that connects with external consoles, is still quite difficult to make a precise navigation feature out of. The feature is also out of the design and development scope of an ING App.

ATM & POS machine expert from ING confirms that users must make a tap to the POS machine to receive the final amount. Sending the final amount directly from a payment console to a smartphone is not yet possible at the moment.

Interview with ING Brand Team

ING brand experts commented about the graphic design of the prototype: “It is nice to make it accessible to people with visual impairment. But the colors might not be so pleasing for other customers. Is there a way to improve the graphic design in a way that it satisfies both the sighted and visually impaired?”

5.3.4. Next Steps

Based on comments from users and ING tech experts, I decided to add a step in the user flow that requires user to make a tap on the machine for the following reasons:

1. Technology feasibility. Payment details cannot be pushed to the user's personal device remotely via bluetooth or airdrop.

2. From user testing, sending payment from a distance is perceived as unsafe among participants.

Moreover, in the second prototype, I removed the current voice-interaction because participants reported they do not want to talk to a smartphone in public. The noise makes it difficult to talk back at the smartphone. From user test, I notice PVIs are more familiar with using screen reader to access contents on their screen. Thus, in the second prototype, I use Protopie to simulated a screen-reader experience to embrace more familiarity in PVIs’ interaction.

5.4 Second Prototype

5.4.1. Pilot test

Figure 70: Pilot testing for second prototype

For the second prototype, I tested with one sighted person with an sleep blinder. The participant tested the prototype twice, with his eyes covered and uncovered.

I did a small role-play session in the context of a cafe. The participant was invited to imagine he was trying to pay for his coffee at a cafe. He was previously taught how to use the screen reader.

As a sighted person, it took the participant a while to get used to the screen reader. He also cheated a little because he remembered where the buttons are.

The participant interacted very well with the vibration and sound guidance when he was trying to establish connection to the POS machine. However, when participant tested the prototype with his eyes open, he pointed out that the GUI is a little boring compared to the audio & vibration cues. “It does not react to me”. Thus, I added responsive graphic element to the GUI design.

