AI FOR PEOPLE WITH VISUAL IMPAIRMENTS: EXPLORING DESIGNING FOR INTERDEPENDENCE

BEATRICE VINCENZI

PhD in Human-Computer Interaction

Centre for HCID
Department of Computer Science
School of Science & Technology
City, University of London

Submitted in partial fulfilment of the requirement
of the Degree in Doctoral Philosophy

March 2022

Beatrice Vincenzi: *AI for People with Visual Impairments: Exploring Designing for Interdependence* ,
PhD in Human-Computer Interaction, © March 2022

SUPERVISORS:
Dr. Alex Taylor
Dr. Sara Heitlinger
Dr. Simone Stumpf

London, UK, March 2022

DECLARATION

I, Beatrice Vincenzi, declare that this thesis was composed by myself, that the work contained here is my own except where explicitly stated otherwise in the text, and that this work has not been submitted for any other degree or processional qualification except as specified. Parts of this work have been published in collaboration with my supervisors.

London, UK, March 2022

Beatrice Vincenzi

COVID-19 IMPACT STATEMENT

This statement is provided for the aid and benefit of future readers to summarise the impact of the COVID-19 pandemic on the scope, methodology, and research activity associated with this thesis. The academic standards for a research degree awarded by City, University of London and for which this thesis is submitted remain the same regardless of this context.

Title of the research project:

AI for People with Visual Impairments: Exploring Designing for Interdependence

The COVID-19 pandemic hit while the Ethics application of study 2 was under approval, therefore the pandemic had a high impact on my PhD research. The original plan of study 2, method and data collection were completely revised. I considered UK Government restrictions on travels and meetings, and University guidelines on adapting PhD research to face this challenging time. Consequently, in study 2 I moved from a co-design approach to a more user-centre design approach, reducing the research period from 6 to 4 months. Data was collected remotely through both online meetings, and asynchronous home activities (Chapter 4).

Changes of study 2 had a significant impact on the thesis narrative. Specifically, findings from study 2.B turned my attention towards design methods, and therefore I re-considered my initial research questions. As a result, I decided to further investigate the design space, exploring a new design method for interdependence and AI (more details on the PhD journey in Chapter 1).

The COVID-19 pandemic had also an impact on the study procedure, and data collection of study 3 (see Chapter 5 for further details). The original plan was to conduct a study in a hybrid format and to involve participants for a week. When I started the recruitment, restrictions on travels and meetings were lifted in the UK, however I had difficulties in recruiting people with visual impairments who were still isolated. I accommodated the final data collection to be both fully remote and accessible, shortening the participants involvement time.

London, UK, March 2022

Beatrice Vincenzi

CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACRONYMS

AI	Artificial Intelligence
AT	Assistive Technology
G	Guide
SG	Sighted Guide
VI	Visual Impairment
VIP	Visual Impaired Person
PVI	People with Visual Impairments
WoZ	Wizard of Oz
WHO	World Health Organisation
BLE	Bluetooth Low Energy
PD	Participatory Design
DSA	Design for Social Accessibility
UCD	User-Centred Design
CSCW	Computer Supported Cooperative Work
TA	Thematic Analysis

If inequality is woven into the very fabric of society,
then each twist, coil, and code is a chance for us
to weave new patterns, practices, politics
its vastness will be its undoing once we accept
that we are pattern makers.

— Ruha Benjamin

ACKNOWLEDGMENTS

In this thesis, I speak of interdependence, and I believe this work itself is the result of a collaborative effort and responsibility that involves people, attitudes, feelings, challenges, hope, places, cities, time, and much more. My PhD adventure started with excitement, it passed through a Pandemic, and it ended in a different country. Therefore, I really would like to take this space to acknowledge everyone who crossed my PhD journey in the last 3 years. I thank you for supporting me and helping me get through every moment. You are all part of this achievement.

Firstly, I would like to say the biggest thank you to my supervisors *Alex Taylor*, *Simone Stumpf*, and *Sara Heitlinger*. *Alex*, thank you for reading, considering and replying to my initial email. It was back then that everything started, so without your support, your kind words, your care, and your help until the end, I would not be here today.

Simone, although on paper you have changed roles from first to the third supervisor, you have always been there as the main guide since day 1. Thank you for teaching me how to plan and do a research study, how to write a paper and all your useful tips on time management and meeting deadlines. I also would like to dedicate some words to you *Sara*. You joined the Team at last, but you shared precious tips on academic writing strategies right when I needed them. A large part of the thesis writing was based on putting them into practice, thank you. I would like to express gratitude to my external examiners, *Stephanie Wilson* and *Catherine Holloway*, for their meaningful and thoughtful comments on my thesis.

There was no research without the 11 *pairs of participants* who took part in the studies. I enjoyed meeting you all and learning from your lived experiences, challenges, and everyday lives. Meeting so many wonderful people has helped me not only conduct this research, but also accept my day-by-day companion Mister Diabetes as well as my daily challenges with smart diabetes management systems.

I will always be thankful to the *HCID Centre*, where I could find a space to learn and grow as a researcher. The Centre puts human wellbeing first. In fact, I found a second home in a foreign country. I met amazing people from all around the world. I would like to say a special thank you to the people who spent some of their time supporting me. An email attachment, a

chit-chat, a meeting, a text message offering advice along the way. In alphabetical order *Abi*, *Adrian*, *Alena*, *Lida*, *Marisela*, and *Tim*, all greatpost-docs, researchers, and academics. I would also like to thank *Sondess*, who I met as a postdoc in the Centre, but soon became a close friend. Merci beaucoup (yeah, I should practice my French with you) for always being by my side physically and virtually.

I must not miss my new and old PhD fellows: *Alex L.*, *Axel*, *Carol*, *Larisa*, *Linda*, *Srravya*, and *Tracey*. Each of you was so kind, and helpful in different ways. Thank you to who shared the former A203 room, who attended morning meet-ups in coffee shops before the pandemic, who showed up to check-in meetings during lockdown, who called me on FaceTime, who shared a virtual space for focusing and writing.

Now that everyone lives in different countries, it feels a bit weird to say thank you to my beloved housemates in London (*Giorgio*, and *Gianmichele*). However, I have spent most of my PhD with you, and I am really grateful of the friendship we have built. I must remember our shared dinners, our walks during lockdown, our barbecues, our board-game nights, our karaoke, our nights on the couch, our relaxing time at Victoria Park, and simply our everyday life together. I am sure we would have celebrated this achievement by ordering food and buying a bottle of wine from our friend in Roman Road. Once again, I would like to thank you for encouraging me throughout my PhD.

Lockdown in London was not easy. Beyond my housemates, I also have to say a big thank you to *Silvia*. She approached and pushed me to watercolor. Painting really helped me to overcome the difficulties of the Pandemic, and in turn the challenges I was facing in my research. I found out an incredible and strong sis-painter, and I really hope our friendship will keep growing beyond our time together in London.

Given the context in which I am writing these acknowledgements—that only you know—please accept my short paragraph. Also, I will not be able to write an entire paragraph as lovely as yours, but I hope you will appreciate my effort. *Fra*, as you said our journey in London started as a bet, which we can say we won. We were not sure where this journey would have brought us, but thank you for walking by my side. The completion of this thesis has been challenging while we've been in the middle of a change in our life, but I am glad we've begun this new adventure, which I think is bringing us new and exciting opportunities. I am looking forward to seeing what else we will build side by side. Thank you for always pushing me beyond my comfort zone, and also negotiating what "us" means after so many years together.

Infine vorrei ringraziare la mia famiglia. Grazie *mamma* e *papà* per aver sempre creduto in me. Lo so che non è facile per voi capire tutto questo e la strada che ho deciso di intraprendere. Ci vuole coraggio per lasciar andare le proprie figlie, sopratutto quando prendono un percorso diverso dai nostri canoni. Per questo vi meritate più di tutti un riconoscimento speciale. Per voi, noi (io e Fra) siamo i vagabondi della famiglia, ma nonostante questo i principi che mi avete insegnato li porto e porterò sempre con me, nel nostra valigia che vedere disfare e rifare di tanto in tanto.

Un grazie speciale va anche alle mie mitiche sorelle, e alle loro famiglie. Siamo sempre state legate, penso che quella stretta stanzetta con 3 letti ha fatto crescere un legame davvero indissolubile. *Chiara* e *Luca* grazie per avermi dato due nipotine stupende. (*Alice* ed *Elisa*) mi riempite di gioia ogni istante che passo con voi e mi avete dato la spensieratezza per affrondare i momenti più bui di questo cammino. *Cri* e *Andrew* (e *Kira*) grazie per averci offerto una magione in questi ultimi mesi. Un posto tranquillo (COVID-19 a parte) per ritirarmi nella mia scrittura era quello di cui avevo maggiormente bisogno.

ABSTRACT

With this thesis I aim to understand what the concept of interdependence offers to the design of novel AI Assistive Technology (AT) for people with visual impairments. The interdependence framework, proposed by Cynthia Bennett and colleagues in ASSETS 2018, emphasises the collective work done by people with disabilities and others to achieve access and independence. In this framework assistive technology is seen as a further way to extend the relations between one another, focusing on how actors are made more or less able through other actors and with technology. Current work in AI assistive technology has neglected this kind of collaboration, opening up opportunities to think differently about the design and role of AI in the future.

Using the sighted guiding partnership as a specific case study, I re-frame the role of AI navigational aid technology, resisting current AI trends which treat blind navigation as an individual activity in need of a technological solution. In opposition to this solution-driven approach, I question how we can use interdependence as the basis for designing AI assistive technologies for people with visual impairments.

Answering this research question was approached in three stages:

1. A systematic and empirical study, investigating how people with visual impairments and their guides accomplish navigation together. I show examples of interdependence in action, where people use multimodal resources to co-constitute a common space to move through together, and I draw important design implications.

2. Approaching a design space at the intersection of AI and interdependence. Focusing on the context of physical disengagement in sighted guiding, I unpack bodily movement language, and I introduce an AI prototype to sighted guiding companions. I discover the skepticism, and challenges in engaging people in thinking about future AI assistive technology.

3. Informed by the previous study, I reconsider the design process and introduce an accessible design methods that invites participants to creatively think about how AI might strengthen the sighted guiding partnership. I show how companions engage in this process, and how the method invites people to reflect, and extend ideas around future AI assistive technology.

The main contributions of this thesis are: (i) a detailed understanding of the theoretical concept of interdependence in the sighted guiding partnership; (ii) extending current design method at the intersection of workbooks and cultural probes; (iii) a methodological contribution in reframing the design space to attend to interdependence and AI.

While this research represents an initial attempt to disrupt social norms and established thinking in HCI research, future work would need to investigate the interdependence frame in different settings, and how the design process can be shaped to accommodate the complexity of AI and people with mixed abilities. New tools and methods are essential to inspire people making alternative AI's designs, which will empower people with disabilities in social life.

PUBLICATIONS

Some work of this PhD Thesis has appeared previously in the following publications:

[139] Beatrice Vincenzi, Alex S. Taylor, and Simone Stumpf. *"Interdependence in Action: People with Visual Impairments and Their Guides Co-Constituting Common Spaces."* In: Proc. ACM Hum.-Comput. Interact. 5.CSCW1 (Apr. 2021). doi: 10.1145/3449143. url: https://doi.org/10.1145/3449143.

[137] Beatrice Vincenzi. *"AI Assistive Technology for Extending Sighted Guiding."* In: ACM SIGACCESS Accessibility and Computing 129 (2020). url: http://www.sigaccess.org/newsletter/2021-01/vincenzi.html.

The following position papers have been accepted for attending CHI workshops:

[138] Beatrice Vincenzi. *"Exploring AI-enabled Assistive Technology in Sighted Guiding."* In: Proceedings of Artificially Intelligent Technology for the Margins (CHI'21 Workshop). ACM, New York, NY, USA. 2021, p. 6.

[140] Beatrice Vincenzi, Alex Taylor, and Simone Stumpf. *"Hacking Sighted Guide Navigation."* In: Proceedings of Hacking Blind Navigation (CHI'19 Workshop). ACM New York NY USA. 2019, p. 6.

1 INTRODUCTION

People living with various forms of Visual Impairment (VI) represent a significant population worldwide [100]. Assistive Technology (AT) has become a common part of daily life for many people living with visual impairments, supporting them in activities and routine tasks, such as reading text, navigating the web, using smartphones, and so on [23, 49, 84, 99, 149]. More recently, Artificial Intelligence (AI) has been promoted as a means for extending these ATs.

The term AI was coined in 1956. Over the last sixty years this terminology has evolved, assuming different levels of detail and understanding, and use in various research and applied domains. The term is also increasing in popularity in general discourse. This increased application and use have resulted in a blurring of meaning. For instance, when asking someone in the street what AI is, they might mention Alexa or Apple's Siri. When asking an expert, they might provide a technical response about what a supervised machine learning algorithm is, and how it is trained, and tested. Given its broad use and understanding, in the following few paragraphs, I describe what I mean by AI, and what AI's perspective I follow throughout this thesis.

On the one hand, AI is often conceptualised as an agent which thinks and acts like a human. In one of the most popular computer science books, Russell and Norvig [108] mention that AI is the attempt to understand and build intelligent entities. *"Intelligence is concerned mainly with rational action"*, and *"ideally, an intelligent agent takes the best possible action in a situation"*. This popular view of AI research emphasises the idea that intelligent systems can think rationally, and act rationally. It promotes a perspective in which the aim is to develop systems which are models of humans. On the other hand, more recent research has also been interested in another level of conceptualizing AI, one that is more focused on and less concerned with replicating human intelligence. Here, AI offers a set of tools to achieve discrete tasks or solve tractable problems.

I embrace this later vision in the following research. I consider artificial intelligence a set of techniques and approaches that process a large corpus of data for specific purposes in specific contexts with specific bounds. Generally, in contrast to traditional computational systems, AI has the ability to learn how to perform some tasks without being explicitly programmed. This is done by learning patterns in very large collections or sets of data. AI experts take data that has

been collected and labelled and use this to train a computational model using AI techniques. Such AI techniques include probabilistic methods, artificial neural networks, machine learning, and deep learning. Today, various AI applications adopt these techniques and have become ubiquitous in daily life. For example, we find this AI in recommendation systems (implemented on YouTube, and Amazon), robotic vacuum cleaners, natural language processing (implemented in Google Translate), affective computing, and computer vision.

This perspective is important to this thesis as it shapes what I propose as a novel approach to assistive technology design. Specifically, it shifts the focus away from building systems that aim to replace human abilities (such as sight) and instead focuses on extending or augmenting people's existing capacities. For instance, rather than building an intelligent agent that might 'see' for an accompanying blind user, my PhD research focuses on how AI can be incorporated into people's actual practices, how it can extend how people already orientate to, make sense of and interact with the world around them. I view the second perspective on AI that I described above as compatible with this, where the AI is not seeking to replicate a human ability but instead responds to the world in a discrete and bounded way. This is seen as a critically important contribution AI can make to assistive technology design, one I have attended in my PhD.

Amongst the various AI techniques, my research mainly focuses on computer vision. Computer vision is an interdisciplinary field which develops algorithms to gain a high-level understanding of images and videos. More recently a sub-area of computer vision has been concerned with applying AI algorithms to extract image/video information. For instance, machine learning and deep learning models are trained for scene and object recognition, event detection, video tracking, 3D pose estimation, and more. In particular, in accessibility and AT research, a growing number of computer vision applications now aim to support people with visual impairments by performing discrete and pragmatic tasks. For instance, computer vision techniques such as identifying objects, people, printed text contents, and social media photos. A large range of smartphone applications and services have also become widely available amongst the visually impaired community. An example is Microsoft's SeeingAI [84] mobile application (or "intelligent camera app" as they promote it) which uses the smartphone camera and computer vision to analyse the surroundings to support VIP to recognise objects, people, and written text. More specifically, *"Seeing AI can speak short text as soon as it appears in front of the camera, provide audio guidance to capture a printed page, and recognizes and narrates the text along with*

its original formatting [...] using the power of AI" [84]. In this thesis, I aim to explore how this orientation might be extended further.

Overall, people with VI, and more generally people with disabilities are early adopters of AI systems, already pushing the boundaries on how AI assistive technology might look like in the future. Computer vision techniques in AI assistive technology have been used to give access to visual context, seeking to simulate human sight, and therefore often treating blindness as a disability to be fixed. For this reason, computer vision techniques offer a fertile ground to explore AI assistive technology design in a different way. Through this research, then, I aim to engage with AI tools and techniques, more precisely machine learning/deep learning algorithm in computer vision systems, and look at how AI can be incorporated into people's actual practices, and what role AI can play in assistive technology for designing future alternatives that better support people's existing capacities.

