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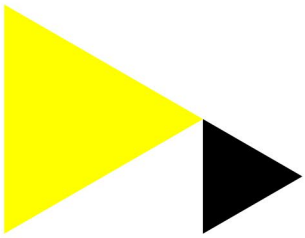

Lessons learned from co-creating a personal wayfinding app with people with a visual impairment

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ABSTRACT *Travelling independently in an urban environment is challenging for people with a visual impairment (PVI). Current Wayfinding-apps lack detailed environmental information and are often not fully accessible. With the aim to design a wayfinding solution that facilitates independent travel and incorporates PVI needs and wishes, we deployed a co-creation design approach with PVI and professionals as co-creators. Our combination of different co-creation techniques and iterative prototyping expands the related research on wayfinding solutions and allowed us to zoom-in on specific features. Our approach started with a user-requirements analysis through self-experience sessions, observations and focus groups. This was followed by iterative prototyping with user evaluations in controlled indoor and outdoor environments. Over a period of two years we created an accessible wayfinding solution in co-creation with 31 PVI and 19 professionals. This resulted in an optimized accessible interface, a personalized route, personalized wayfinding instructions and detailed orientation and environmental information. Lessons learned for co- design with PVI included setting up an accessible workshop environment, applying diverse evaluation methods and involving reoccurring participants.*

Keywords: *co-creation, co-design, visually impaired, assistive technology, wayfinding, navigation, urban space, smartphone*

Introduction

To overcome difficulties with wayfinding, people with a visual impairment (PVI) use wayfinding-apps. Current apps often lack detailed environmental information and are not fully accessible. To design a wayfinding solution that facilitates independent travel, we deployed a co-creation design approach. Our approach built on related research, expanding and combining common techniques, leading to an adapted co-creation approach for PVI. This allowed us to zoom-in on specific features and to create an accessible wayfinding app. This paper presents our iterative design approach and the lessons learned.

Related Research

Earlier research has involved visually impaired users in designing wayfinding solutions. For each phase we describe the user's influence using this method.

Need Analysis

For gathering requirements and generating ideas, techniques as observations, interviews and group discussions have been used.

Atkin et al. (2015) explored limitations and improvements of wayfinding signing with a digital layer through observations. This method allowed for real-time detection of shortcomings. Petrie at al. (1997) gathered user requirements through interviews and group discussion with users and professionals. This approach gave participants the opportunity to express their problems, desires and ideas without having to consider the limitations of the technology.

Prototyping

Williams et al. (2015) explored the design of new navigation technology using workshops. In a small group setting participants and facilitator crafted a new navigation wearable using available hardware components. By changing the material and activity, the sessions gave insight into design considerations that typically do not arise in group discussions or are easily overlooked by designers.

Both the MOBIC system (Petri, 1997) and the Navcog system (Brady, 2015) were explored via Wizard-of-Oz prototype studies. Wizard-of-Oz studies allow the researcher to evaluate the implementation of an idea before the system is fully developed. In these studies, proof-of-concept prototypes are presented to the user as a working solution, when actually the functionality is simulated by a person (wizard).

Brady et al. (2015) combined multiple designs in their prototype evaluation. This allowed them to expand the influence the user can have over a design in one test session. Atkin et al. (2015) evaluated prototypes with PVI and professionals over multiple iterations, allowing the design to evolve. The iterations allowed the user to get familiar with the prototype and influence the design step-by-step. The Navcog app was evaluated in a shopping mall while accompanying the user

(Ahmetovic, 2016). This outside-the-lab, but relative safe environment, allowed for testing while the app was not fully implemented.

User Involvement Activities in Our Study

Designing a wayfinding solution for PVI is challenging due to variations in visual limitations and accompanying symptoms. To incorporate their perspective we involved 31 PVI with various visual impairments and 19 professionals as co-designers. Our co-creation approach started with the context specification and needs analysis followed by iterative prototyping and user evaluations in controlled indoor and outdoor environments.

Phase 1: Context Specification and Need Analysis

Through self-experience sessions, observations of an orientation and mobility training, and a series of focus groups, we specified the context, identified the main problem area's and formulated the user requirements.

To empathize with the PVI's experience, we participated in a wayfinding exercise with special glasses that simulated visual impairments. This self-experience session helped us to understand common problems, fears and frustrations PVI encounter while navigating.