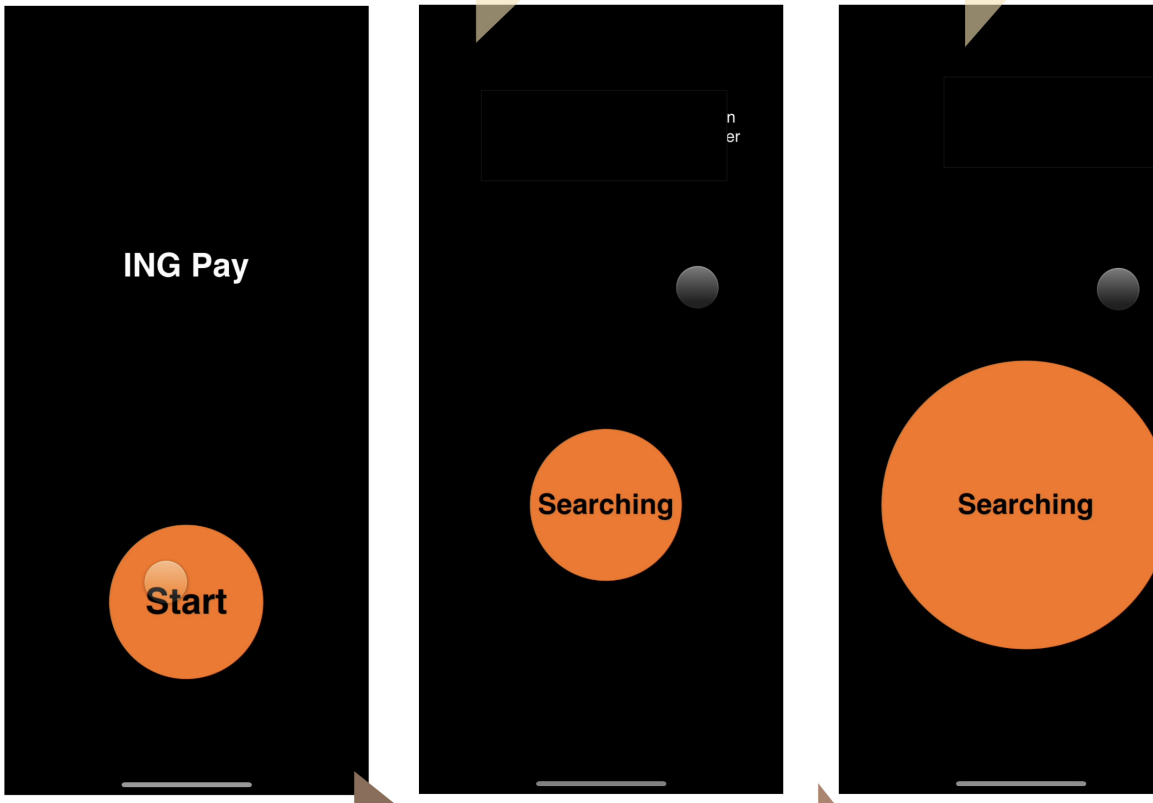
Beeps & vibrates
help user detect

App Actions

Vibrates & make beeping sound to guide user

Graphic exp
as user ge
closer to P

Screen Display



User Actions

Use voice over to read the interface and double tap to start payment (Single tap to identify button and double tap

Locate the POS machine following sound guidance

Tap smartph
POS mach

PVI stands at the counter, with ING App opened

PVI starts moving smartphone towards the POS to establish connection

Connection establis
payment detail pus
to PVI's smartphon

This part is confusing in the current payment flow

faster/slower to
the POS

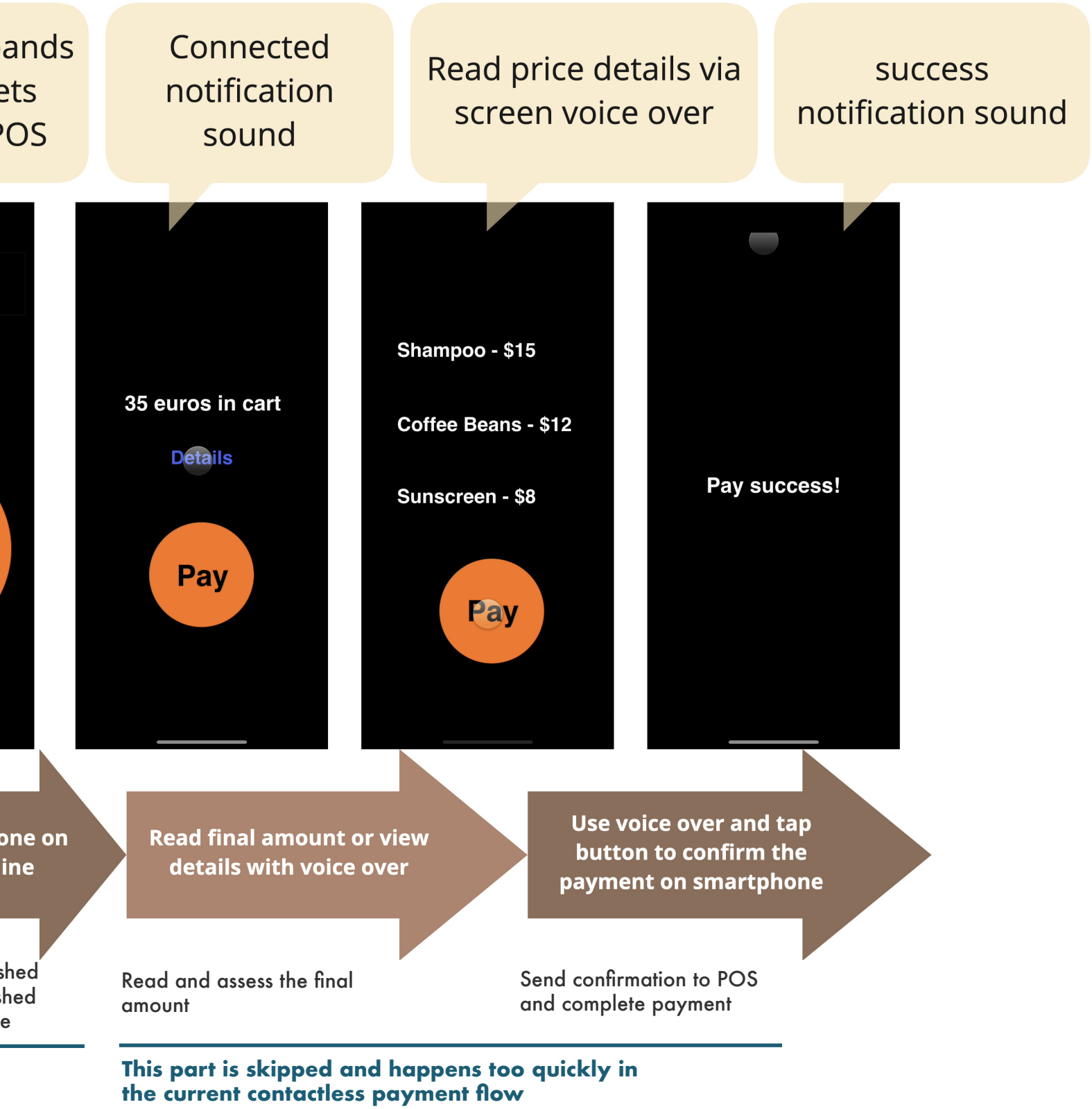


Figure 71: User flow of the second prototype

5.5 Second User Test

5.5.2 User test activities

Due to time limit, I was only able to test the second prototype with one participant with low vision. (We had to test the prototype to the Ziezo Beurs Fair on September 30th) This participant does not often use screen readers and can locate the POS machine with her sight.