Specifically, in HCI and accessibility research, increased attention has been given to designing and developing AI assistive technology to aid independent navigation for People with Visual Impairments (PVI). In previous research, much effort has been dedicated to providing the individual with wayfinding guidance, and complementary information about the physical features in an environment such as proximity to obstacles, curbs, hazards and landmarks [3, 47, 48, 61, 79, 85]. Several of these research projects and commercial applications integrate machine learning and computer vision into these systems. For instance, NavCog [3] uses AI techniques to predict the best route and provide turn-by-turn instructions, Bbeep also predicts the future position of pedestrians and tracks the user's path [67].

In the following, I aim to engage with the design of technologies that include AI to assist guidance. However, in contrast to prior research, my work is informed by a perspective that stresses the interdependencies between users with VI and others. My thinking draws on work in disability studies that highlights the significance of interdependence as opposed to independence [12, 35, 69]. It also builds, in particular, on the notion of an *interdependence frame* proposed by Cynthia Bennett, Erin Brady and Stacy Branham [9] in ASSETS 2018. The interdependence framework is a new design perspective which emphasises the collective work done by people with disabilities and others to achieve access and independence. Further, the authors make clear that these relationships are not only between people but also include the interplay between AT and the environment, thus opening up a new orientation for AT design. It is an orientation that resists the current AI trends on independent navigation, and blindness as

a disability to solve. Instead, it considers what role AI might play in extending individual and collective capacities.

To meet this aim I consider the sighted guiding partnership as a specific case study for this research. The sighted guiding partnership is an explicit example of people collaboratively navigating together. Indeed, in this practice, people with visual impairments are assisted by sighted people in daily routine journeys (see section 2.1.1). Their physical connection establishes ways of working together, making their partnership an interesting *problem space* for this research.

In this thesis, I will focus on how to design AI assistive technology for sighted guiding through an interdependent lens. Throughout this research, the design journey I follow is mapped in the double diamond (see Figure 1.1) introduced by the *Design Council* in 2015 to illustrate the design process [27].

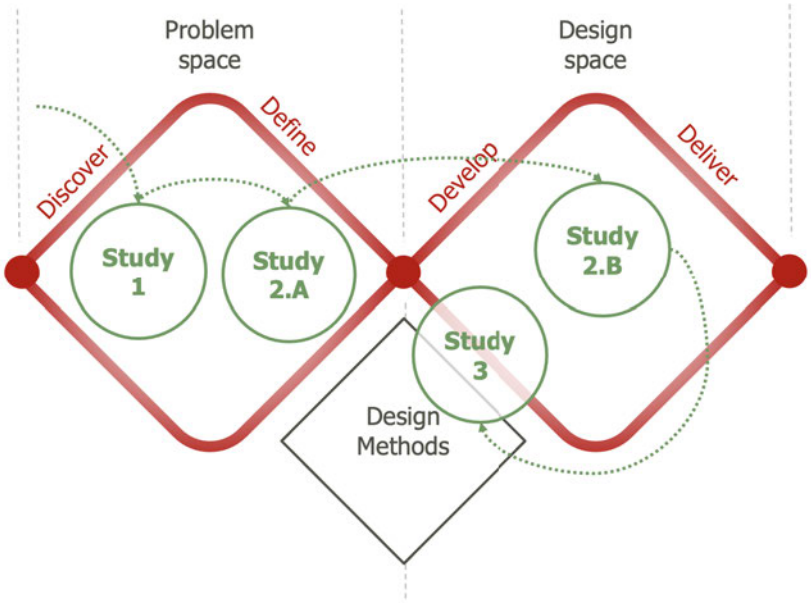


Figure 1.1: The double diamond illustrates the design process of this thesis.

In Figure 1.1, the *problem space* represents the process of investigating, understanding better the target population, and defining challenges from the gathered insights. As a first step, I explore the *problem space* of sighted guiding which provides a deep understanding of the goals, actions, and opportunities for design within this area (study 1 Chapter 3, and study 2 part A Chapter 4). Indeed, currently, the literature does not investigate how people with visual impairments and their guides collaboratively accomplish navigation together. A way to approach

this aided guidance from a perspective of autonomous travel is to reduce the "problem" of navigation to a sequence of steps and the movement from one place to another, and ultimately, to look to solutions that replace the sighted guide with an AI system. In contrast, when viewed in terms of interdependence, another way to approach the problem is to recognise movement and space not in strictly euclidean, geometric terms but as something that is co-produced and mutually orientated to accomplish activities like navigation [29]. As a reminder for the reader, the notion of *'problem space'* does not refer to something that this research aims to solve. Indeed, I do not seek to 'solve' the 'problem' of blind navigation nor to treat blindness as an 'issue' to be 'fixed'. Instead, this research recognises and acknowledges people's abilities and agencies, and it focuses on exploring how and where people's collective capacities might be enhanced with and through AI technology. Thus, the interdependence frame seems especially applicable in understanding sighted guiding.

After the exploration of the *problem space*, this PhD research journey turns its direction towards the *design space* (see right side of Figure 1.1). The *design space* investigates potential artefacts aiming to address the problem space. It also concerns the use and exploration of design methods which support a better investigation of the design space. In the second part of my research, I explore a *design space* for sighted guiding showing responses to design alternatives (study 2 part B, Chapter 4). Finally, I investigate possible design methods within an interdependence framework to explore a new and more appropriate design space (study 3, Chapter 5), and therefore what and how methods help to design AI assistive technology for strengthening the sighted guiding partnership.

The interdependence concept in assistive technology has been recently introduced in HCI, hence there is no research on how to design AI assistive technology for interdependence. This opens new challenges (i) in engaging people with mixed abilities in the design process; and (ii) in thinking about alternative AI technology, highlighting the need for research to investigate current and new design methods which help to better explore the design space.

In the following sections, I define the research scope, I describe the research aims and questions. After that, I will state the contributions of this work, and the methodology I have adopted throughout. The Chapter will end with the outline of the thesis.

1.1 RESEARCH SCOPE

The aim of this thesis is to gain insight into what interdependence offers to the design of novel AI-based assistive technology for people with visual impairments. Therefore, this research deals with two predominant types of study: study 1 (Chapter 3) and study 2 part A (Chapter 4, section 4.3) explore the *problem space*, and study 2 part B (Chapter 4, section 4.4) and study 3 (Chapter 5) investigate the *design space*.

As a *problem space* for this research, I look at the specific case of the sighted guiding partnership (see previous section). So, this research does not look at other daily situations in people with visual impairments life, nor other guiding relationships (e.g., guide dogs).

Further, as I will mention in each study I focus only on established guiding relationships (such as friends, and family members). This choice is the consequence of (i) ensuring that sighted guiding companions have some experience in guiding each other; (ii) investigating their established interactions as safely as possible.

Turning the focus towards the design space, a preliminary AI prototype has been built. However, the scope of this research does not explicitly explore the building and evaluation of AI interventions. Also, I did not develop new AI algorithms. Preliminary AI prototypes have been built from existing AI computer vision algorithms, and introduced to participants during my research only as means of exploring the design space and design methods.

1.2 RESEARCH AIMS AND QUESTIONS

Taking up the call from Bennett et al. [9], the overall aim of this PhD journey is to understand what the concept of interdependence, and more specifically the interdependence framework offers to the design of novel AI assistive technology.

The following 4 research questions guide this thesis journey:

RQ1: As an exploration of the problem space, **how do people with visual impairments and their sighted guides accomplish navigation together?** (Study 1, Chapter 3)

The journey starts with investigating the problem space, specifically, I consider how the sighted guide partnership offers an example of (i) people with VI working with others—in this case their sighted guides—and (ii) an interdependent partnership potentially open to AI-based interventions.

RQ2.A: In a deeper exploration of the problem space, **how do companions use body movements in sighted guiding?** (Study 2.A, Chapter 4)

While guiding a person, body communication plays a relevant role in sighted guiding. Through study 1, I became interested in body movements and gestures and how they allow companions to convey important information, helping them to accomplish navigation together. Unpacking this body communication, helped to identify the strengths and limitations of body language, especially in moments of physical disengagement. Study 1 revealed these moments can be particularly challenging. Building on this, my interest moves towards investigating body language and limitations, narrowing down the problem space to moments in sighted guiding when companions physically disengage and move apart.

RQ2.B: In an exploration of the design space, **how can an AI prototype extend body language when companions physically disengage in sighted guiding?** (Study 2.B, Chapter 4)

With the introduction of a preliminary AI prototype—aiming to enhance these moments of physical disengagement—the research turns the focus to the design space. I consider an User-Centred Design (UCD) approach to engaging companions in a workshop and ask for their feedback and initial inputs on the AI prototype. I discover companions' scepticism and negative feedback from a participants' pair. I step back and reflect on the difficulties (i) of involving people with VI in the design process, and (ii) of thinking about AI assistive technology which prioritises individual abilities and collective capacities.

RQ3: In an exploration of the design space, **how can we employ design methods to help people creatively think about AI and interdependence?** (Study 3, Chapter 5)

In the final stage of my PhD journey—informed by my previous work, and supported by other recent work [7, 89]—I then re-consider the design process. I introduce a new accessible method that extends workbooks and cultural probes to better engage with people with mixed abilities. I investigate and reflect on ideas presented by people, and how the method opens up the design space to think creatively about interdependence and the use of AI assistive technology in the future.

1.3 CONTRIBUTION

The overall contribution of this PhD thesis is a reframing of designing at the intersection of AI assistive technology for people with visual impairments and interdependence. This is done through a specific and intentionally narrow focus, so looking at the sighted guiding partnership. This overall contribution consists of 3 smaller ones:

CONTRIBUTION 1: A detailed understanding of the theoretical concept of interdependence in the sighted guiding partnership.

This contribution is associated with RQ1, which is mainly addressed by adopting an ethnography method to video record and qualitatively analyse daily and familiar journeys of 4 participant pairs (Chapter 3, study 1). Findings offer examples of interdependence in action and reveal important multimodal resources that people collaboratively use to accomplish navigation together. A minor contribution also comes from study 2 part A, see section 4.3 (RQ2.A). Specifically, I gain insights about body language and its limitations in sighted guiding.

CONTRIBUTION 2: A methodological contribution in reframing the design space to attend to interdependence and AI.

This contribution is associated with RQ2.B and was achieved by travelling from study 2 part B to study 3. Indeed, introducing an AI prototype to people (see section 4.4) allowed me to reflect on the challenges in engaging people to think about future AI assistive technology. Findings offer important reflections and insights on design methods for interdependence and AI, which drive the final stage.

CONTRIBUTION 3: A contribution in extending current design methods at the intersection of workbooks and cultural probes.

This contribution is associated with RQ3 (Chapter 5), which is addressed by adopting a more speculative design approach through an accessible and interactive workbook. In a remote setting, I involve pairs of participants to engage with design materials, discuss, and reflect on design proposals and ideas. Findings offer insights about to what extent workbook components help participants (i) to think openly and creatively about future assistive technology and the role of AI, and (ii) to actively participate and engage in the workshop. Through some examples, I will show that tasks and proposals work differently for each pair. However, participants engage

well in the activities and show they are able to reflect on and propose adaptations to potential future AI systems.

1.4 METHODOLOGY

The methodology I adopted in this research changed throughout the three studies and helped to shape the PhD narrative. Step by step, gaining knowledge of the target population and experience in research helped me to shape my perspective and position as a researcher. Over time, I understood my intention was to have an interpretative and reflexive approach. However, throughout this research, the methods and techniques I used did not always help to foreground interdependence and people's abilities/agencies. Overall, this qualitative research is comprised of 3 small-scale exploratory studies understanding the problem space of the sighted guiding partnership, and approaching the design space with an exploration of design methods at the intersections of AI and interdependence. Looking at a few pairs of participants allows me to attend to a generative diversity in voices, thoughts and experiences. In the following, I present the principles that guide my research practices, and why I chose to use certain methods or tools in my studies. I hope to provide an overview which helps to better outline my research journey.

1.4.1 *Study 1: Ethnomethodology Approach*

I approached study 1 (Chapter 3) following an ethnomethodology approach [29]. A compelling paper from Due and Lange [31] offers relevant lessons from an ethnographic and ethnomethodologically orientated study of people with vision impairments navigating with guide dogs. The work presents an analysis of visually impaired people competently navigating their environments with guide dogs. Specifically, it highlights a distinction between the use of a white cane, seen as "problem-oriented", and the guide dog, seen as "solution-oriented". So, in contrast to the white cane, guide dogs do not inform their companions about obstacles but instead help to establish safe routes. This different orientation draws particular attention to the interdependent relations between the person and their guide dog. Thus, as highlighted in section 3.2.4, the ethnography perspective seems promising to foreground the lived experience of people, and how interaction is made intelligible and thus consequential to the members of a setting.

I conducted this initial research through an empirical qualitative study in which I asked sighted guiding companions to video-record their journeys using body cameras. Video data is

analysed with interaction analysis, which is a qualitative research method, well established in studies of the workplace [53, 54, 80]. Interaction analysis is also adopted in HCI and Computer Supported Cooperative Work (CSCW) research as a method of analysis to study disability in context. For example, Goodwin [43] has used this research method to demonstrate that limitations to vocalised speech can in many ways be overcome through pointing gestures, head-turning, and gaze in collaboration with others in a setting. The primary focus of this first study was not extracting a set of design implications, but instead examining, in detail, a very particular form of social activity (namely, how social order is accomplished). This orientation was important to attend to people's interdependencies and resist solution-driven analysis. I explored in more detail this perspective in study 3 (see section 1.4.3). The techniques I used in this first study also allowed me to start reflecting on the researcher's positioning (further details in section 3.4). It is fair to say that the method I chose allowed for a particular understanding of sighted guiding. As a consequence of this choice, I may have risked glossing over the skill and know-how *felt* by the participants. Therefore what a researcher sees and hears may not be what participants hear, see, and feel.

1.4.2 *Study 2: UCD Approach*

Approaching the design space at the intersection of AI and interdependence is challenging. On the one hand, there are methods and techniques which are commonly used for AI technology design, and on the other hand, participatory methods are increasingly adopted for designing technology with people with disabilities (see section 2.5). When dealing with AI, researchers tend to reduce AI complexity and iteratively build prototypes and test them with people. Thus, I conducted study 2 adopting an UCD approach. The choice of the method was also a consequence of the beginning of the COVID-19 pandemic, which hit at the start of study 2 (more details are reported in the COVID-19 statement, included at the beginning of this thesis). This approach allowed me to carry on my research, following the University guidelines on adapting my own research plan, considering the difficulties everyone was facing at that time (e.g., restrictions on travel and in-person meetings). Thanks to the UCD approach, I involved people in understanding better the problem space (part A, see section 4.3), and exploring the design space, introducing a preliminary AI prototype I developed (part B, see section 4.2).

Data from both parts of the study was analysed through Thematic Analysis (TA) [18, 19]. Thematic analysis indeed is not prescribed to a tight methodology, instead, it is a flexible method

and has a variety of paradigmatic or epistemological orientations. This makes it appropriate as an approach for both analysing the problem space and exploring the design space. Also, when taking an interpretive orientation, thematic analysis can enable the development of knowledge that is constructed through interactions between the researcher and the research participants, revealing the meanings that are socially constructed. In study 2 I generated themes inductively and deductively, so considering knowledge I gained from previous studies and leaving the space open for the emergence of new meanings. This was highly relevant in part B (see findings section 4.4.4), where a critical data interpretation highlighted limitations of the specific UCD techniques I adopted. The analysis helped me to realise that current AI design methods and methodology are too limited to creatively think about possible future AI alternatives which centre interdependence. In summary, methods and tools (e.g., the AI prototype itself) promoted technological solutions that aim to prioritise (an impoverished idea of) independence, rather than what we know to be the collaborative work that takes place in sighted guiding.