To further empathize with PVI's experience and explore the design space of wayfinding applications, we observed two PVI (male, age 41 and female age 43) during an orientation and mobility (O&M) training with smartphone apps. The session consisted of route planning, wayfinding and an evaluation of the navigation experience.

Building on the insights from these earlier sessions a focus group study was set up. We conducted four focus group sessions with a total of 16 PVI (7 male, 9 female; age 43-72) with various visual impairments (e.g. blind, limited sight and milder visual impairment). Group sizes were small, to create a comfortable and noise free environment. A fifth focus group was organized with 9 care professionals who support PVI with navigation and accessibility. During the focus groups four themes were explored: (1) current navigation problems (2) experience with navigation aids (3) preferences for a new wayfinding technology and (4) exploration of an initial concept for the wayfinding app. The application concept was presented as a scenario (user journey story). The scenario described route planning, different route situations, app functionalities and feedback modes.

Table 1. *Iterative prototyping sessions in chronological order*

No.	Session Type	Participants	Activity
1	Clickable prototype test on route preparation (smartphone)	10 PVI (age 46 – 63, 3 male, 7 female), all PVI participated earlier	App walkthrough
2	Clickable prototype test on route preparation (smartphone), Wizard-of-Oz test on multimodal communication (smartwatch)	4 PVI (one male, three female) (age 46 – 57), 4 PVI participated earlier	App walkthrough followed by indoor navigation task
3	Co-creation workshop with clickable prototype 1 & 2 (smartphone)	6 PVI, 5 care professionals, 1 ICT professional and 4 Interaction Design professionals, 4 PVI participated earlier	(1) Discussion of a user journey map to validate the wayfinding problem experience (2) Evaluation of prototypes.
4	Case study on route preparation and clickable prototype test on wayfinding (smartphone)	1 PVI female, age 71, 1 O&M professional	(1) Design app and route with the participant and professional (2) App walkthrough, and outdoor navigating task
5	Clickable prototype test on route preparation (smartphone)	6 PVI (3 male, 3 female, age 50 – 80)	App walkthrough
6	Wizard-of-Oz test on multimodal communication (smartphone, smartwatch, bone conducting headset)	2 PVI (female, age 30 and unknown)	App walkthrough, and outdoor navigation task (in a safe environment)
7	Wizard-of-Oz test on wayfinding messages (smartphone, bone conducting headset)	6 PVI (4 male, 2 female, age 44 – 69), 6 PVI participated earlier	App walkthrough, an outdoor navigation task with expanded and condensed wayfinding messages
8	Wizard-of-Oz test on multimodal communication (smartphone, smartwatch, bone conducting headset)	4 PVI (3 male, 1 female, age 25-48), 2 PVI earlier participated	App walkthrough, followed by outdoor navigation task with expanded wayfinding messages and multi-modal communication.

Phase 2: Iterative Prototyping

In the second phase we developed our wayfinding solution with PVI and professionals as co-designers through iterative prototyping. The input from phase 1 served as the groundwork for this phase. The app matured from clickable prototypes, to Wizard-of-Oz prototypes, to a working prototype (Figure 1 and 3). We applied different test setups with different stakeholders (Table 1). We slowly expanded the app functionality and focused on different aspects, including route preparation, communication methods and personalization. By applying a hands-on approach through clickable prototypes, user interface design was a factor that was improved through each iteration. User feedback was gathered via the think-a-loud method and a questionnaire