Although she wasn't able to test all the features of the second prototype, the participant liked the high-contrast display and large font size in the App. She also expressed positive emotions towards the GUI interaction.

The participant was also very positive about the flow. Especially the step that allows her to take time and check the final price directly on her smartphone. The participant currently uses Google Wallet on her android device for her daily payments, which does not show the final amount . She expressed her preference for the prototype during the test.

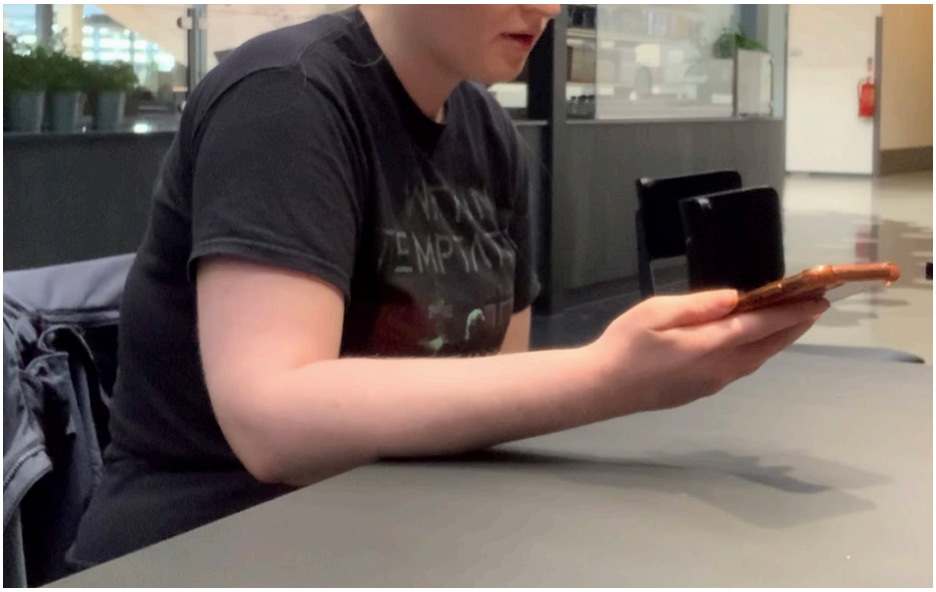


Figure 72: User test for the second prototype

5.5.2 Final concept

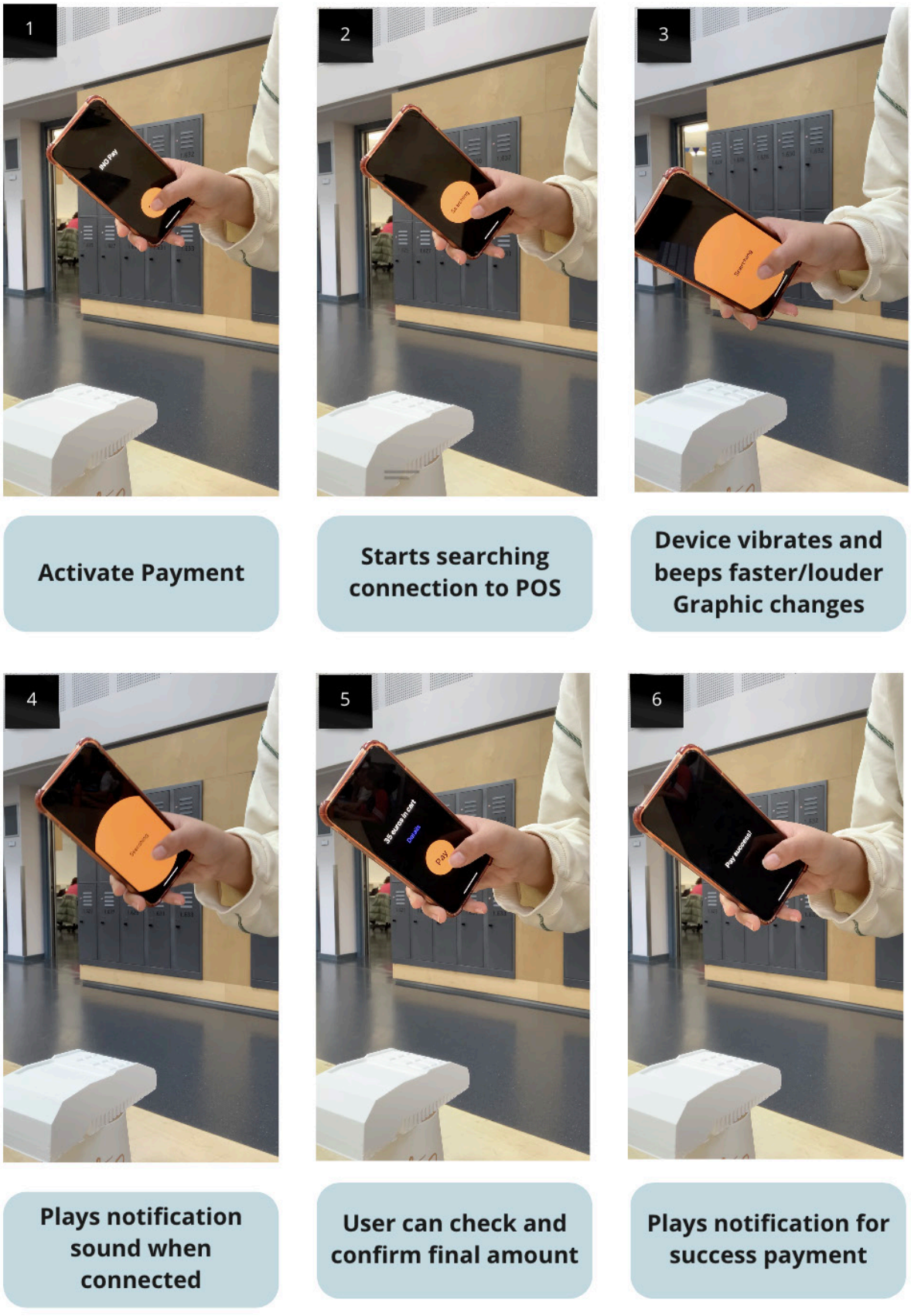
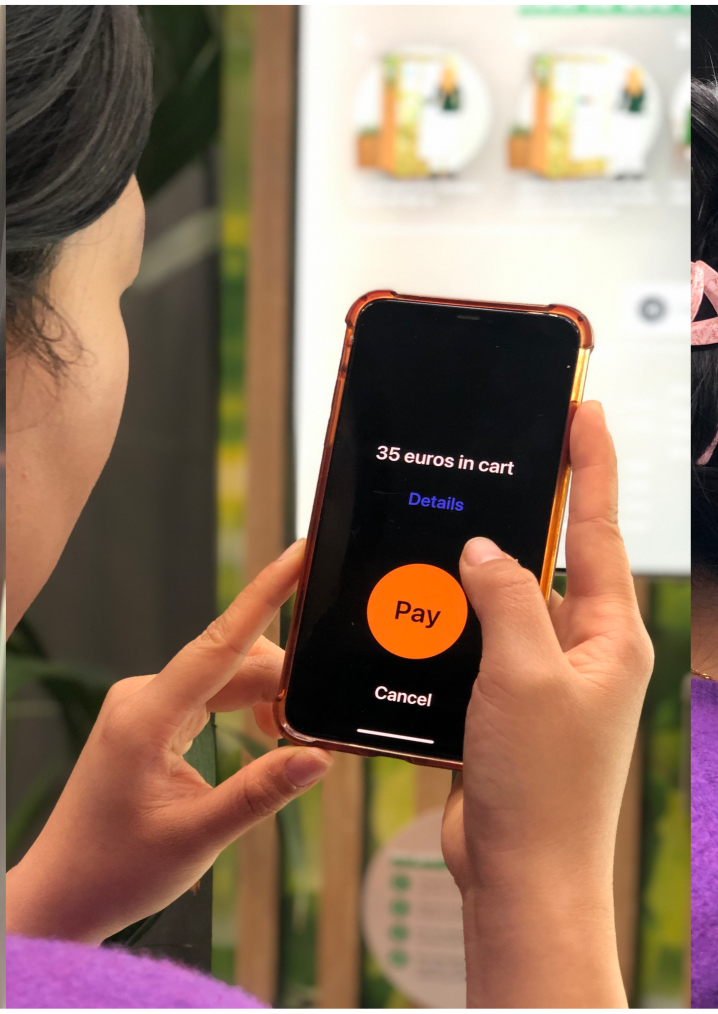