1.4.3 *Study 3: Interpretivist Approach*

Informed by study 2, at the start of the last study I reconsidered the design process, and I came back to the reflexive and interpretive orientation, I was attending in study 1. I believe this orientation helped to resist the idea of solving a problem and instead maintained open-ended possibilities. Specifically, I needed new methods and tools that could help to think beyond current AI use and foster creativity, imagination, and interdependence. I steered towards more speculative methods. I drew from workbooks and cultural probes [38–40], which are exploratory methods developed to collect inspirational data for the purposes of defining a design space and setting a design trajectory (e.g., "How do people describe their real-world experiences?", "How do people make sense of diverse scenarios?", and "What are people's responses to a range of technological proposals/provocations?"). Inspired by these two methods, I have developed my own workbook as a method to work with people with visual impairments and stimulate their creative thinking (see study 3, Chapter 5, section 5.2). I presented the workbook to companions and asked them to complete and reflect upon proposals and ideas.

Analysis of output data was at first another stumbling block: the difficulty was to resist forms of analysis which result in a list of system requirements. However, previous work in HCI (e.g., [28, 118, 126, 136]) recognises probes methodology and builds forms of analysis which embrace subjectivity and interpretation to tell inspirational stories about participants' responses which

might inform the design in the future (see 5.2.6). Also, recent work shows that the reflexive method is used in accessibility research [56]. Authors position themselves as both researchers and participants to examine their experience with disability. Thus, this methodology embraces an interpretive approach and recognises subjectivity in the description of the findings. The recognition of the researcher as an interpreter instead of an objective observer is also discussed by Dourish [29], and it is in accordance with feminist stances [50, 128]. Following these trends and forms of analysis, I decided to take a similar collaborative approach. In study 3 the analysis was conducted through a qualitative and interpretative approach.

1.5 OUTLINE OF THE THESIS

CHAPTER 2: RELATED WORK. This Chapter begins with an overview of the literature review which shapes this thesis. It begins with introducing the target population of this research and describing the sighted guiding partnership. The evolution of disability thinking is then described to help the reader understand the perspective around disability that I consider throughout the thesis. The state-of-the-art of AI assistive technology and design approaches is presented to better define the research context. It follows a detailed description of the *interdependence framework*. The Chapter ends with a summary of the research gaps that this thesis aims to fill.

CHAPTER 3: INTERDEPENDENCE IN ACTION. Chapter 3 presents the first research study. The Chapter starts with motivation and research questions for study 1. I describe the method, participants, data collection and analysis of an empirical study with 4 participant pairs. In the findings section, I present in detail 6 segments to show how companions use multimodal resources to accomplish navigation together. The Chapter ends with a discussion of design implications, and limitations, and sets the stage for the next step.

CHAPTER 4: APPROACHING A DESIGN SPACE AT THE INTERSECTION OF AI AND INTERDEPENDENCE. This Chapter describes the second research study. I first describe motivations and research questions. Through a two-part study, I mitigate from investigating the problem space to exploring the design space. Part A unpacks body language, narrowing the research context to physical disengagement. The study procedure, participants, data collection and analysis, and findings are reported in detail. I then present part B, which describes the design and implementation of a preliminary AI prototype, and its introduction to sighted guiding companions. Study

procedure, data collection and analysis precede findings, which show important reflections and a re-consideration of the design space and methods. The Chapter ends with a discussion section.

CHAPTER 5: MAKING SPACE FOR AI AND INTERDEPENDENCE. Informed by the previous study, Chapter 5 presents study 3: I first introduce the workbook, a new accessible design method to better engage with people with mixed abilities. I then describe the study procedure, participants, data collection and analysis of remote meetings where companions reflect and complete the workbook activities. A finding section follows to present to what extent the method helps companions to creatively think about interdependence in their partnership and alternative AI design.

CHAPTER 6: CONCLUSION. This Chapter presents thesis contributions and study findings. It highlights some limitations of the work and an overview of possible future directions.

2 RELATED WORK

2.1 PEOPLE LIVING WITH VISUAL IMPAIRMENTS

People living with various forms of visual impairment represent a significant population worldwide. The World Health Organisation (WHO) reports that globally, approximately 1.3 billion people live with some form of visual impairment in 2018 [100]. In the UK, almost 2 million people are living with a visual impairment and around 360,000 of these are registered as partially sighted or blind [94]. Regardless of the form of visual impairment, age, and causes, the target population of this research is composed of adult people, who have been registered as either severely sight impaired (blind) or sight impaired (partially sighted). To be registered legally as blind or partially sighted the visual acuity level and visual field degree have to be highly damaged and neither glasses nor eye surgery can solve or improve the condition. Moreover, often severe and partial sight impairment conditions interfere with the individual's abilities to perform activities of everyday life, since visual information access, in a world with a predominance of visual content, can result difficult, tiring and frustrating. Nowadays the visually impaired community still suffers from forms of oppression, such as marginalisation, and powerlessness [26], therefore people affected by these conditions might benefit from this research.

2.1.1 *The Sighted Guiding Partnership*

Although people with visual impairments can be considered clinically vulnerable, this research looks at people who have an active social life. Indeed, people with visual impairments are early adopters of assistive technology and AI. For instance, they are skilled users of screen readers and other common smartphone applications for completing daily tasks. Some applications, for example, SeeingAI [84], enable people with visual impairments to recognise objects, barcodes, printed texts, and photos on social media through the smartphone's camera without requesting additional assistance from sighted people. Some others (e.g., BeMyEyes [153], and BeSpecular [93]) use video calls or chats to connect a person with VI with a sighted person so that they can ask for a description of the surrounding, a colour of a dress, the expiry date of some food. Many

also use navigational aids to travel daily, such as BlindSquare [11], and Soundscape [83] applications which use audio-based technology to enable people to build a richer awareness of their surroundings.

Beyond short or long canes, and guide dogs, people with visual impairments often are also supported by sighted people who—in this case—are called sighted guides. This work looks indeed at the sighted guiding partnership. Pairs of this research are companions composed of a person with visual impairment and a sighted guide with an established relationship through guiding, which means they are familiar with and they feel comfortable walking together using the sighted guiding technique.

Sighted guiding is a common and daily practice in the visually impaired community when travelling with family, friends, or assistants. It provides an enjoyable way to explore familiar and unfamiliar environments, for building and intensifying relationships, and for feelings of freedom [35, 69, 78, 123]. In the past fifty years, organisations and charities have increasingly proposed sighted guiding training held by specialists to teach sighted people the basic ingredients of this technique, and how to approach and provide assistance. Today, the sighted guiding technique is standardised. If someone needs support, the guide bends their arm parallel to the ground and offers the arm or elbow to the other person. In this configuration, the guide is one and a half steps ahead of the person with visual impairment, and in this way, the pair can walk together [105].

Figure 2.1 illustrates the difference between the sighted guide configuration (on the right) where the person with visual impairment holds the guide's arm and a configuration (on the left) of two people walking side by side. Sighted guiding is a clear and explicit example of people working together thanks to the fact that people with visual impairments are physically connected to their guides' body. Therefore, this case seems highly relevant to this research.

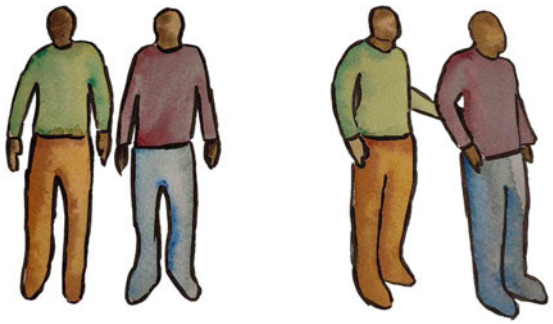


Figure 2.1: Side by side configuration on the left and sighted guide configuration on the right.

2.2 THE EVOLUTION OF DISABILITY THINKING

Since people with visual impairments are often categorised as people having disabilities, I think it is relevant to reflect on the term *"disability"*, its evolution, and how I intend to use this term throughout this research work. At the beginning of the twentieth century, the *medical model* (also known as the individual model) was the dominant perspective around disability. The medical model considers disabilities as dysfunctions (physical or mental) of the human body, which should be treated and cured for returning to a healthy (normal) condition. This perspective—supported by medical experts—sees the future of disability in terms of medical research, individual treatments, and familiar or professional assistance, often giving access to appropriate healthcare and educational facilities.

Visual impairments may be considered a disability at first. Indeed, people with visual impairments experience a physical dysfunction of their sight. Different forms of visual impairment exist and cover a wide range of visual function losses. Beyond their medical condition, the visually impaired community is also involved in popular social media and organisations worldwide as disability justice activists, promoting independence, inclusion, and empowerment of VI people in an increasingly digitalised society. People with sight loss categorise themselves as *not disabled*, and the medical model becomes too limited to describe people's lives, capacities, and needs.

In contrast with the paradigm just discussed, since the 1970s, disability has been defined not as a medical category, but as a social one. Disabled activists started refusing the role of medical experts in disability ordering, and began *"to proclaim that they* [*knew*] *what* [*was*] *best for themselves and their community"* [26]. Briefly, they argue disability is socially constructed, and therefore it is not the physical or mental dysfunction that defines them as disabled, but how society imposes disability definitions and views on people. Not only activists but also disability studies scholars have influenced the social model perspective. Specifically, Micheal Oliver reflects on a *social model* to point out that disability and illness are not the same concept [98]. The social model moves away from disability as illness and focuses on describing disability as a social-material construct. Altogether, the social-material environment where disabled people are living, for instance, physical and intellectual barriers, and the biased cultural perceptions are the sources of disability [36]. Removing physical-social barriers from the world and giving equal opportunities represent a greater potential benefit.

Nowadays, for instance, new tools and software packages are developed to give access to digital visual content, such as PDF files, presentations, images, videos, and so on. Having a

tagged PDF, or an alternative image description for a slide presentation, allows people with visual impairments to be able to access the content on their own, resulting in feeling more included in society, and so, empowered. However, the social model does not seem to be the final solution to forms of marginalisation that people with visual impairments experience in their everyday life.

What is neglected in the social model is the complete detachment of the impaired body in how disability is represented [12]. The single-person body is totally ignored. In the social model, the term body unites under the same umbrella all diversities with the aim to solve disability on a large scale. Also, the environment takes a broader sense, it includes physical buildings, products, and surroundings, but also people, technologies and so on.

This perspective is criticised by a third model, which tends to give back importance to the diversity of bodies, highlighting that difficulties—that people with disabilities experience—are not only a matter of access to resources and physical spaces [12], but they emerge from the interaction of the single person's body with the surroundings. Scholars from disability, science and technology, and geography studies have named this perspective in different ways, from *relational* and *materialist model* to *non-representational theory*. Under this perspective, disability studies scholars have contributed to defining differently the "normal" or able body. The "abnormal" or disabled does not reside neither in an impaired body nor in a specific environment, but in the in-congruent relationship between these two entities [90].

Coming back to the previous example, disability is not located in the visual impairment, nor in the digital content (e.g., slide presentation, or picture) being inaccessible. Certainly, having an alternative description for a slide presentation is a requirement for accessibility, but it is not sufficient for experiencing independence, inclusion, and empowerment. Disability is produced through interactions, interactions between people with VI and others, interaction with the digital content, how the visual impairment is disclosed, the attitude towards disability, and all other forces which can influence the overall experience.

The *relational* model sets the ground to investigate the role that assistive technology has played so far. Through this research, I am also interested in exploring social and other difficulties people encounter when interacting with people and technology, and which new opportunities can raise to better empower and include people in their social life.

2.3 A DIFFERENT PERSPECTIVE: THE INTERDEPENDENCE FRAMEWORK

Recent research has stressed the agency of people with disabilities in their collaborative work with others and demonstrates how both access and independence are achieved through this interdependence [8, 9]. Thus, assistive technologies should not be approached as a *"gap between disabled bodies and environments designed for non-disabled people"* [9, p.161], but as an aspect of the ongoing interplay between different actors and the specificities of any one setting. *Be My Eyes* [153] and *BeSpecular* [93] offer two compelling examples of services that open up a space for such mutual and collaborative work, providing people with visual impairments remote access to crowd-sourced communities of sighted users.

The interdependence concept draws from and has been intensely discussed in disability studies. What might be captured loosely as the *relational perspective* [12, 69] (described in section 2.2) understands disability as being in continual production, where bodies, technologies, settings, etc. are unceasingly entwined to make actors more or less able. Moser [90] shows how disability is not something fixed within the body, but is manifested through interactions with the environment, other people and technology: *"disability is not something a person is, but something a person becomes"*. Similarly, Goodwin [43] presents a systematic analysis of a person with aphasia who is able to speak only three words but nonetheless acts as a competent speaker. Through Goodwin's work, we see how a complex conversation can unfold with few words, but in combination with body movements and gestures, and the interplay with the talk and actions of other actors. Ability and disability are then capacities made possible through relations with others.

While previous HCI research has paid attention to the social features of settings, it has primarily been related to the ability-based design of technology or the social implications of existing ATs (see section 2.5). For instance, previous perspectives highlight mismatches between the different ways sighted and non-sighted people interact with their surroundings, and thus how appropriate feedback is important in navigation [143]. The form and function of an AT have also been considered in terms of how it influences social interactions, self-perception and social acceptability [121, 122]. In light of the research in disability studies, such approaches present relatively static versions of the relationships between the actors, and what capacities they may have to work together.

Relationality and the interdependence perspective thus open up opportunities to think differently about the design of AT and consequently about the use of AI in this context. Bennet

et al.'s frame [9], in particular, sees AT as a further way to extend the relations between one another, focusing on how actors are made more or less able, relationally, through other actors and with/through AT. Therefore, the interdependence framework, proposed by Bennet et al., allows us to better draw out the roles of people with disabilities during the collective work they do to achieve access. This new design perspective can help reveal relations, multiple forms of assistance, and the contribution of people with disabilities which often is unseen.

Other recent work further illustrates the complexities of these social relations and how (dis)ability disappears or emerges through them, bringing to the foreground interdependencies. Thieme et al. [132], for example, examine how people with visual impairments negotiate their abilities and how they sense the environment through different resources and collaboration with others in several contexts during the Rio Paralympics. Similarly, research has shown the collaborative work done between people with VI and people who are sighted to co-create an accessible home environment [16], and how a mixture of abilities can operate together to achieve tasks [17]. Task completion is also complemented by other forms of encounter, such as expressions of care which are usually neglected when developing AI assistive technology. By exploring encounters among people with visual impairments and sighted people who complete tasks together, Bennett et al. [8] examine other forms of interdependent work that give rise to access. A recent work also proposes the PLACES framework to expand the understanding of leisure experiences of people with VI in nature [5]. Authors show that outdoor leisure activities do not only depend on physical access to a public park but how people with VI and others are contributing to the experience.

Nowadays, the design and use of ATs is an established area of research in HCI. Many are computer vision technologies that support people with visual impairments to complete tasks such as the identification of objects and people, and the description of images/GIFs on social media [63, 66, 71, 77, 124, 146, 150]. These applications are widely available and affordable amongst the visually impaired community. For instance, VizWiz [10] application allows people with visual impairments to receive an image description from algorithms or crowd people, however, this and other services do not adapt to social interactions and contexts. More recently, there has been a few attempts in shifting the focus towards social activities and interactions [72, 89]. For instance, Morrison et al. [89] have presented a preliminary computer vision system intended to support open social interactions of a blind boy in a controlled family dinner. However, there is little work on how we can design AI assistive technologies and applications which go beyond the accomplishment of individual tasks, and pay particular attention to social activities

and relations. The work that stands out in this space (i.e., Morrison et al. [89]), serves as an inspiration for this PhD and, alongside Bennett et al. [9], defines the starting point for the focus on my research. Specifically, Morrison et al.'s work helps to foreground complicated instrumentalist assumptions about assistance and demonstrate that AI might enable and extend human capacities differently from the discrete tasks widely supported. Building on this work, through this research, I investigate how we can design AI assistive technology to support social interactions in the context of sighted guiding since it represents a specific case of collaboration.

2.4 AI ASSISTIVE TECHNOLOGY

The UK Government website in October 2021 defines Assistive Technology as "*products or systems that support and help individuals with disabilities, restricted mobility or other impairments to perform functions that might otherwise be difficult or impossible. These devices support individuals to improve or maintain their daily quality of life by easing or compensating for an injury or disability*" [44]. Firstly, the definition includes people living with different disabilities. As quoted, the definition also covers a wide umbrella of devices and services. This is because assistive technology's appearance has changed considerably over time. As explained in section 2.5, AT might be a hardware component to add to existing technology, or it might represent a service or software (e.g., screen readers software). Recently, HCI research has also shown how common technology becomes assistive upon their uses. For instance, Jahan, Barbareschi and colleagues investigate the impact of mobile technology on people with disabilities in low or middle-income countries [6, 62]. For this group of people, mobile phones are changing their purpose. They are perceived more and more as assistive technology. Indeed, per se, the smartphone does not ease an injury or disability but serves the purpose of supporting independence and promoting well-being through specific applications and services. Similarly, smartphones have received a growing interest from the visually impaired community, and nowadays the industry sector offers many applications to help people with VI in their everyday tasks.