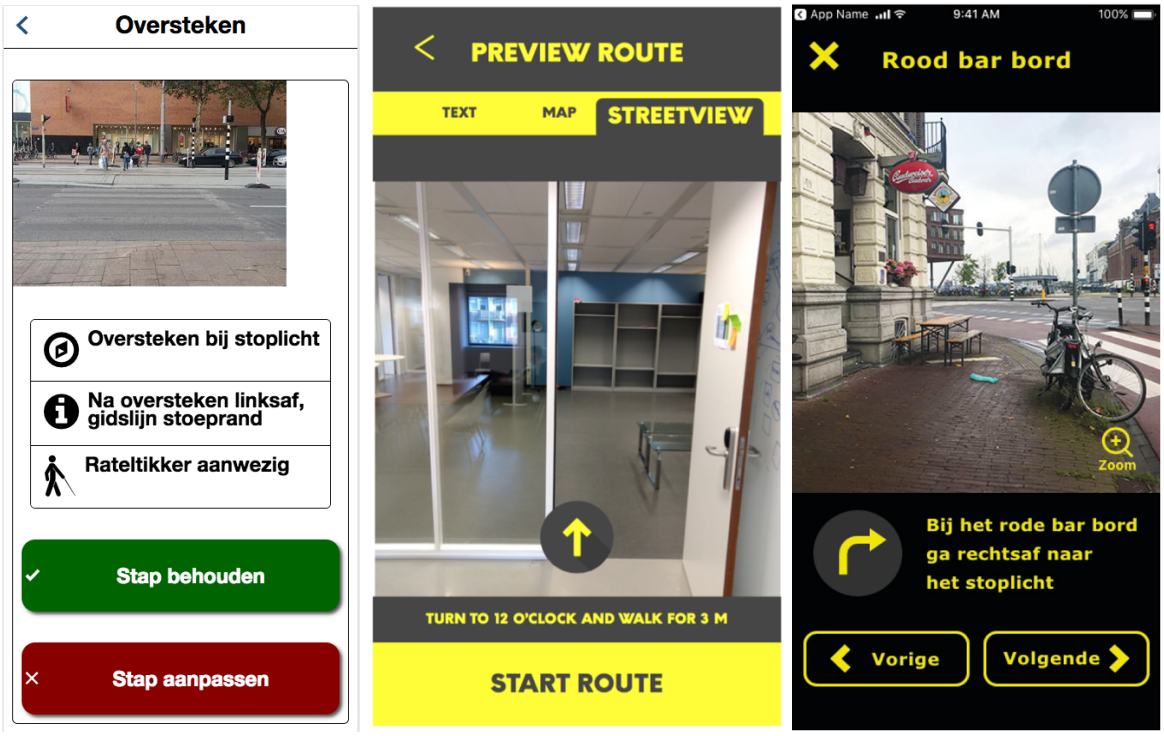

Figure 1: Clickable prototypes for route preparation and wayfinding. From left to right: a) Session 1 web-app, b) Session 2 web-app, c) Session 4 iPhone app

Clickable Prototypes

The first clickable prototype (sessions 1 and 3) was a web-app for the smartphone (Figure 1a). Route information was provided via categories and could be customized. The second clickable prototype (sessions 2 and 3) was a web-app for the smartphone with Android smartwatch app (Figure 1b). Route information was selected via a wizard interface. With both designs, participants encountered accessibility issues but were very positive.

The third clickable prototype (session 4 and 5) was a native iPhone app (Figure 1c). The app allowed the participants to trigger voice messages during wayfinding. The participant of session 4 wanted to use the app in daily life. Participants of session 5 encountered accessibility and navigation issues and were not satisfied with the inconsistency of the wayfinding message structure.

Co-Creation Workshop

The effectiveness of design 1 and 2 were compared in a co-creation workshop (session 3) (Figure 2). The participants were divided into four groups with PVI and care professionals in each group Interaction Design professional acted as facilitators for each group. Participants used their own smartphone or provided devices, next to an App print-out on A3 paper. Both apps were considered an improvement over existing wayfinding apps. However, the customizable app was preferred over the wizard-style app.

Figure 2: Co-creation workshop with prototypes, accessible tools and facilitators.

Working Prototype

The working iPhone app prototype (Technology Readiness Level 6) was used in sessions 6, 7 and 8. An Apple watch app and bone conducting headset allowed for multi-modal communication during wayfinding. Messages were provided via vibrations, message type icons and short instructions on the smartwatch accompanied by audio tunes and voice messages on the bone conducting headset (Figure 2). For session 7 and 8, a route of 1 km in urban Amsterdam was set out, including obstacles that are typically encountered outdoors. The wayfinding messages were triggered via Bluetooth beacons, activated by a researcher, ensuring that at messages were presented by the app at specific locations. When the route is provided online the app could be used on an iPhone in any location where Bluetooth beacons or GPS are available.

Figure 3: Bone conducting headset, iPhone and Apple watch app prototype for wayfinding via multi-modal communication. A message used in session 7 and 8 is displayed on the devices.