Figure 73: Second prototype demonstration



Finding the POS machine

After logging in, the App changes the beep and vibration frequency to help the user find the POS machine

Read payment details with access

Users can confirm the final amount on thei devices - using accessibility features such reader

sibility features

r mobile
as screen

Confirm payment

Payment confirmed on users' personal device

Figure 74: Second prototype demonstration

Evaluation at Ziezo Beurs


WORLDWIDE Vision
24 RUNNING BLIND

6.1 Final Evaluation

This chapter presents the evaluation results of the final design at Ziezo Beurs 2022, the biggest annual fair for people with visual impairment in the Netherlands. The goal of the final evaluation is to test the desirability and accessibility of a mobile payment interaction for PVIs. The evaluation creteria is the same as in Chapter five.

The accessibility is evaluated by observing whether the PVI participant can independently complete a simulated payment task. Each test is followed up with an interview to evaluate the desirability of the PVI participant. The participant is invited to share their feelings during the payment process.

All PVI participants were randomly selected at the fair, with no previous knowledge about this project. Among all six test, four were successful. One was interrupted and one failed.

For all the successful tests, participants were invited to fill out the interaction profile to validate if the intended emotions were evoked during their payment

	Gender	Age	Vision	Payment	Result
P1	Male	30-40	Low vision, uses voice over on iPhone	Contactless card	Success
P2	Female	30-40	Pointed vision, can see phone screen, uses a cane	Contactless Card	Success
P3	Male	40-50	Blind	Card and PIN	Success
P4	Female	10-15	Blind	N/A	Interrupted
P5	Female	10-15	Blind	Card	Fail
P6	Male	40-50	Low Vision, uses voice over on iPhone	Apple Watch	Success

Figure 75: List of participants for the final evaluation

6.2 Test Activities

Figure 76: Ziezo Beurs 2022 in Utrecht

The evaluation testing activities were spread over two days. On the first day, pilot tests were performed at the fair with PVIs who have previously participated in the research. The goals of the first day tests were to observe the feasibility of conducting evaluation tests at the fair.

The loud crowds at the exhibition space gave PVI participants a hard time hearing the voice instructions from the prototype. Moreover, most PVIs at the fair were busy with visiting all the booths and had very limited time to participate in the evaluation test. Therefore, on the second day, the tests were conducted in the lobby at the exit of the exhibition hall. It is a quieter space where people take a rest after their visit

A total of six PVIs participated in the evaluation test. Four of them were able to successfully complete the payment. These participants do not have previous knowledge about the graduation project and were randomly invited from the lobby.