More generally, assistive technology aimed at people with VI seeks to support them by improving access to technology, their independence and, in turn, their quality of life. Prior work has designed solutions addressing a wide range of activities such as reading, writing, gaming and navigating. Currently, these AT solutions work by augmenting or replacing vision [141, 149], e.g., applications that help people with limited vision to magnify any text, image or video that the device captures [99, 149] or transform graphics, images, or text into audio and synthesise speech

through screen readers or haptic information to braille devices [2, 103, 133]. In addition, there is also a drive to leverage assistive technology for some tasks that rely on visual information, such as the identification of objects. Early technology in this area uses crowds sourcing for generating alternative descriptions of images (e.g., VizWiz application [10]). Other technologies make use of video-call application services to connect with sighted people and ask for a description of the surroundings (e.g., BeMyEyes [153]).

More recently, artificial intelligence has been promoted as a means for extending these ATs. For instance, applications such as *SeeingAI* [84] and *BeSpecular* [93] by taking a picture of the surroundings they tell people what is recognised. These applications also recognise written text, barcode, and currency [23, 49, 84]. Other recent research studies how to generate automatic alternative descriptions from images in social media. [76, 146], or again other work has focused on personalised object recognition through a smartphone application [131].

2.4.1 *AI Technology for Navigation*

Independent navigation for people with visual impairments is considered a major challenge, drawing significant attention from the research communities in both HCI and AI [48]. Here, AI is often used to solve a functional task, where the user follows instructions to successfully reach a destination. Hence, research has focused on supporting how users navigate physical spaces, and aiding in the identification and proximity of walls, curbs, obstacles, streets, etc. often using beacons [3, 73, 79, 130, 151] or computer vision systems [3, 61, 73, 134]. For example, the *Cities Unlocked* project [85]—a collaboration with *Microsoft* and *Guide Dogs for the Blind*—proposes a wearable headset connected to a smartphone application to receive information about a current location, surrounding streets and landmarks, and help to explore the surrounding environment and to reach a destination. The *NavCog* system is exclusively for indoor use and relies on Bluetooth Low Energy (BLE) beacons, installed in the environment, to estimate the user's position and provide turn-by-turn instructions [47]. A recent application, *BBeep*, predicts the future position of pedestrians and tracks the user's path; when it predicts a potential collision between the traveller and the pedestrian, the system alerts both the user and the nearby pedestrian [67].

Again, these solutions target autonomous travel, treating navigation as a functional task. As a consequence, they place the emphasis on accurate information about the environment to provide greater independence to the user. Relationships with other people (e.g., pedestrians,

assistants, guides, friends, etc.) are given little consideration, with others' bodies largely treated as physical masses, either moving or stationary, and as something to be avoided.

2.5 DESIGN APPROACHES TO AT FOR PEOPLE WITH VISUAL IMPAIRMENT

The evolution of disability thinking described in Section 2.2 had also some impact on assistive technology design approaches, and methods adopted by HCI researchers. The early accessible computing goal was to make technology accessible for people with disabilities. Technology was designed and built for an average or standard user. In this context, assistive technology included assistive components inserted between the user and the system to fit a "nonstandard" user. The add-on components were then adaptations to accommodate users' needs to a technology which was immutable. This view centralises disability rather than people's abilities.

To address this problem, Woobbrock et al. [145] introduced the ability-based model and its seven design principles. This model shifts the burden of accommodation from humans to the system. Drawing inspiration from other approaches at that time, this approach focuses on people's abilities throughout the design process. The goal was to provide personalised user interfaces that can adapt themselves to the user's abilities, orienting towards *"what the user can do"*, and moving away from *"what a person cannot do"* and *"what 'everyone' can do"*. Researchers have criticised the exclusion of other important factors such as attitudes, and social situations which impact users' willingness to adopt and use accessible technology. To incorporate not only functional, but also social factors, Shinohara et al. [119, 120] proposed the Design for Social Accessibility (DSA) perspective, and through a series of user-centred design workshops show how their method—based on cards—generates accessible designs and appropriately engages users with and without disabilities. Although perspectives on how to design assistive technology are changing, the design of AI-AT for interdependence remains unexplored in HCI research.

Overall, as mentioned by Preece et al. [64], in the UCD approach real users and their goals are the driving force behind technological development. This approach relies on three principles: early focus on users and tasks, empirical measurement, and iterative design. When working with AI in assistive technology, the typical approach adopted to explore the design space is indeed the UCD method. It involves reducing AI complexity and iteratively designing and building rapid prototypes, refining and evaluating them with users [24, 68, 147]. Even though this method allows for a shift in the focus of interactive system design from the system to the user, increasingly AT research has established that people with disability, and so people with visual impairment need

to be more actively involved in making a contribution to the design and content development process. People have to be taken into account not only for user requirements and needs in an iterative fashion throughout the design and development life cycle but also when important decisions have to be made throughout the process. In this case, the end-user is added to the team of designers and assumes a more active role. Traditional approaches such as Participatory Design (PD) and co-design methods [92, 112, 113] have been naturally adopted when designing technology for people with disabilities, and nowadays are still the most adopted in the AT area.

PD represents a different approach toward technology design in which people who use technology also play a critical role in designing it [14, 117]. It pushes the boundaries of the UCD approach with the idea that end-users can design technology solutions on their own (not mere "involvement"), and the designer moves into a supporting role. Participatory Design was rooted in Scandinavia during the 60s-70s, and now it is well-established all over the World. Over the years, other forms and similar approaches have been developed and recognised by the research community, for instance, the co-design methodology [113]. As in other approaches, co-design requires the end-user participation in the design process as much as possible, however, it stresses the need of the user as a designer not only in the decision-making but also in idea generation.

More generally, these approaches help to foreground the lived experience of people with disabilities, and respect and recognise their way of interacting and knowing the world. For instance, Neate, Wilson and colleagues [95, 144] explore a variety of co-design techniques. The emphasis is on creating tangible design languages. In their work, they investigate the combination of personas and participatory techniques in working with people with aphasia. PD approaches also help to move beyond methods such as empathy exercises, which reinforce prejudice, misconceptions, and disability as something negative. Similarly, common design methods used within a participatory approach are highly visual, raising new challenges in involving people with visual impairments in the design process. Methods such as speech-based techniques (e.g., scenarios, and narratives), low-fi artefacts, and other tangibles artefacts (LEGO models, cardboard mock-ups, and so on) are used as adaptations of visual techniques, and to create a more accessible design space [20, 81, 82, 96, 97, 110]. For instance, Metatla et al. explore various cross-modal techniques to help make the co-design process accessible for people with visual impairments [81].

More recently, auto-ethnography has been used by researchers with disabilities to tell their personal stories. In ASSETS 2020 several researchers with visual impairments and other

disabilities expressed their experiences in different contexts. For instance, Stephens et al. told about the preparation and challenges of a recreational journey on a cruise as an independent blind traveller [125]. Noticeably, Hofmann et al. [56] have used this method to tell about their personal experience as researchers living with disabilities, They focus on moments when their disability was misunderstood, suggesting a more strong integration of disability studies perspectives and disabled people into accessibility research.

The literature demonstrates that there is limited research that investigates methods for designing AI assistive technology, involving people with visual impairments in the design process. More recently, research has shown the difficulties in involving people with disabilities in different phases of the design process of intelligent systems. For instance, Morrison [88] illustrates challenges in imagining new technologies that are tuned to people with VI needs and aspirations. Others highlight the difficulties in engaging with the autistic population when AI prototypes have been introduced in the design process [7]. Yang et al. [148] show that uncertainty around AI's capabilities, and output's complexity, which are intrinsically built into an AI system, may be a reason for design challenges. In particular, iterative rapid prototype methods which are commonly used during the design process might not be enough when working with AI.

2.6 SUMMARY AND RESEARCH GAP

The literature review presents the models of disability and introduces the theoretical framework, which this research draws from. It also illustrates two important areas which direct the next steps of this PhD work.

Firstly, the literature reveals that the interdependence frame seems especially applicable to understanding sighted guiding. However, as section 2.4 reports, AI assistive technology for navigational aid has been approached from a perspective of autonomous travel, reducing the "problem" of navigation to a sequence of steps and movements from one place to another. Therefore one direction this research takes is understanding the *problem space*, viz. looking at the sighted guiding partnership from an interdependence perspective to design AI assistive technology, instead of focusing on solutions that replace the guide with an AI system.

Secondly, design approaches presented in section 2.5 demonstrate that there is no HCI research looking at how to design AI assistive technology for interdependence. Although parallel research strands investigate accessibility and inclusion through participatory and UCD methods for AI prototyping, new challenges will rise when engaging people with mixed abilities in

thinking about the future role of AI technology. Therefore, it will be beneficial to explore current and new design methods which help to open up the *design space* at the intersection of AI and interdependence. New tools and methods are essential to inspire people to make alternative designs of AI, which will empower people with disabilities in social life.

The next Chapter investigates the sighted guiding partnership, presenting the first study undertaken for this research.

3 INTERDEPENDENCE IN ACTION (STUDY 1)

3.1 MOTIVATION AND RESEARCH QUESTIONS

In order to design AI AT for navigation aiming to extend the interpersonal interactions between people with visual impairment and sighted people, it was important to investigate the problem space, and therefore understand how people accomplish navigation together. As described in section 2.4 previous research has focused extensively on assisting navigation in the physical environment, by providing information about surroundings, through, for example, object recognition, obstacle avoidance, physical distance, the proximity of walls and so on. More recently, computer vision, artificial intelligence and machine learning have been leveraged in these navigation systems. However, research has not focused yet on how to design an AI system for supporting mutual interaction during navigation. What tends to be ignored is that many people with visual impairment rely on and work with others to navigate their daily routines, commonly relying on what is known as a sighted guide (see section 2.1.1). The interdependence framework has been presented by Bennet et al. [9] in ASSET 2018, and has been of inspiration for this work.

The aim of this study was to answer the following research question:

> **RQ1:** As an exploration of the problem space, **how do people with visual impairments and their sighted guides accomplish navigation together?**

This research question has been broken down into 2 smaller ones:

> RQ1.1: How do blind people and guides organise their bodies (and speech) with respect to one another to successfully orientate to and move through the world?
>
> RQ1.2: What are the opportunities for AI assistive technology in sighted guiding?

The remainder of this Chapter first describes the study method. This is followed by a findings presentation and a discussion section.

3.2 METHOD

To investigate the sighted guiding relationship, I conducted an empirical study in which I invited people with visual impairments and their sighted guides (with whom they usually travel) to video-record their real-world journeys using body-worn video cameras. As I assumed interpersonal coordination to be a key element in sighted guiding, I analysed collected data using interaction analysis to examine the details of how guiding and being guided were accomplished.

I now provide details on the participants in the study, how the study was structured, carried out, ethical considerations, and how I collected and analysed the data.

3.2.1 *Participants: the Sighted Guiding Team*

I recruited pairs composed of adults: a person registered severely visually impaired (blind) or visually impaired (partially sighted) and a sighted guide. Both had to live in the UK and know each other through guiding for at least 3 months. This allowed me to ensure that they had some experience in guiding each other, to investigate their established interactions as safely as possible, and also to observe their relationship with each other that might differ between pairs in terms of harmony, care and mutual understanding.

Participants were recruited through adverts via social media, emails to existing contacts and printed flyers. Since I was targeting both sighted and visually impaired people, different formats were essential; I made considerations for the diversity of vision impairments and accessibility of all electronic materials. I excluded people with cognitive or mobility impairments from the study that could have prevented them from giving informed consent or being able to travel outside the home without additional assistive mobility aids (a complete list of inclusion and exclusion criteria can be found in Appendix A.4). Accessible participant information sheet and consent form were emailed to participants in advance (see Appendixes A.5, and A.6). Informed consent was obtained at the initial face-to-face meeting between each pair and the researcher. Approval for this study was granted by the Computer Science Research Ethics Committee at City, University of London. Appendix A.1 reports the Ethics application submitted for this study. In appreciation of the participant's contribution to the research, I offered a £25 voucher per person.

Four participant pairs took part in the study and Table 3.1 reports a summary of demographic information I gathered (Appendix A.7 reports a list of demographic questions). The names used throughout the thesis are pseudonyms. As shown in Table 3.1, these pairs knew each other

between 2 and 20 years, ranging from only knowing each other through guiding to being married. For instance, Alan and Nick have a mentor-friendship and they have known each other for one to two years. Nick is the main founder of a charity and Alan is involved in a creativity project run by Nick's charity. Nick guides Alan every week from the tube station to Nick's studio and vice-á-versa. Nick said that guiding Alan every week is only a small thing that happens during the journey, there is much more going on and travelling with Alan is a great occasion to build their friendship. In contrast, Megan and Jack's relationship is quite different. They have known each other for 2 years and Jack has been guiding Megan for 1 year from time to time, but only when Megan needs particular assistance for travelling in unfamiliar and crowded places. Megan is quite independent and ordinarily uses a long cane in her daily journeys. While some of the participants had no sight, some participants were able to distinguish light and dark. In addition to sighted guiding, they also used tools such as white canes and guide dogs to travel on their own. All participants living with sight loss had an active life, using assistive technology such as screen readers, voice synthesizers, etc.

Pair *Person with VI	Relationship	Info about their vision	Aid for travelling	Assistive Technology
Megan* and Jack	2 yr - Guiding relationship	R: no vision L: blurry vision since birth	Long cane and sighted guide	Screen reader Voice synthesizer Magnifier
Alan* and Nick	2 yr - Mentorship	No vision since birth	Long cane and sighted guide	Screen reader Voice synthesizer Braille
Luke* and Alice	7 yr - Close friends	Light and dark for 27 yr	Long cane and sighted guide	Screen reader Voice synthesizer Apps on mobile
George* and Sara	20 yr - Married couple	R: only central vision L: blurry-no color for 35 yr	Guide dog and sighted guide	Screen reader Voice synthesizer Large monitor High contrast on computer/mobile

Table 3.1: Study 1: Demographic Information.

3.2.2 *Study Procedure*

Each pair was involved in the study over a period of 5 days. The procedure consisted of an initial meeting, and the pairs recording journeys (Figure 3.1).

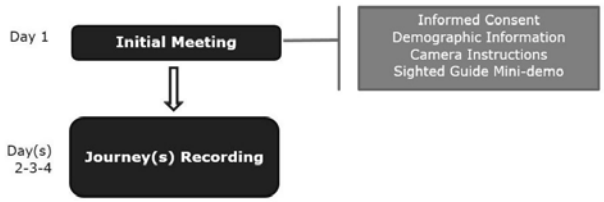
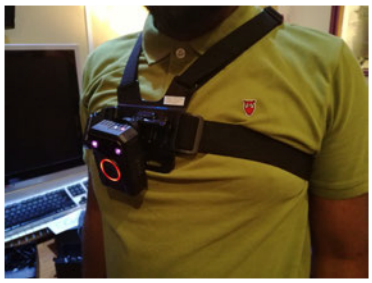


Figure 3.1: Research study procedure.

During the initial meeting between the pair and the researcher, I obtained informed consent and gathered demographic information. I then gave instructions on how to wear and use the cameras. Video recordings were captured using two body cameras, as illustrated in Figure 3.2. Cameras were worn by both participants using a harness at chest or shoulder height. The right position and orientation of the camera depended mainly on the difference in height between participants and how close they usually walk. I was interested in capturing the physical connection between the guide's arm and the visually impaired person's arm and the upper back of the guide. These parts of the body were captured by the visually impaired person's body camera (see Figure 3.2a). The second body camera, worn by the sighted guide, was aimed to record the guide's perspective. During the first meeting, I also did a mini-demo to verify that the camera configuration worked in relation to how pairs travelled together, using a wifi connection between the camera and the researcher's phone app.