In session 6, one participant who had little experience with wayfinding apps, had difficulties with navigation and the content and structure of the wayfinding messages.

A new wayfinding message structure was integrated in the app and evaluated in session 7 (van der Bie, Jaschinski and Ben Allouch, 2019). Despite some remarks all participants found the new app and messages an improvement over the existing wayfinding solutions they used.

The full multi-modal wayfinding system with smartphone app, smartwatch app and bone conducting headset was evaluated in session 8 (van der Bie, Ben Allouch and Jaschinski, 2019). Although not all vibration patterns were detected, participants were positive about the new multi-modal system.

Lessons Learned

Over a period of two years we created an accessible wayfinding solution in co-creation with 31 PVI and 19 professionals The combination of involving users through different phases and prototypes allowed for the detailed evaluation of different aspects of the navigation app resulting in an optimized and accessible interface, a personalized route, personalized navigation instructions, and detailed orientation and environmental information.

Lessons Learned Phase 1

In Phase 1 we performed self-experience sessions to empathize with the user's wayfinding experience. Although this was very valuable, the designer's experience does not reflect the broad spectrum of wayfinding issues the visual impaired community experiences. Therefore, we advise to use self-experience sessions in combination with other requirement gathering methods.

From the observation sessions we learned about the limitations of currently available software regarding accessibility and interface design. Also, we got a first impression of what type of information is useful and how this could be communicated to PVI.

We performed focus group sessions with a diverse sample of PVI and professionals. The PVI shared what users want from a wayfinding app. The professionals confirmed these requirements and provided new and interesting aspects that PVI did not discuss or forgot to share. The user story provided a fast way of receiving feedback before an actual app was created. User experience sessions can take up multiple hours, limiting the number of users that can be involved. Through our group setup and by involving professionals we included multiple perspectives and gained initial feedback in a time-sensitive manner.

Lessons Learned Phase 2

Co-Creation Workshop

The workshop gave insights into missing features and necessary design adjustments. The tools used in the workshop facilitated the process and should be selected carefully and be adapted to the PVI participants. The online clickable prototypes worked well for the user evaluation. Although the PVI participants were often not able to read the enlarged printouts, they still served as a valuable tool to collect feedback. The group facilitator allowed the discussion to continue while organizing the feedback. We also learned that, despite forming subgroups the session was too crowded and noisy, resulting in extra stress and fatigue for the PVI participants. One participant left due to the noise. For new co-creation workshops with PVI we would recommend arranging only one group per room.

For most sessions we provided participants with detailed travel instructions and a pick-up from public transport. They were used and appreciated by the participants. Still, despite the accessibility of the location, for the workshop and focus group sessions we encountered participants cancelling

the meeting at the last moment. To still get valuable results, we recommend to account for a one-in-five cancellation factor.

Case Study Design

The case study design allowed zooming-in on specific parts of the app and receiving fast feedback from one representative of the user base. The difference in experience between the case study participant (session 4) and other participants (session 5) showed that when designing an app for one person, directly generalizing for the full target audience can be difficult. Still, combining this design method with an evaluation by a larger user group allowed for detecting important features that were missing, as the inconsistency of wayfinding messages.

Iterative Prototyping

Through iterative testing with mostly reoccurring participants, we explored different user interfaces, various communication methods (with wearables), and slowly transitioned from save indoor environments to urban Amsterdam. New participants showed that the learning curve of new technologies such as wearables can be high. A short explanation was not sufficient for participants to familiarize with the multi-modal system. The inclusion of participants that were familiar with the system from previous sessions allowed for a smaller learning curve and a more authentic setup.

We found value in changing variables slowly towards real-life situations. We tailored our wayfinding message structure through sessions 1,2,4,5,6 and 7, starting our experimental setup with app walkthroughs, followed by lab and enclosed outdoor wayfinding sessions, finishing with outdoor wayfinding sessions. The transition to a more challenging environment resulted in finding new errors in message structure and content. By creating a user test for the wayfinding message feature (session 7), we could zoom-in on the effectiveness of our solution.

Conclusion

By involving the users as co-designers of our wayfinding solution, we were able to create an accessible design for PVI. Our approach differs from earlier approaches with regard to the methodological diversity and many iterations. This allowed us to focus on specific features such as the structure and communication of the wayfinding messages.

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