6.3 Test Procedure

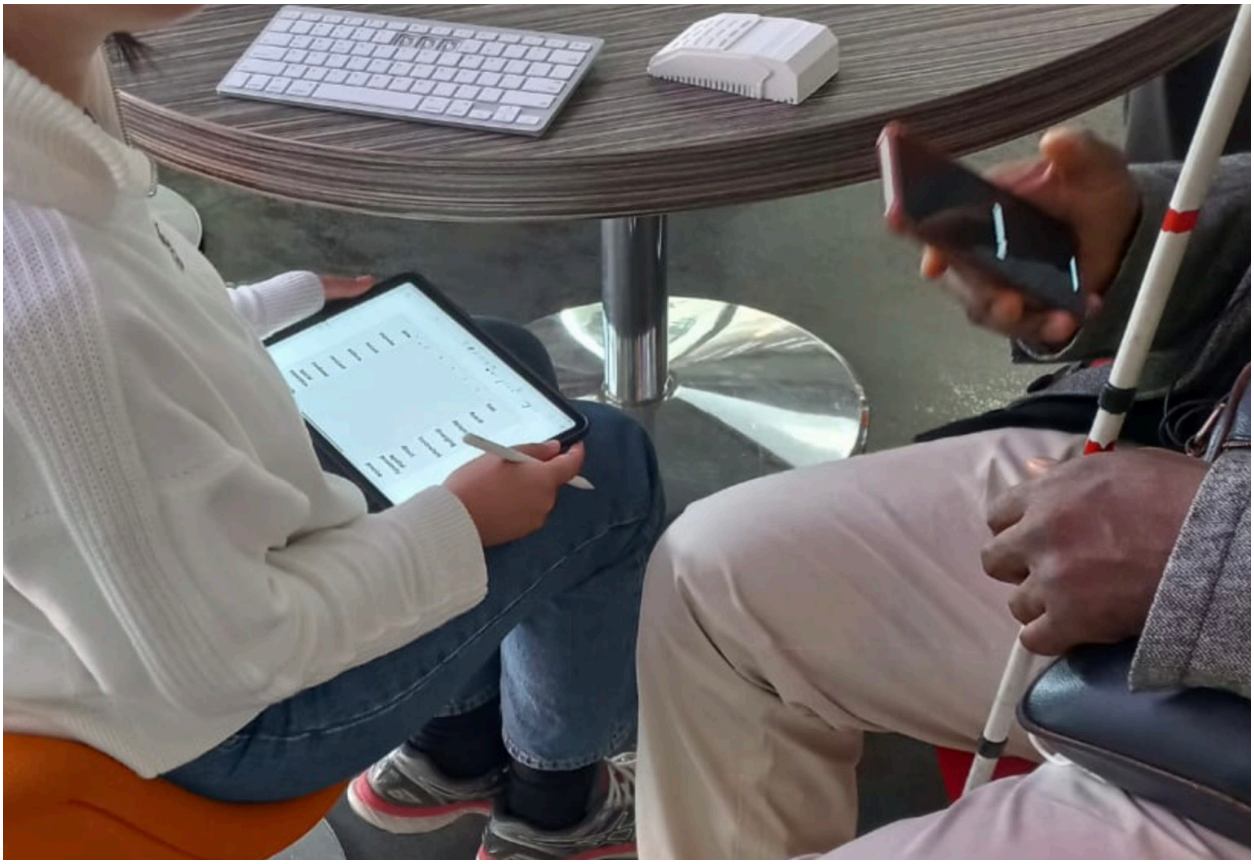
6.3.1 Testing with PVI

Each testing session lasted for about 30 minutes. The PVI participants w invited to sit at a table, where they learned about the content and design goal of the research project. Afterwards, the prototype was handed over to the participant. The participant was asked to imagine he/she is at the check-out counter of a supermarket, where item scanning is done and it is the moment to make a payment.

The accessibility is evaluated by observing whether the PVI participant can independently complete a simulated payment task.

Each test is followed up with an interview to evaluate the desirability of the PVI participant. The participant is invited to share their feelings during the payment process. In addition, the model in Figure x from Chapter 3 is used to analyze the interaction quality of the final design.

Figure 77: Interview users after test at Ziezo Beurs



6.3.2 Testing with PVI's Companions

Figure 78: Participant's wife volunteered to test our prototype after her husband

At the fair, I also tested the prototype with PVIs' sighted companions, they are family, friends and caretakers of PVIs. These sighted participants have extended experience helping PVIs with their daily tasks. Most of these participants voluntarily joined the test and shared their insights

The prototype received surprisingly positive comments from sighted participants. Mostly because they can directly benefit from PVIs' independence. When PVIs can complete payments individually, these sighted participants are also freed from helping with PVIs' payment.

The positive comments from sighted users prove that the benefit of inclusive design projects not only help the disabled, but can also be extended to a much larger population.

The GUI interaction also helped with the collaboration between PVIs and sighted people. At the fair, when a sighted person sees the participant struggling with finding the POS because the graphics is also hovering on the screen, they immediately helped PVIs to find the POS machine.

6.3.3. Test results from Ziezo Beurs

Green dots represent the ideal interaction profile in Figure 68. Overall, the interaction profiles from the user tests fit well with the ideal interaction profile. Proving that the design intervention made PVIs feel safe, respected and competent with their payment.