Participants had three days (day 2, 3, and 4) to video record at least one journey lasting at least 20 minutes to guarantee enough valuable data. The journeys were chosen by the pairs themselves; the only stipulation was that the journeys be familiar to them, for example, going grocery shopping, to a museum, to a GP appointment, a coffee to meet friends, etc. This guidance was given because I was interested in the routines of everyday life and in capturing the ordinary ways people manage their partnerships. In addition, this choice allowed me to mitigate ethical concerns related to participants' safety (see the Ethical consideration sub-section for further details).

(a) VI person wearing camera.



(b) Sighted guide set up.

(c) Frame from video data showing both different perspectives: VI person perspective on the left and sighted guide on the right.

Figure 3.2: Body cameras set up.

3.2.3 *Ethical consideration*

During the plan of the study the ethics have been considered extensively, and the approval was granted by the Computer Science Research Ethics Committee at City, University of London. More information about the ethics application and related materials can be found in Appendix A.1. Risks and burdens addressed during the application were related to (i) participants' abilities and safety; (ii) data leaking; (iii) confidentiality of data.

PARTICIPANTS ABILITIES AND SAFETY. Accessibility and safety did not involve considerable burdens. All materials were created in both written and digital formats. Digital versions were made accessible through screen readers. I also provided options for signing the informed consent (e.g., recording an audio signature, and using a signature guide). A major concern was related to the journey itself. Although people with visual impairments are often considered adults at risk in the Ethics application form, I looked for people who were independent and capable in their daily life activities. Moreover, thanks to the established partnership through guiding I was seeking, the study took place in a safe condition. Indeed, sighted guiding provides an enjoyable way to explore familiar and unfamiliar environments across the visually impaired community [123],

for building and intensifying relationships [35, 69], and for feelings of freedom [78]. In addition, to mitigate ethical concerns related to participants' safety, I asked them to choose routine journeys of everyday life.

DATA LEAKING. Since participants had body cameras at home for three days, the journey session was a critical stage for potential data leaking. Cameras could have been stolen, and/or unauthorised people could have access to sensitive and confidential data. To minimise the risk of unauthorised access to the video data, I used two S-EYE body cameras from Shelleyes Group, with built-in the AE256 encryption protocols. This protocol encrypts video data on the fly and data access is password protected. Cameras were also highly appreciated by participants because they were accessible, had a simple layout, big buttons with different textures, and a variety of audio and vibration feedback features.

CONFIDENTIALITY OF DATA. Given the chosen method of analysis described in Section 3.2.4, the complete de-identification of participants' faces in video data would have limited the ability to analyse data and communicate findings of my research study at conferences, workshops and in publications. However, I acknowledged, participants could have been concerned about revealing their identities through video recordings and there may also have been threats to privacy for those who have not agreed to participate in the research (e.g., bystanders). To address these issues, the following precautions have been taken to secure people's right to and protection of privacy:

- Only the project team, composed of supervisors and myself, had permission to review video data containing participants' identifiable faces during the analysis phase.
- Participants have given explicit consent for using video data segments in academic publications, presentations and workshops and they had the opportunity to express their preference about whether they wanted their faces blurred. Further, I used pseudonyms instead of their real names in any publication and throughout the project.
- Both audio and video data intended for any academic publication were reviewed to find identifiable data, such as names of participants, friends, family and names of workplaces or locations frequently visited and so on. This data has been anonymised (e.g. audible redaction, and/or blurring). Bystanders were also blurred.

- Both audio and video data have been encrypted and stored in a folder protected by a password on an external hard drive and have been managed only by myself.

3.2.4 *Data Collection and Analysis*

In order to analyse the collected video data, I proceeded to a video data pre-processing. Figure 3.3 shows the steps I followed in cleaning data before analysis. Even though I asked people to record journeys of at least 20 minutes, video data was stored in the camera memory in clips of ten minutes each by default. Therefore, the entire journey was divided into several clips. Firstly, I downloaded from the cameras all clips of all participant pairs. For each pair, I collected 2 different video perspectives: the guide's perspective (G's clip in Figure 3.3) and the guided person's perspective (VI's clip in Figure 3.3). I then synchronised each clip of both perspectives using Adobe Premiere Pro CC 2018 video editing software. To do so, I created a new video file containing both frames so that the guide's video and the guided person's video were displayed, visually, side-by-side (see Figure 3.3). After that, I synchronised the video and audio tracks. The video data pre-processing has been done for all video clips, and the new synchronised files have been used for data analysis.

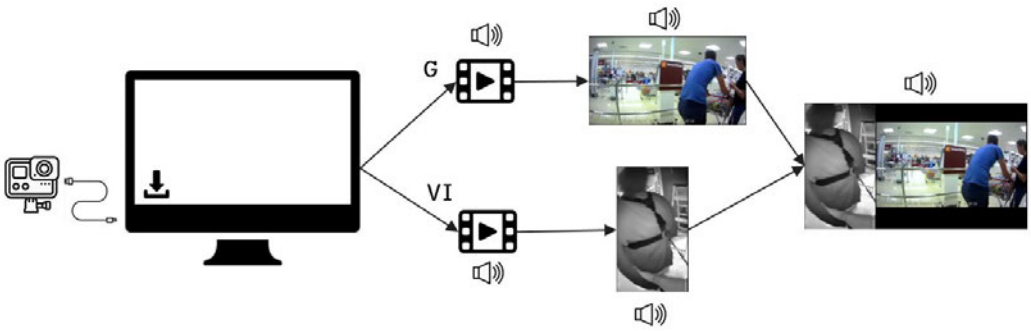


Figure 3.3: Steps of video data pre-processing.

Across four participant pairs, I collected 6 journey records in 23 shorter clips of 10 minutes (i.e., a total of 4 hours of journey data). For each pair, Table 3.2 summarises briefly the context of their journey ('description' column), how many journeys I collected ('journey' column), and how many synchronised clips of 10 minutes I analysed ('clips' column).

The data was analysed with interaction analysis, which is a qualitative research method, well established in studies of the workplace [53, 54, 80]. The theoretical underpinnings of this approach, owing much to conversation analysis and ethnomethodology, offer a means of

Pair *Person with VI	Journey	Description	Clips
Megan* and Jack	1	Journey from City, University of London to a store in the city centre. The pair walked, took the tube and did some shopping at the store.	7
Alan* and Nick	2	Journey from the tube station to Nick's studio and vice-versa. The pair walked and took the bus.	2+2
Luke* and Alice	1	From home to a high street to do shopping in different shops and a supermarket.	5
George* and Sara	2	During the first journey they did shopping in a big supermarket and then in a smaller store nearby. On the second journey, they walked in a high street and got into different shops.	4+3

Table 3.2: Video data information

understanding how interaction is made intelligible and thus consequential to the members of a setting, so, for example, how people cross a road at traffic junctions without constant collisions [75] or musicians achieve synchrony [142]. Over the past two decades, it has also emerged as a research method to investigate specialised forms of social activities [53] and more recently in everyday and technology-mediated settings [22, 70, 104].

Interaction analysis is also adopted in HCI and CSCW research as a method of analysis to inform technology design, for example, to describe how tourists work together in groups, collaborate around maps and guidebooks [21], how passers-by interact with urban technology in public space [4], and how people collaborate and jointly interact with other mobile technologies while driving [101]. Especially relevant to the work I present, Due et al. [30] show how people are able to detect obstacles during navigation using a white cane and describe design implications for future technology. More generally, interaction analysis has been used to study disability in context. For example, Goodwin [43] (a central contributor to interaction analysis and conversation analysis), has used the research method to demonstrate that limitations to vocalised speech can in many ways be overcome through pointing gestures, head-turning, and gaze in collaboration with others in a setting.

In practice, interaction analysis relies on repeated and careful re-watching of recorded video to produce detailed transcripts of spoken and interpersonal interactions, including non-verbal communication (for example how people orient their bodies, which gestures they use, what they are pointing to and so on) to investigate "*the ways in which specialised tasks and activities*

are accomplished through embodied activity, activities that involve the interplay of talk, visible conduct and the use of various objects and artefacts, tools and technologies" [52].

In my research, because of the depth and detail of interaction analysis, I chose to focus attention on salient segments/excerpts from across the 23 clips I collected. I conducted interaction analysis following these steps.

STEP 1 – TIMESTAMP ANNOTATION. During the first video watching, I annotated a timestamp for each clip when interesting interactions caught my attention. An example of annotation is reported in Figure 3.4. As suggested in [65], I wrote down actions and timestamps spontaneously, without questioning myself and being explicit about the criteria used to define what was interesting in that context. Secondly, I went back to the timestamp annotations, I discussed with my supervisors what was happening, and how participants interacted with each other in that situation, and we selected clips which represented examples of coordinate interactions (for example, how companions move through obstacles, how companions start and end the journey, how they use body movements, verbal utterances, and so on).

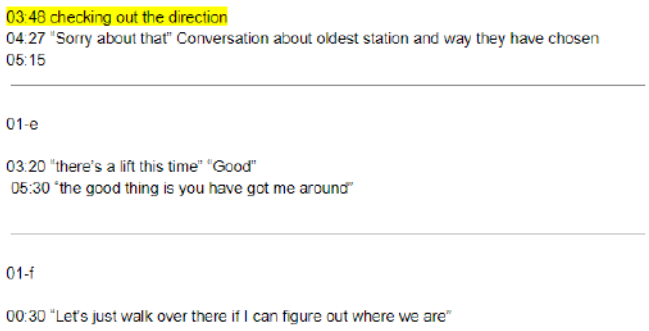


Figure 3.4: Example of timestamp annotation.

STEP 2 – SEGMENT IDENTIFICATION. In this stage I then defined 40 segments. A segment or excerpt is a short footage from the data, which lasts on average 20 seconds. Segments were chosen through repeatedly watching the recorded data around the selected timestamps, individually and as a team, and identifying parts I felt presented compelling examples of coordinated interaction. In particular, I looked for examples of how the participants worked together to move through/past obstacles such as narrow gaps, curbs, cars, and other people,

and how they managed barriers or crossing thresholds such as moving in/out of buses and stores. I also paid particular attention to moments which emphasised the work done by pairs to co-locate themselves in the guiding configuration while for example shopping, paying at the counter or beginning/ending a new journey.

STEP 3 - TALK TRANSCRIPTION. I proceeded with a more in-depth analysis of the 40 segments. I carefully re-watched each segment several times to produce a transcript of the verbal communication. Talk transcription draws from conversational analysis and its principles. Therefore at this stage, I focused on talk, pause, change of voice and pitch, open-up and closing [116], and troubles and repairs [115]. The interaction analysis syntax —I used— is reported in Appendix A.8. Figure 3.5 shows what a talk transcription looked like after this step. At the end of this stage, video segments and transcriptions were re-watched and discussed with my supervisors to think about what was happening in more detail, and start identifying initial common themes. Initial common themes were related to resources, interdependence work, people's agency, guiding control, and challenging moments.

07:04 N: yeah yeah did he recommend as an organization?
07:06 A: no::, I just I kinda did my research and I found it // and I was like oh god this is- this is what I found and it was like awesome=
N: ah
07:12 N: =did he enjoy working for them?
07:13 A: I think he did yeah
(0.5)
07:18 A: I think he- I think he knew he might interview me also // he is quite handy=
N: ah, okay
07:23 N: =( ) inside the track
07:24 A: yeah, pretty much

Figure 3.5: Example of talk transcription.

STEP 4 - NON-VERBAL COMMUNICATION TRANSCRIPTION. In this stage, segments were watched again individually and with my supervisors to decide which ones to pay further attention to. The choice was based on the initial themes, and diversity of coordinated interactions. I detailed the analysis of around 20 segments adding information about non-verbal communication. Specifically, I focused on gestures, walking, orientation, changing of space in relation to one another, distance, objects, and actions. I added annotations on the transcription, often including screenshots from clips as shown in Figure 3.6.

[Alan and Nick are walking at normal speed, next to each other. Alan is holding Nick's elbow]
07:04 N: yeah yeah did he recommend as an organization?
07:06 A: no::, I just I kinda did my research and I found it // and I was like oh god this is- this is what I found and it was like awesome=
N: ah
07:12 N: =did he enjoy working for them?
07:13 A: I think he did yeah

[Nick is slowing down while he is turning on his right and is passing close to other pedestrians and then speeds up again]
(0.5)
07:18 A: I think he- I think he knew he might interview me also // he is quite handy=
N: ah, okay
07:23 N: =( ) inside the track
07:24 A: yeah, pretty much

Figure 3.6: Non-verbal communication.

STEP 5 – SEGMENT DESCRIPTION. Detailed segments were discussed again with my supervisors thinking about what people did in relation to one another, how that happened, and which alternative actions people could have taken in response to some events. We also discussed segments in relation to the initial themes. Refining themes allowed us to select 10 segments which represented a variety of examples. I expanded these segments, introducing some contextual information about participants' relationships, the actual vision of guided companions, and how they usually approach the sighted guiding technique (see Figure 3.7). This information was used to put actions into context. In a similar way to how interaction analysis findings are reported in CSCW [22, 55] and in other research communities [43, 70], I chose to present segments that best illustrate the themes documented in Section 3.3. Specifically, segments were selected that featured different aspects of the use of multimodal resources to co-constitute a common space; the interdependent work done in sighted guiding; and instances of ruptures and repairs to common space.

Segment: **Passersby coming up**
From video P01_J01b.mp4 (07:04 - 07:27)

Participants:
Alan - VI
Nick - G

Context:
Alan is totally blind since birth, he usually goes around using a long cane, however he does not use it if Nick is guiding him.
Alan and Nick are in a mentor-friendship and they have known each other for one/two years. Nick is the main founder of a charity in London that helps express young adults through music and other creative processes such as acting, creative writing, filmmaking, dance and so on. Alan got in touch with Nick to take part in this project. They see each other every week and the journey from the tube station to Nick's studio and vice versa is very common for them. Nick uses to guide Alan since they have met and throughout the video records it is clear that this guiding relation is well-established. During the interview Nick says that guiding Alan every week is only a small thing that happens during the journey. Indeed he says there is much more going on and traveling with Alan is a great occasion to build up their friendship.

Analysis:
In this clip Alan and Nick are walking toward the tube station and they are approaching a crossroad where they have to turn on the right. Some other pedestrians are approaching the same crossroad and walking very close to our friends.
The conversation is a question and answer between Nick and Alan. This turn-talking pauses when Nick starts slowing down and turning on his right to avoid pedestrians and take the right way. At this point there's not interruption by Alan, but he decides to resume the conversation as soon as they speed up. In this fragment we can see how Alan is actively engaged in the journey and how the feeling of shifting from a situation potential critical to a usual walk enables him to relate with Nick. We can also notice how important is the timing of the pause in the talk in relation to the walking speed. Indeed as soon as Nick is walking closer to the passersby he slows down and the conversation stops for 5 seconds. Has Alan realised that something is changing in the environment? What the segment shows is that it is Alam himself who actively resumes the conversation when Nick speeds up. There is not an explicit attempt to describe the space around, but the change of walking speed and the pause of talk is an implicit combinations of resources that helps Alan to receive clue about the environment through and thanks this interpersonal relational with Nick

[Alan and Nick are walking at normal speed, next to each other. Alan is holding Nick's elbow]
07:04 N: yeah yeah did he recommend as an organization?
07:06 A: no::, I just I kinda did my research and I found it // and I was like oh god this is- this is what I found and it was like awesome=
N: ah
07:12 N: =did he enjoy working for them?
07:13 A: I think he did yeah

Figure 3.7: Example of contextual information.

3.3 FINDINGS

Below, I select a set of 6 relevant segments/excerpts out of 40 to present the findings. For each segment, I present a short description to introduce the participant pair and the context of their journey; this is followed by a detailed analysis. A transcription of the conversation, along with images to show non-verbal communication, is attached at the end of each sub-section. Appendix A.8 provides a detailed explanation of symbols used in the transcription.

Through the following analysis, I aim to develop three ways of making sense of the sighted guide relationship paying particular attention to the ways interdependence plays into their coordinated actions and movements. Broadly, I show (i) how a common space is co-constituted

between people with vision impairments and their guides; (ii) how, as a form of interdependence, this work together is interwoven into the ordinary and unfolding sequence of interactions; and (iii) how the unfolding relations in/through space are subject to rupture and open to repair.

3.3.1 *Co-constituting a Common Space*

In the first of the analysed segments, I describe how pairs work together to establish a common space to move in and through. Specifically, I show how a mutual orientation to talk, body movements and gestures, and other objects help to constitute a space that can be navigated together. Noteworthy will be the coordinated actions between the pairs, what I wish to highlight as the *co-constituting of space*. It is through these coordinated orientations and actions that I will show *how*, exactly, interdependent relations are accomplished between people with vision impairments and their guides.

3.3.1.1 *"Come on Step Down":*

Through this first excerpt (see Segment 1), I begin the analysis by considering how both talk and objects—objects like canes—play into constituting a common space between pairs. Luke, Visual Impaired Person (VIP), and Alice, Guide (G), are walking in their neighbourhood as the conversation turns to the nice weather over the last few days. The friends walk side by side—Luke is holding Alice's arm with his right hand and holds a long white cane on his free (left) arm. As they approach a sidewalk curb (line 12), Alice announces *"come on ↑step down Luke"*. This utterance and Alice's *"curb and bicycle ↑step up"* in a subsequent turn (line 17), briefly interrupt the ongoing conversation.

Notice, first, how talk itself is being used to coordinate actions and establish a common understanding of space. Well-established works in conversation analysis show that *how* talk is conducted can serve as a resource in the organisation of turn-taking [109]. For example, how interlocutors say what they say can indicate the way a sequence of turns occurs, the opening up and closing of topics of talk [116], and the repair of troubles in talk [115]. (In conversation analysis, repair refers to the ways in which talk is kept on track. Repair techniques can be displayed through a subsequent spoken turn, but also using a variety of non-lexical speech perturbations, cut-offs, sound stretches, onomatopoeic words, etc.). What these works allow us to identify are the relevant methods used to establish the change in a conversation's topic and

how some changes are achieved turn-by-turn, coordinated through a mutual exchange of verbal and non-verbal signals.

In the segment described above, Alice forewarns Luke of the sidewalk's curb through a change in tone and raising pitch in talk (i.e. *"↑step"*). This adjustment in talk provides Luke with a cue, indicating the utterance refers not to the ongoing topic—the weather—but another matter, in this case, to do with navigation. Further, phrases such as *"come on"* and *"Luke"* are used to emphasise a discontinuity between the primary topic and the navigational cues she provides. This, I might suggest is one reason why Alice does not have to begin a lengthy explanation of the approaching curb, but is simply able to say *"step up"* or *"step down"* to establish a shared sense of space.

Of course, the act of walking together, and the mutual awareness that obstacles like curbs and steps must be managed together, also attribute phrases like *"step up/down"* with an *indexical* quality. That is, I see that *when* something is said can serve as an *index* to a feature in the environment without an explicit need to describe it in full (similar to saying, for example, *"that"* and pointing at something). The critical point here is that space for Luke and Alice is being continually composed or established through an ongoing and interwoven set of mutually produced and intelligible resources.

Let us consider one further point from this excerpt. Above, it seems Luke's white cane plays a consequential role. The cane has just touched the pavement (Fig. 3.8d) when Alice says: *"step down Luke"* and, again, is swept against the sidewalk corner when she announces *"step up"* (Fig. 3.8f). The importance of the white cane as a resource to detect troubles and obstacles has been explored by Due et al. [30, 31]. In their work, they observe how visually impaired people use their canes to skilfully and competently navigate while traversing known routes; this illustrates the variety of resources being brought to bear on navigation. What the interchange between Luke and Alice adds to this previous research is a recognition of the coordinated actions between a pair walking together: the synchronisation in time and space—between Alice's talk, Luke's cane sweeping, and their shared walking pace—looks to be critical to their successful navigation and for Luke to confidently take the following next step up. Notably, there is no hesitation on Luke's part, and there are no pauses or the need for other repairs [109] after Alice's alert. The cane becomes relevant because what Luke perceives through it is combined with Alice's utterances, her change in pitch and tone, and their common movement. Again, altogether, I witness a rich and multi-threaded composition of space, and a space constituted together.

Segment 1 - **Come on step down** (Luke and Alice)

```
1     L:    that's nice, isn't it?
2     A:    that felt like the other week
3     L:    ye::ah
            0.4

            Fig 3.8a
            ▼
4     L:    this will (of an autumn) not just straight into winter
5     A:    yes::
6     L:    really nice
7     A:    I know
8     A:    o::h () we are going to (X) today Luke // too much (checking) traffic probably
9     L:    *(what's the plan)*

            Fig 3.8b
            ▼
10    L:    still traffic // alright
11    A:    *((coughing))*

                                                  Fig 3.8c
                                                  ▼
12    L:    in theory it may be a good go for the camera=

                                    Fig 3.8d
                                    ▼
13    A:    =come on ↑step down Luke=
14    L:    =( ) this is illegal I mean // ehm
15    A:    *((laughing))* it is not illegal Luke it is perfectly safe
16    L:    it is not true // ( )

                              Fig 3.8e   Fig 3.8f
                              ▼          ▼
17    A:    *curb and bicycle, ↑step up*
      →     0.5
18    A:    ye:::ah we made it
19    L:    yap
20    A:    so far
21    L:    one piece
```

(a) L and A walking on the pavement

(b) L and A approaching a curb

Figure 3.8: Segment 1 - Come on step down (Luke and Alice).

(c) step down L

(d) The cane is touching the pavement

(e) A alerting L about the curb

(f) step up

Figure 3.8: Segment 1 - Come on step down (Luke and Alice).

3.3.1.2 *"Go Skinny":*

In a second segment, *"Go skinny"*, I draw attention to the use of *gestures* and the *body* as common resources and how their use serves, like talk, to co-constitute a space and aid navigation.

In this second segment, another participant pair, George (VIP) and Sara (G), have just paid at a supermarket checkout and are heading towards the store's exit (Segment 2). Approaching a narrow gap to their right, they walk at a regular pace, almost side by side, with George holding Sara's arm (Figure 3.9a). As they near the gap, Sara prolongs the word *"because"*. She then pauses before saying *"go skinny"* (line 3). As they step forward, now at a slower pace, Sara stretches out her arm and then brings it behind her back. George is guided by Sara's arm movement and steps behind and further from her (Figure 3.9c).

As with the example above, this segment illustrates how pairs arrange their bodies and talk as they move through space and encounter obstacles. Thanks to Sara's gesture (stretching and moving her arm behind her), the two change their body configuration to pass through the narrow gap. Sara's extended *"because"* and then *"go skinny"* anticipates this gesture, as does the pair's slowing down. Again, there is no need to explicitly announce the presence of an obstacle. Rather, the gap is indexed through the coordinated acts of speech and bodily movements.

Of particular interest in this segment is what follows. As the pair move through the gap, a pause in talk occurs. Not unlike the occasional pauses in talk between automobile drivers and their passengers [70], the pause marks a shift in focus and a tacit agreement that another matter demands immediate attention—the silence between George and Sara at the same time is demanded by the need to navigate the narrow gap and is a signal of the work they are engaged in to move through it. Moments later, the pair's resumption of talk is tacitly accomplished in a similar way. Moving his hand from Sara's wrist to her upper arm, George both returns to talking and moves to restore the side-by-side configuration (Fig. 3.9d and 3.9e). It is only then that Sara bends her arm to accommodate George beside her again (Fig. 3.9f). This sequence ends with a *"well done"* from George (line 4), a typical utterance used in closing a sequence [116] and Sara returning to the faster pace of walking.

What is apparent in this interchange is how it is not just that bodies and talk are working together. A common space is also being established, one where through a series of interwoven utterances and bodily movements a narrow gap is collectively established and navigated. Despite their different capacities for seeing and a variety of bodily and spoken interactions, full with nuance and subtlety, the two succeed in composing a space to move through. As Goodwin exemplifies in the analysis of talk between Chill, a man with aphasia, and his family, situations are made mutually intelligible through the situated conduct of the interlocutors (i.e., talk and gestures) [43]. Likewise, between George and Sara, space is made mutually intelligible and indeed actionable through the couples combined and sequential interactions. In other words, it is through their actions together, that a space-in-common is constituted.

Segment 2 - **Go skinny** (George and Sara)

Fig 3.9a

1 S: she might not, she she was talking about it before she ran away
2 G: right

Fig 3.9b

3 S: becau::::se [pause] right go skinny
→

Fig 3.9c

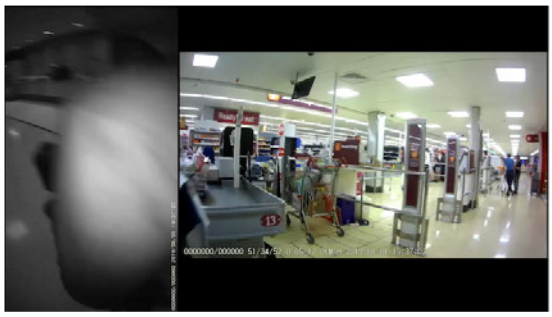
[Sara moves her arm on her back. George's hand follows her arm. They are further to each other. Slow down and Pause in talk]
0.8

Fig 3.9d Fig 3.9e

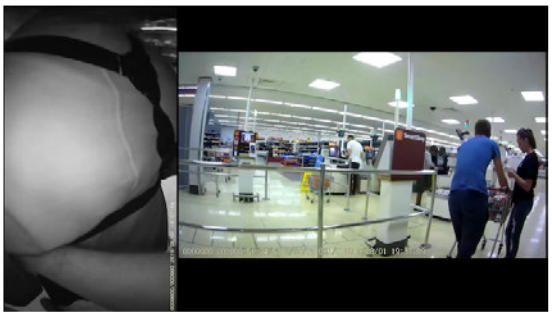
[George moves his arm from Sara's wrist to Sara's upper arm]

Fig 3.9f

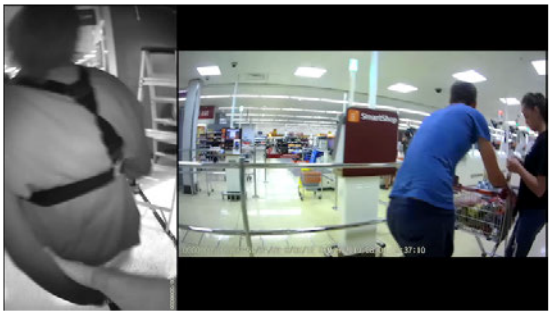
4 G: well // done [they speed up]
5 S: *sh*thank you she was ( ) she was talking about before she went away becau::se she
6 said even though she spent a week with him she hasn't spent any time with ( ) she
7 is not gonna seen him for a couple of weeks [pause] she wants to [pause] see him
8 basically
9 G: I am sure she will be fine



(a) Narrow gap between two persons and the wall/trolley



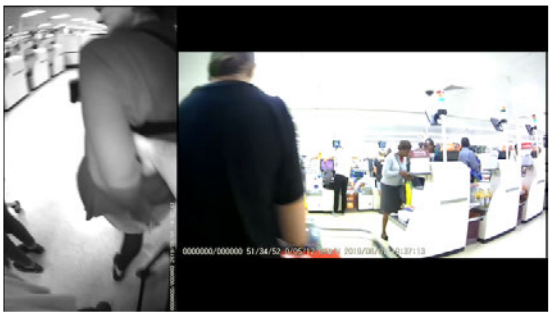
(b) Go skinny



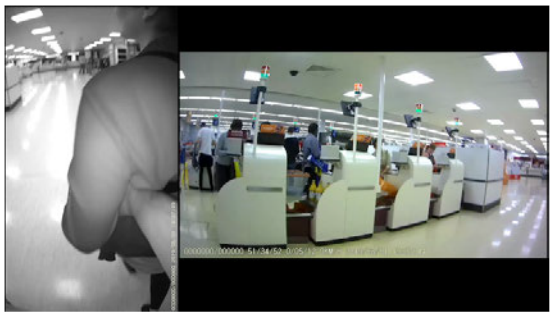
(c) S moves her arm on her back

(d) G moves his hand up

Figure 3.9: Segment 2 - Go skinny (George and Sara)



(e) G holds S's upper arm



(f) G and S speed up

Figure 3.9: Segment 2 - Go skinny (George and Sara)

In sum, through the above, I have illustrated how a common space can be co-constituted between people with vision impairments and their guides. That is, when couples do not share dominant sensory modalities (in this cases, sight), a particular work is made apparent that helps to establish a space in common and the capacity for movement through it. As I have seen, multiple resources are employed to provide information about bodies and their movements *vis-à-vis* the physical environment. Critically, this work is mutual, drawing on shared orientations to and mutual interchanges around talk, body gestures and movements, and objects.

3.3.2 *Interdependence Interwoven into the Sequential Interactions between Pairs*

The analysis so far highlights how resources do not always explicitly refer to the physical environment or deliberate navigation. Instead, the segments illustrate a complexity to the timings and rhythms people deploy while they coordinate their (inter)actions and interact with the environment and other objects.

Thus, I begin to see how interdependence is enacted through a continuous, intermingling of the "simplest systematics" of talk and interaction [109]. The conventional idea of a guide chiefly doing the work of guiding a person with visual impairments belies the continual back and forth between the two actors, a relational achievement that makes even the most routine and unremarkable movements a highly collaborative venture. Although I want to avoid any crude parallels, I find a similar sophistication between people with vision impairments and their dogs [111], and indeed between people and dogs more generally [42, 74]. The point here is not that human guides are analogous to guide-dogs, but that there is a nuanced and interwoven character of such relations that turn on different but also shared sensory modalities and resources.

Following on from the above examples, through two further segments I want to further draw out the subtleties of this collaborative work and in doing so give particular emphasis to the interwoven and mutual engagements between people with visual impairments and their guides. That is a necessary interdependence in their relationships.

3.3.2.1 *Passers-by Approach:*

Turning to the third of the segments, where Alan (VIP) and Nick (G) are making their way to a Tube station, I find much in common with Segment 2, above. As in the example with Sara and George, who pause their conversation to pass through a narrow gap, I observe Alan and Nick momentarily falling silent as they navigate around some approaching passers-by (lines 6-7). The conversation pauses as the pair slows down and veer to the right to avoid the upcoming pedestrians (see Figure 3.10). However, in contrast with the earlier example, there is no explicit announcement from Nick, of *"go skinny"* or otherwise. The change in direction and speed, and pause in talk appear to be sufficient for Alan to recognise that the space ahead is changing. Along with these cues, Alan responds accordingly, working in synchrony to maintain the silence and giving the pair the chance to attend to the approaching obstacle. I know that such synchronous interactions between interlocutors emerge through "a rich interplay between language processes and outward action" [106, p. 76], and that even the organisation and sequence of pauses and the return to talk depend heavily on verbal and nonverbal cues by both speakers [25]. This exchange then demonstrates a mutual dependence. Certainly, Nick is leading, but Alan is responsive to the subtle pace and rhythm of the cues and plays his role in constituting and navigating the space. If the situation was otherwise, I might imagine spoken interruptions, the need for repair, or possibly a collision with the passing pedestrians.

The same coordination is seen in the couple's return to their original walking pace and conversation. Guiding, Nick appears to initiate the increased pace of walking and as this occurs Alan restores the conversation (line 7), picking up where they left off. It is in this sense that the two are co-participants in the accomplishment of the navigation. Both are enabling each other through the use of verbal, bodily and spatial resources and through a mutually coordinated sequence of interactions.

Segment 3 - **Passers-by approach** (Alan and Nick)

```
      start [Alan and Nick are walking at normal speed, next to each other. Alan is holding
            Nick's elbow]
1     N:    yeah yeah did he recommend as an organization?
2     A:    no::, I just I kinda did my research and I found it // and I was like oh god this
3           is  this is what I found and it was like awesome=
4     N:    *ah*
            0.2
5     N:    =did he enjoy working for them?
6     A:    I think he did yeah

            Fig 3.10
            ▼
            0.5 [Nick is slowing down while he is turning on his right and is passing close to
      →     other pedestrians and then speeds up again]
7     A:    I think he  I think he knew he might interview me also // he is quite handy=
8     N:    *ah, okay*
9     N:    =( ) inside the track
10    A:    yeah, pretty much
```

Figure 3.10: Segment 3 - Passers-by approach (Alan and Nick)

3.3.2.2 *Freezing-up:*

Through this next example, I want to continue with this idea of how a pair enables each other in and through their turn-by-turn interactions. The situation I now turn to, is though, a more complex one where a couple loses contact with one another. In the segment in question (Segment 4), Luke (VIP) and Alice (G) have just bought drinks and food in a café and are walking away from the till. As Luke takes the opportunity to move his cane from one arm to the other (Figure 3.11b), Alice lets go of him and then turns back to retrieve something from the counter (Figures 3.11c and 3.11d). At first glance, Luke's reaction to being left on his own, stopping

suddenly, or *"freezing-up"*, looks to signal his inability to act. I might assume he is at a loss, unable to manage on his own.