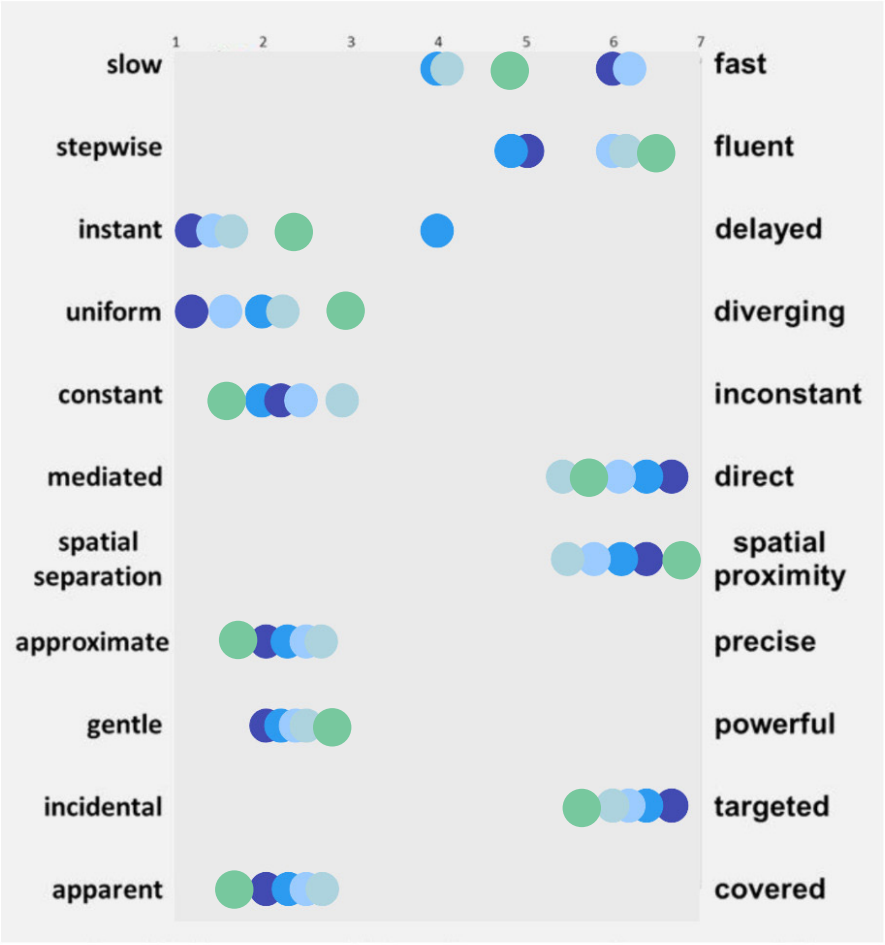


Figure 79: The interaction profile from the evaluation tests turned out to be very unified. The profile has reached the ideal interaction profile from 5.4.1.

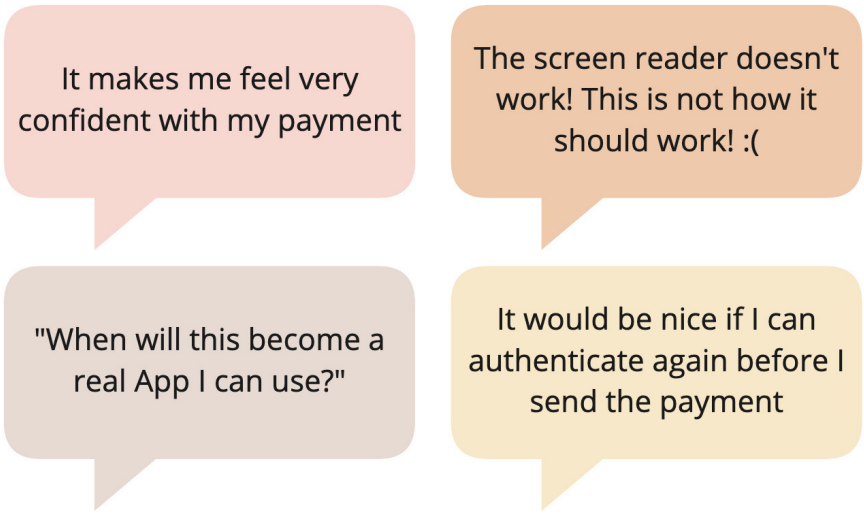


Figure 80: Comments from participants at Ziezo Beurs

5.3.4. Insights from evaluation

Out of six user tests, four participants completed the simulated payment task successfully. One test was interrupted by non-test related factors. One test failed. I generated the following insights from the user tests.

1. Provide diverse tools for accessibility: The loud crowd at the fair gave PVIs a hard time hearing the voice-over, this problem is applicable to stores and supermarkets as well. Most participants said it is not a problem, because they can wear headphones for the screen reader. The vibration also helps in this scenario. This fact proves that a truly inclusive interaction should provide user with diverse cues to complete their tasks in different situations.

2. The user experience of accessibility features: One test failed due to glitches in the prototype. The participant started feeling very frustrated as soon as she realize the voice-over is not working smoothly and refused to proceed. I also notice that young PVIs are less tolerant towards slow and glitchy screen-readers than older PVIs.

Another PVI commented: “This prototype is very nice, but I think I don’t mind paying with the current contactless card for small amounts.”

PVIs have diverse needs and preferences for accessibility features in their daily life. Although the prototype has limited functionality that fails to offer personalized experience to PVIs. It is important to give PVIs the autonomy to adjust accessibility features to meet their personal capabilities and preferences.

3. Privacy Concerns: Some participants expressed their concerns about privacy with mobile payment. However, the afforded interaction in this prototype is perceived as safe and reliable. Some PVIs are concerned that unlocking their phone for payment can expose other data on their device to risks and fraud. This comment informs us that when we provide PVIs with a mobile payment service, we also need to ensure the safety of other content on their smartphone. The advantage of a bank card is that it is an individual item. Paying with a bank card does not give strangers access to other valuable belonging. However, card payment does not afford the rich interaction qualities a mobile device can offer. It would be nice to combine the individuality of a card and the advantages of a mobile payment App. For example, an app can be activated without giving access to other Apps. Or a digital card that can tell PVIs the final payment amount.