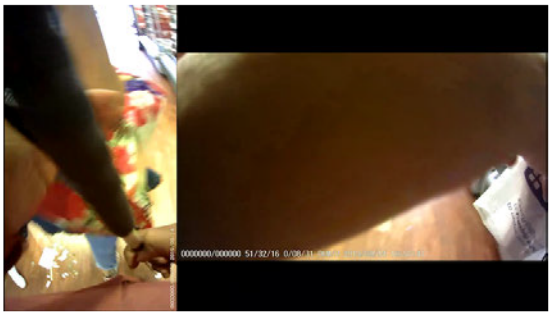
The reader should know, however, that Luke is in fact a highly independent man who lives on his own and regularly travels by himself. A more nuanced reading of the situation I encounter in Segment 4 is then that, in unexpectedly losing hold of Alice, Luke is responding to a *re*-configuration of space. As I have seen in each of the examples above when a person with a vision impairment holds their guide, a space—a space to move in—is constituted together. To freeze here is to adjust to a new space and the alternative possibilities it affords. It is likely a response to avoid potential collisions with others, yet it also invites something more. As Middleton and Byles suggest in their studies of people with vision impairments travelling in cities, freezing can also be a sign of one being open to other "interdependent exchanges" [86, p. 82]. Thus, Luke's freezing-up might be read equally as an opening for Alice to replace her arm, an active cue for her to re-establish physical contact.

Let us review the sequence (lines 3-6) in finer detail to consider the possibility of this greater interdependence between the pair. Luke's first action (moving his cane from one arm to the other, see Figure 3.11b) suggests he is already seeking to repair an unusual arrangement. In the sighted guide configuration they regularly adopt, Luke usually holds Alice's left arm. When Luke lets Alice's right arm go, he is thus seeking to re-establish their regular respective positions. Stepping away (Fig. 3.11c) and turning towards the counter (Fig. 3.11d), Alice appears to respond to Luke by stretching her left arm toward him (Fig. 3.11d). Not able to reach him, she says *"come on Luke"* (line 6), re-establishing a common space before she is actually able to make physical contact.

Segment 4 - **Freezing-up** (Luke and Alice)

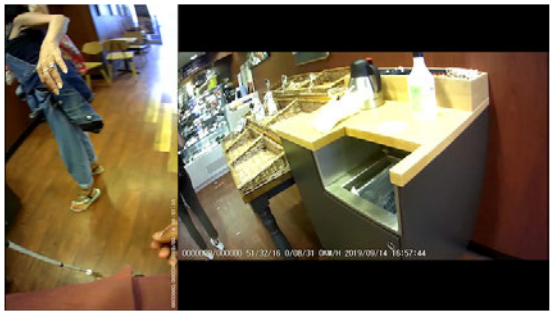
```
                [L and A they have just bought some food and they are approaching some table to
                have a seat]
1       A:      come one // Luke
2       L:      *do you want* to try the vegan

                    Fig 3.11a
                    ▼
3       A:      yeah

                Fig 3.11b
                ▼
                [L lets go A's arm to change the arm that supports the cane]
    →
                                                Fig 3.8c
                                                ▼
                [L slightly stretches his arm to probably find Alice's left arm]
                0.4

                                            Fig 3.11d
                                            ▼
4       A:      ok yes, of course I forgot=
5       L:      =eh?
                0.2

                            Fig 3.11e
                            ▼
6       A:      come on Luke
```

(a) L and A are walking towards some chair



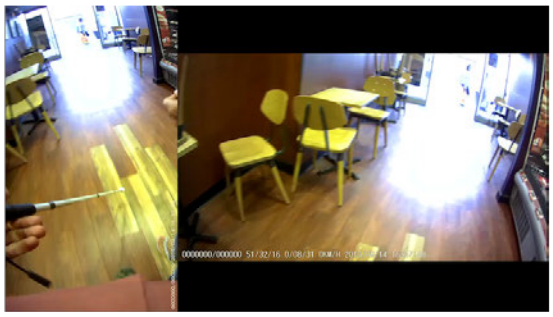
(b) L changes hand's cane

(c) A steps forward



(d) A turns toward the counter

Figure 3.11: Segment 4 - Freezing-up (Luke and Alice)



(e) L is holding A's left arm

Figure 3.11: Segment 4 - Freezing-up (Luke and Alice)

The broader point to draw from these segments is the ongoing and orchestrated work of interdependent interactions. At a micro-level of interaction, involving forms of talk, gestures and body movements, pairs build up and continually attune their relations with one another. For Alan and Nick, and Luke and Alice, the interdependencies between the couples move fluidly, but there is an agency in both directions, the actions from one member of a pair invite actions from the other, the resources are used by one and in turn create the conditions for the other to act. In this way, interdependence is threaded through the relations, it is an integral feature for couples moving in and through spaces together.

3.3.3 *Ruptures and Repairs to Common Space*

In their article *Troublesome Objects* [30], Due and Lange describe how the sweeping white cane can help to detect obstacles, but also simultaneously marks an arch in front of the person using it, alerting passers-by that the space should not be obstructed (also see [143]). Again, I suggest that this constituting of space is performed in a similar way between people with visual impairments and their guides. Between the pairs, I find a common space being co-constituted through fine-grained and nuanced interactions, and, specifically, emerging through interwoven and sequential acts of talk, bodily movements and gestures, and mutual references to objects. In this way, the interdependent production and use of space can be understood as a taken-for-granted feature of ordinary (inter)actions.

So far, I have presumed a fluid and untroubled co-production of these acts and the corresponding realisation of a common space. When navigating together, however, I also find pairs may need to put more explicit effort into establishing what, exactly, constitutes a common space and how to (inter)act in it. As I saw in the last example (3.3.2.2), ruptures can arise that demand

repair to reestablish a space in common. In this section, my interest thus turns to how people with visual impairments and their sighted guides negotiate their ideas of space. Specifically, I present two segments, *"Wait here, wait here"* and *"Two for six"*. The former explores, in detail, how the coordinated actions of *"letting go"* can change the focus from a common space to a more personal one. The latter, *"Two for six"*, describes how a change in pitch is used as a resource to repair and re-establish a common space.

3.3.3.1 *"Wait Here, Wait Here":*

In the first of these two examples, I return to Alan (VIP) and Nick (G), see Segment 5. Here, the pair are leaving a café, walking side-by-side with Alan holding Nick's left elbow. Reaching the doorway, Nick realises they have forgotten Alan's backpack. *"Wait here, wait here"*, he exclaims (lines 5-7), as he turns and removes his arm from Alan (Fig. 3.12a). Nick's utterance is pronounced using a firmer tone of voice to emphasise its different, instructional status in talk. As I see Nick return to the table where the bag has been left, Alan's subsequent question: *"that's bad, isn't it"* is left unanswered (lines 8-9).

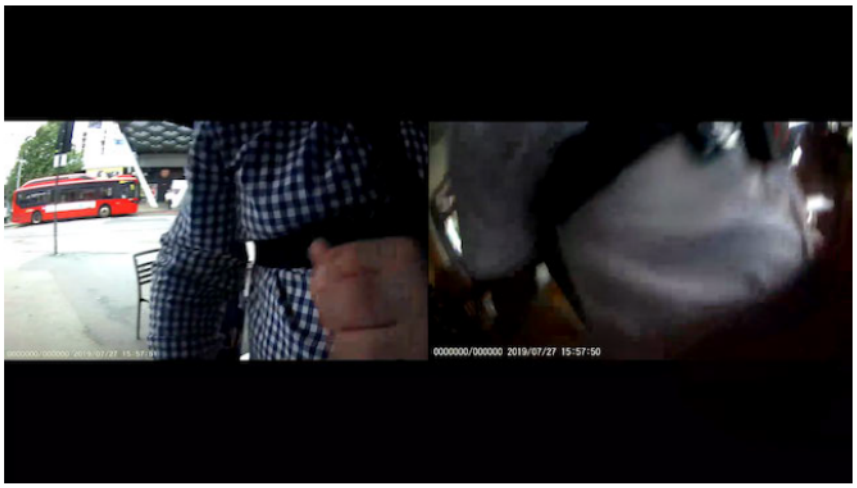
I see here how a pair moves from coordinating their actions and co-constituting a common space to operating alone. That is, the pair go from being physically co-proximate (with Alan holding Nick's arm), moving together, and Nick offering a verbal indication of his relative movement, to each individual operating in separate, personal spaces. Like Luke and Alice in the previous example (Segment 4), this transition from being together to being separated is not without its troubles. Alan's unanswered question suggests a problem: even though Nick alerts him with *"wait here"*, the follow-up question shows the transition is not mutually intelligible—that the changing circumstances are not understood simultaneously or equally by the pair. Alan's question is left as a rhetorical statement, whether intended or not. The contrast with the coordinated actions and flow of talk I see while pairs co-constitute a common space is stark.

The problem appears to turn on the abrupt shift between common and individual spaces. In her study of "interactional spaces", Mondada [87] details the systematic use of movements, gaze, body orientation and mutual adjustments to describe the transitions from passing pedestrians, unknown to each other, to their focused co-participation in public space. What Mondada demonstrates is the nuanced work that is performed to accomplish such transitions. Although the change is in the opposite direction—from shared to individual spaces—I might expect to see a similar work between Alan and Nick. And yet such work is notably absent. To begin, their

physical contact serves as an explicit resource to share and negotiate space together—in the guiding configuration, each individual's movement has a direct consequence on the other's. It would seem though that the hurried letting go is a trigger for the difficulties. Nick's ambiguous "wait here" and imperceptibly timed move away from Alan breaches the co-constituted space. Though sequential turns in talk can go some way towards easing the transitions and repairing them (again, see Segment 4), Alan's question fails to achieve this and I witness a rupture that goes unresolved, at least for a time.

Segment 5 - **Wait here, wait here** (Alan and Nick)

```
1     N:    alright
2           0.2
3     N:    is it quite handy doing it here at the cafe that's give us another two minutes walk
4     A:    yeah
                                          Fig 3.12a
                                          ▼
5     N:    I left your bag behind, wait here
      →     [they are in front of each other. A is not holding N's elbow]
6     A:    oh //shit
7     N:    *wait here*
            [N goes back inside the cafe to retrieve the bag]
                                  Fig 3.12b
                                  ▼
8     A:    that's bad, isn't it?
9           0.3
                    Fig 3.12c
                    ▼
10    A:    haha::ha=
11    N:    =ok I'll carry it, here it is
12    A:    oh thanks man
13    N:    hahaha
```



(a) N spontaneously turns toward A and the physical contact is broken

Figure 3.12: Segment 5 - Wait here, wait here (Alan and Nick)

(b) N has left A's immediate proximity

(c) A laughs while N approaches him, lifting up his left arm

Figure 3.12: Segment 5 - Wait here, wait here (Alan and Nick)

3.3.3.2 *"Two for Six":*

In this next example, let us further examine the transition between common and personal spaces, and consider in particular how ruptures in the former can be open to repair. Sara G and George G are at a shop's checkout waiting to pay for some socks for George (see Segment 6). They are standing a short distance from one another in a queue, with George holding the pack of socks they have chosen earlier. Looking at and referring to the pack, Sara says *"this is four pounds"*. Although they are not in contact, the socks serve as something in common, an object they are mutually attending to through both touch and speech.

In the midst of this exchange, Sara notices a new pack of socks and decides to return the old ones to some hangers in a nearby aisle (line 6). Saying *"just put this back"*, she walks away from

George (Figure 3.13d). The change in body configuration and distance marks a transition in their respective positions in space, though, as in the previous example, there are signs of trouble. The alert, *"just put this back"*, is ambiguous and the transition is not simultaneously recognisable to both parties. Indeed, Sara's utterance is said *sotte voce*, so may well not have been heard by George. Again, an interdependence between a pair is shown to be fragile and the common space enacted through them working in concert is ruptured. This is seemingly confirmed in George's next turn *"do you think"* (line 8). Although Sara has moved out of immediate earshot, George asks the question using the same pitch and without changing his orientation (Figures 3.13e and 3.13f), suggesting he is not aware Sara has left his immediate vicinity.

It is at this point that I see, on Sara's part, an attempt to repair the rupture in space. Saying *"You can get two for six pounds if you want"* (line 9), she raises the pitch of her voice and overlaps George's prior turn (line 8). Such overlaps have been noted as the source of troubles in video-mediated talk that is prone to latency and temporal delays [107], and are also known to be common in repairs to the order of turns between interlocutors [114]. Here, though, Sara appears to be making amends to a discontinuity in the co-constituted space between the pair. Her first *"...two for six"* utterance is a reference to the new pack of socks she has found, but in talking over George (seemingly with some urgency) she also makes apparent her change in location—possibly recognising he had not been aware of it. And, again, Sara's repetition of *"two for six pounds"* (line 11) is in response to George's questioning *"ehm?"*, but also reinstates her spatial location beside him and a return to a common space. Sara's words, then, do more than maintain the sequence of turns, they indicate both her spatial location and her return to the mutuality or interdependence between the pair.

Segment 6 - **Two for six** (George and Sara)

Fig 3.13a

1 S: this is four pounds
2 S: do you wanna get those actually?
3 G: yeah probably they will be alright=
4 S: =it's quite nice

Fig 3.13b Fig 3.13c

5 G: (there's any one more once) but::
0.2

Fig 3.13d

6 S: ↓just put it back
→ 0.2
7 G: they are alright

Fig 3.13e

8 G: do you think e::hm they're normal

Fig 3.13f Fig 3.13g

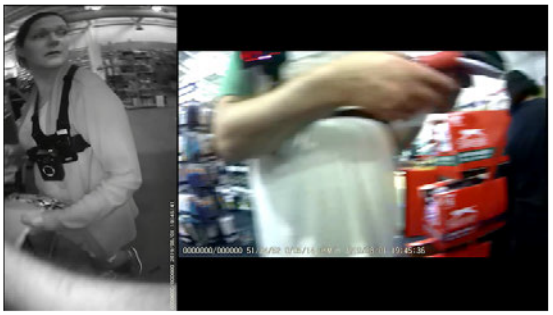
9 S: ↑↑you can get two for six pounds if you want
0.6
10 G: ehm?=

Fig 3.13h

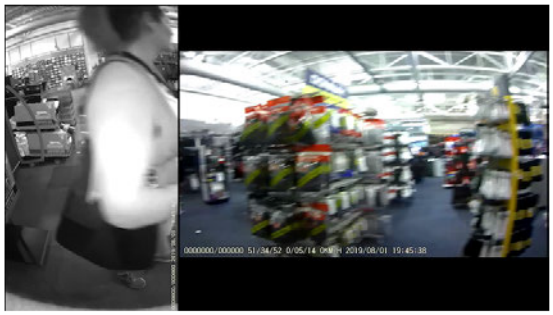
11 S: =↑you can get two for six pounds
12 G: do I need to

(a) S gives to G a new pack of socks

(b) S is putting the old pack of socks in a wrong place



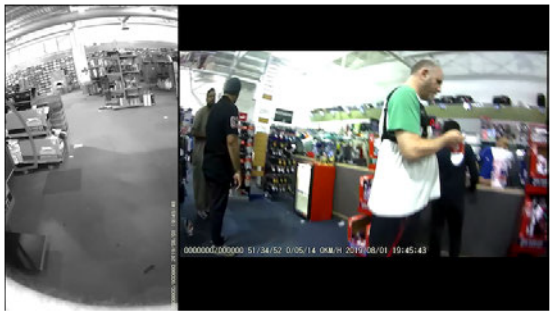
(c) S turns on her left, she wants to put back the old pair of socks



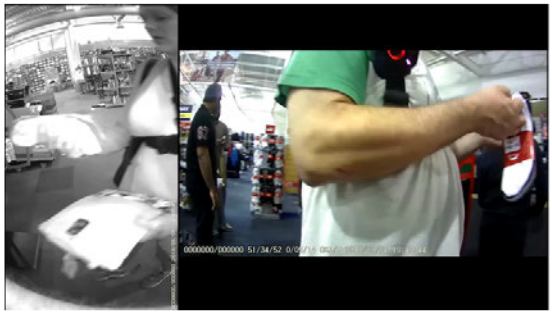
(d) S is going away from G to put back the old pack of socks

Figure 3.13: Segment 6 - Two for six (George and Sara)

(e) G stands at the check out, while S is away



(f) S is coming back to the check out



(g) S is close to G

(h) S is repeating what she just said looking at G

Figure 3.13: Segment 6 - Two for six (George and Sara)

In sum, in this last of the empirical sections I have seen how ruptures can occur in the mutual constitution of common space. In other words, the interdependent relations formed in and through navigation—between blind people and their guides—can be subject to breakdown, and such breakdowns can breach or rupture the co-constitution of common space. It would seem such ruptures occur when pairs lose the ability or fail to maintain the coordination of actions through talk, gestures and body movements, or reference to common objects. I have also seen, however, that ruptures can be repaired through these same resources. For example, modifications to the sequential order of talk (e.g., 3.3.3.2) can be used to reconstitute a common space that has momentarily been disrupted. As I will see below, a recognition of such ruptures and repairs invites an opportunity for thinking about the role of AI in assistive technologies that support navigation.