6.4 Reception within ING

The concept received the Best CX Improvement Award on ING's Customer Experience Day 2022

Conclusion and Reflection

7.1 Project Conclusions

This graduation project started with three research questions:

1. **What is it like to pay in public as a PVI in the Netherlands?**

2. **How can design remedy the mismatches between current payment infrastructure and PVIs' capability?**

3. **How can we make PVIs feel socially included during their payment?**

Payment involves a series of complex interactions that includes human-machine interactions and social interactions. Nowadays, payment are supposed to be digital, fast and frictionless. However, these attributes often make PVIs feel out of control with their payment. Because the interactions afforded by the system are usually mismatched with PVIs' capabilities and habits. In such context, PVIs' interaction with the POS machine feels like slow dancers who are suddenly forced to dance to fast-paced jazz music. Their steps become hasty and fragmented, leaving them feel embarassed and insecure.

The current payment system often leverages visual perception. Most information is only available in visual forms, thus affords PVIs and sighted people extremely different experiences. PVIs usually receive unreliable and inaccessible help from sighted people because sighted people are usually unaware of these mismatches. Making PVIs feel excluded and unrespected.

After I understood the mismatches in PVIs' payment experience, I organized co-creative sessions with ING to identify an overlapping sweet spot between ING's service domain and PVIs' payment pain-points. In the end, I decided to improve the mobile payment experience for it shows the most potential of improvement for both ING and PVIs.

Another important aspect of this project is to make PVIs feel included during their payment. As a common daily task, payment should be accessible to everyone. I want PVIs to feel safe, competent and respected in this daily interaction. Together with PVIs, I reflected on moments in their life that triggers positive emotions, I extracted the interaction attributes of these triggers and concluded that the concept

should be perceived as familiar, accessible to PVIs. In addition, it should facilitate PVIs' competence in decision making.

Based on these insights, I made prototypes to test the accessibility and desirability of the design intervention that allows PVIs to:

1. Have more time for readying and agreeing payment

2. Access the final amount before exchanging

3. Create same level of experience for both sighted people and PVIs

The final concept was tested and positively receive at Ziezo Beurs by PVIs who have no previous knowledge about this project. It also received the "Best CX Improvement Award" from ING.

7.2 Limitations

Selection of Participants

At the beginnign of this project, I struggled to find PVI participants to join my research activities. Due to language barriers, my participants are mostly Dutch residents who are fluent in English. The fact that I could meet and get in touch also means they have good mobility and are engaged in online and off-line communities. Most of my participants are financially stable and have good technology literacy.

However, I am aware that there are PVIs with more complex disabilities (e.g. deaf-blind, mobility impairment) that are not represented in this research. Living with a disability can also cause lower-income. These PVIs may have different payment preferences than my participants. In future works, it is helpful to research on how PVIs of different financial status and social status react to payment accessibility issues.

Long-term Impacts

During this project, I were only able to test with participants within limited amount of time. When a new product is introduced, it usually takes people a while to get used to it and fully integrate it into their daily life. For people with disability, they might develope new adaptations around the product and establish new social dynamics around it. I were not able to observe these effects due to time and resource limitations.

7.3 Reflection and Suggestion

Designer's role in an Inclusive Design project

This project allows me to explore the role of an inclusive designer in a multiple-stakeholder project. In this project, the designer must constantly communicate and align the interests of PVIs and the service provider. Moreover, when stakeholders from the company cannot participate in the research activities, the designer must effectively communicate the mismatches to the stakeholders and make the right design decisions together.

In this project, the co-creative workshop effectively engaged the stakeholders. By letting the participants experience simulated disabilities, contribute a PVI's perspective and engage in brainstorming activities, participants from the company could quickly start diving into the topic and empathize with users.

Achieving Accessibility is a Joint Effort

Achieving inclusion requires a joint effort from everyone in our society. In this research project, I worked with ING to improve the mobile payment experience for people with visual impairments. However, there is still a lot more to do. We can only achieve accessibility if everyone in this society is engaged in the effort.. As this report shows, the accessibility of Store settings, the awareness of shoppers and cashiers, and the desire for the POS machines play a significant role in PVIs' shopping experience. I was happy to have shared the importance of accessibility with many people during my research process. I hope that more companies, organizations and individuals can become aware of the importance of accessibility and are willing to improve the accessibility of our infrastructure.

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[The End]

For an inclusive future.