3.4 LIMITATIONS

The research I have presented has been conducted through audio-visual recordings of participant pairs and made explicit use of body cameras, detailed transcription, and interaction analysis. Altogether these have offered a valuable method to highlight the complex interplay of talk,

gestures and body movements, and other objects in sighted guiding. However, I recognise there are some technical, ethical and methodological limitations that arise in the research and that deserve reflection to improve future studies.

At a technical level, body cameras were a useful tool to capture participant interactions, moment by moment. However, my perspective was limited to the video frames provided by both cameras. These views sometimes did not record everything that might have been relevant and were obviously unable to capture the degree of bodily and tactile contact between pairs. Despite my study procedure—that included demonstrating how to wear the cameras, and trial runs with the participants to find the optimal arrangement of cameras (see Section 3.2.2)—such limitations are thus likely to have led to missed details. For instance, in some cases, a participant's camera had been set up not to capture the torso or arms of the other member of the pair, so I was unable to see how movements and gestures were used. Likewise, the pressure of a grabbing hand or the tension in an arm, shoulder, or the movement of a body were undoubtedly useful resources between pairs that I might have had some visual indication of, but I could not confirm. I recognise that all methods come with their limits so my recommendation here is not to suggest additional recording equipment, but rather to recommend explicit acknowledgement of what is and is not available to analysts through specific methods (see below).

Body cameras also raised some ethical considerations throughout the study. My research was conducted in public spaces and participants had cameras at their homes for 3 days. This raised the risk of data breaches, and consequently the danger of data access by unauthorized people. It was for this reason that I decided to use body cameras that encrypted media at the point of capture, with access only possible using a password. I am aware, however, that more precautions could have been considered with respect to the confidentiality of data. Capturing private and sensitive information is highly likely using video recordings and this may in turn increase the risk of harm to participants. I might have, for example, reduced such risks by asking participants to review their media and to delete any sensitive video after recording their journey and before researchers could access them.

The last consideration relates to the methodology and the relationship between the recordings and analysis, and the activity as experienced by participants. In research that uses video and conducts interaction analysis on such recordings, particular assumptions are made about the access to the situational details. In practice, this method allowed us to examine, in detail, a very particular form of social activity (namely, how social order is accomplished). However, it is evident that what I as an analyst see and hear may not be what participants hear, see and,

indeed, feel [65]. I am also likely to miss much of the intimacy and care that play a relevant role in pairs' relationships, a commitment to understanding one another and the compulsion to do well together [8]. It is fair to say that the method I chose authorised a particular understanding of sighted guiding, but may in doing so have risked glossing over the skill and know-how *felt* by the participants. I, therefore, recognise that other subtle dimensions of interaction may have been precluded in my method and thus were not available to me in the analysis, results and findings.

3.5 DISCUSSION

In the above-detailed examination of six segments from a larger corpus of video data, I have given particular focus to the ways people with vision impairments and their guides navigate together. Findings, overall, show that this navigation involves a mutual investment in constituting a space to move through—*co-constituting a space in common*. Space here is understood not to precede interaction, nor is it a given. Rather it is jointly accomplished, brought about through an unfolding set of relations [29]. Step-by-step, turn-by-turn, and in close bodily correspondence with one another, the pairs above show that space is (and in some cases isn't) *made* navigable, together. It is, in this way, that I find an interdependence at work in the sighted guide relationship. For pairs, a back-and-forth in talk, bodily gestures and movements, and mutual references to objects are all involved in co-constituting and navigating a common space.

In this chapter the emphasis then is empirical, seeking to reveal the "how" of sighted guiding. As a reminder for the reader, I will be turning to the question of design space and methods later in the thesis (Chapters 4, part B, and 5).

Again, I wish to consider how AI might be employed not as a means to "solve" undertakings like navigation—that is so often situationally dependent and thus a significant challenge to model [127]—but to complement and possibly extend individual and collective capacities [8, 9]. My interest in AI is consequently not to make up for some deficiency in sighted guiding, but to consider what AI might offer in the collaborative achievements between actors. I seek to follow a more fundamental line of inquiry tied to questions about the role of AI in supporting collective autonomy and agency. It is through this line of inquiry that I point to, in the following subsections (see 3.5.1, 3.5.2, and 3.5.3), three areas that might be considered in designing AI-enabled assistive technology. I bring the discussion to a close by reflecting on the limitations of the research I have conducted and my plans for future work.

3.5.1 *The Use of Talk, Bodies and Objects as Resources*

As I noted in Chapter 2, a common approach to design AT for navigational aid is to view it as a problem of travelling from one place to another, using verbal or acoustic feedback to signal landmarks and ensure obstacles are avoided. A presumption is that navigation can be aided by recovering the *de facto* details of the physical environment. This arguably seeks to tackle "the problem" of navigation in sighted terms, privileging the visual organisation of a scene and providing a means for a user to "see" what is around them.

What I wish to highlight first, then, is that this framing of the design space may be misjudged. As an alternative, I begin from the basis that sighted guide partnerships are a routine part of navigating for people who are blind or vision impaired (and incidentally they are also deeply intertwined with friendships and family relations [35, 69]). A goal might thus be to support these partnerships rather than assume they can be replaced with technology. The findings extend this perspective, suggesting that the details about an environment might be more usefully represented in terms of how they relate to one another in terms of temporal concurrence or sequence. This reduces the emphasis on doing the work of recognition and, instead, places it on how, exactly, resources like *talk*, *objects*, and *body movements and gesture* are routinely used between people to navigate together.

In 3.3.1, I illustrated how such resources are used to co-constitute a space in common. Crucially, it is not the resources alone that help but how they are situated with respect to the sequential order of events. Thus the parsimonious use of language or gestures—e.g., saying *"step down"* or *"go skinny"*, or bending an arm—can provide the necessary detail that avoids long-winded disruptions and helps to co-configure a legible space for pairs to move in. Similarly, the pack of socks that George and Sara hold (3.3.3.2) does not present itself as a resource because of what it is, but how it is held by the pair and communicates their spatial relationship.

The above examples also reveal how multiple, temporally concurrent actions and resources come to be critical to the ways pairs navigate together. Alice's *"Come on step down"* foreshadows the curb, but it is also set alongside Luke's cane sweeping across the curb (3.3.1.1). The resources, produced in concert as well as in sequence, are what attune the pair to their surroundings and, again, make features relevant so that they can co-constitute a space and navigate the curb without noticeable hesitation.

From this perspective, I suggest the design space for assistive technology that supports navigation could look beyond the mere description of the physical environment (e.g., the detection

of specific obstacles nearby, and turn-by-turn instructions). An AI-enabled AT could approximate the salience of features in a scene by attending to how they are used as resources *vis-á-vis* the unfolding sequence of interactions. The key emphasis of such an AT would need to shift away from natural language processing, gesture or object recognition to mapping how relevant aspects such as talk, objects movements and gestures mutually give rise to their use as resources. For example, it is remarkable in the sequences between George and Sara (3.3.1.2) and Alan and Nick (3.3.2.1) that silence operates as a marker for approaching obstacles. The silence says, literally, nothing, but through its timing with approaching obstacles signals a necessary shift in attention between the pairs.

One area in which this idea of reorienting design to detect sequences and multiple, concurrent interactions may have material impact is on how AI-enabled systems are trained. Currently, ATs providing navigation support use computer vision and machine learning algorithms for object detection and recognition. These systems rely on trained models using well-known datasets such as *ImageNet* and *Microsoft's COCO*. Such large-scale datasets contain many labelled common objects placed in everyday settings, and modelling is often intentionally designed to complicate the recognition task and background/foreground segmentation. Generally, the goal is to extract the object from its surroundings and achieve high accuracy in object recognition under varying conditions (including where the background is dynamic, e.g. video). Consequently, trained models can yield impressive recognition results that are largely dependent on the dataset/training data. Given the significance of the production of resources in sequence and concert, the challenge here may not be to extract details such as body parts and objects (and also talk and audio) from segmented backgrounds. Instead, it may be to determine ways of labelling data and producing datasets that account for how these details are placed in sequence or used in concert with what might ordinarily be treated as extraneous background noise. This would be to apply greater attention to how features are *made* relationally relevant in contexts like sighted guide navigation. My intention here is not to discount the considerable labour involved in data labelling and producing datasets, but to suggest there may be alternatives to mainstream paradigms in AI/ML recognition systems, ones that respond more directly to the constituted settings in which the systems are used and are sensitive to the ways in which multiple resources are coordinated in action.

3.5.2 *Greater Interdependencies*

The design surrounding navigation-based AT might then benefit from shifting attention away from the problem of recognising details in a user's environment to supporting the means by which the world is made meaningful through talk and interaction. Relatedly, such research might question a further presumption: that *independence* is the sought-after goal, that people with vision impairments should, through technology, be given the means of navigating on their own. Again, in examples where AT has been designed to support navigation, it is often the case that it is treated as an individual accomplishment and thus something to be solved for the individual. Where the recognition of other people is addressed, it is either to recognise them as an obstacle [3] or to detail their attributes (e.g. "man, aged 35", etc.). What I want to suggest is that the support for navigation in assistive technologies might instead show concern for how people actively work together, and how they rely on one another to move together.

Consider the example *Freezing-up* (3.3.2.2) in which Luke seemingly freezes when left on his own. As I suggested, this might easily be read as him faltering, losing his capacity to move as his guide, Alice, leaves his side to return to the counter in a café. However, it can at the same time be thought of as an opening. To *freeze* here is to open up the space for something else to happen, to create the conditions for another to act [86]—in this case, for Alice to turn and step back, and adjust to Luke's outstretched arm. The slowing down of pairs presents a particularly interesting case of coordinated actions. Across the examples, I repeatedly saw such slow-downs. I found them to be triggered by a guide's reduced walking pace, the movement of an elbow, or the resistance in forward momentum (and no doubt other hard-to-detect actions). And, they would often come with corresponding actions from the person being guided, a similar slow-down, and possibly a silent pause or step closer to the guide. As on other occasions, actions were reciprocated, but in this case, they also made room for something more to happen. In the examples in sections 3.3.1.2 and 3.3.2.1, the change in walking pace accomplished between pairs created the conditions for attention to be given to other things, for bodies to be realigned, or talk to be resumed. These are small openings, but at the same time through coordination between actors something new is made possible. The co-constituted space enacted between a pair affords new sets of further interaction. Many movements on the part of the participants might be understood in a similar way; slowing down, pauses in talk, interruptions and so on can be seen as ways to maintain coherence in a pair's co-constituted common space.

Such micro-adjustments and subtlety in interaction present significant challenges for AI-enabled AT. Recognising how one person's actions trigger or are reciprocated by another—amidst a complex mixture of interactions and across highly variable contexts—is nontrivial and unlikely to be tractable by AI systems for some time, if at all. However, what might be manageable is the recognition of microlevel but detectable actions, and system output/feedback corresponding to these actions. So, what if an audible sound accompanied and reflected a pair's pace or even a pause in talk as they navigated an obstacle or approached passersby? Crucially, such interventions would not replace the coordination between pairs, as it was solving "the problem" of obstacles. Instead, it would aim to serve as a further resource for opening up the possibilities and potentially affording the space for new (inter)actions. Sound reflecting the presence and relative proximity of an obstacle during a pause in talk could, for instance, make the need to veer one way or another more predictable or a return in talk more open to both parties. These would though be resources that hold the options open rather than dictate specific actions. They would also need to be sensitive to the availability of information to both parties in ways that were not disruptive to ongoing interaction.

3.5.3 *Ruptures and Repairs*

The ruptures I recounted to common space (3.3.2.1 and 3.3.3.1, 3.3.3.2) and the possibility for repair (3.3.3.2) present cases of both clear breakdowns and opportunities for intervention from AT. When pairs lose contact with one another, I find there can be an abrupt change to the space they are in. A shift must be made between a co-constituted and shared space to individually managed spaces, and problems can arise accordingly. In *"Wait Here, Wait Here"* 3.3.3.1), for example, Alan is left talking to himself when Nick lets go of his arm to retrieve the forgotten bag. The common "freezing" may be an action inviting another action, but it is always a reactive one and one that awaits a response from the guide or another bystander.

In conversation analysis, a *transition relevance place* refers to a moment in turn-taking where a place is opened for a follow-on turn from an interlocutor (i.e. when a transition to the next speaker becomes relevant) [109]. A question (ending with a rise in pitch) is one obvious example, but so are pauses and non-linguistic utterances such as "huh", "uhmm" or "errr". To ease the abrupt ruptures to common space between people with vision impairments and their guides, I might imagine a similar cue provided by an AT. The challenge in designing the AT would be how to aid the noticing of mutual configurations of space. An AT could indicate a moment

of *transition relevance* by signalling the possibility of a reconfiguration of space. Changes to actors' orientations to talk (e.g., moving from facing one another to looking outwards) or changes in their relative spatial arrangements (e.g., a shift in orientation to something else in space) could be relayed using audible or tactile feedback to indicate the possibility—the relevant place—for changes.

Most obvious here would be one member of a pair walking away. More subtle cues might also be recognised, however, such as a guide's abrupt rotation away from a pair's direction of travel, as in Alice's movement (3.3.3.2), or a guide's words said *sotto voce*, with indexical spatial references such as "over there" or "wait here" (e.g., 3.3.3.1 and 3.3.3.2). Further work would need to be done to understand how talk and bodies could be used as a resource in this way, but as above the key recommendation here is not to treat this as a replacement for existing cues, but as a way to add to the resources pairs already have available to them to make space mutually meaningful and relevant.

To extend this point, in another of the examples, *"Two for Six"* (3.3.3.2), Sara illustrates how subtle cues in interaction can repair breaches to a shared space. A spoken response to George's turn, and indeed a raise in pitch and the overlap in talk, signal both a change in the talk, but also serve as a bridge, reconstituting the shared space. I find another example of how the use of interactional resources—in this case, talk and turn-taking—provides a means of managing space and bodily coordination. Yet, I also see that the recovery of ruptured space is, again, largely weighted towards action from the guide. When people with vision impairments and their guides are in contact there is a recognisable back and forth, each person may be capable in different ways but together they are able to coordinate their actions to move through space (for the most part) unproblematically. But when the common space is breached the balance changes, and the guide becomes the proactive member of the pair; the person with the vision impairment becomes far more reactive in what they can do. *"Two for Six"* 3.3.3.2) illustrates this. The opportunity to repair is open to Sara as the guide. Continuing with proposals for AT that complement pairs' interactions, I might here consider how information is provided to re-centre the agencies, to allow more possibilities from both parties.

I can learn lessons here from the broader body of work in CSCW. For example, in their study of systems designed to assist driving, Perterer et al. [101] show how advanced driver assistance systems fail to make use of the collaborative work involved in driving, where front-seat passengers often come to share tasks and duties. The authors suggest that driving could be thought of in more distributed terms, and correspondingly in-car systems could be designed to

further extend the joint work, involving front-seat passengers in activities such as monitoring the speed of the car and assisting with navigation devices. This resonates with Bennett et al.'s [9] discussion of "crowd work" in AT, in which systems might inspire new forms of collaboration where people with disabilities are not only the recipients of assistance but become proactive companions in completing tasks.

In summary, coming back to the sighted guiding practice, such a design orientation might be explored further by considering how companions invest resources to locate each other in space. The relative spatial representation of nearby people with respect to a user has been proposed elsewhere (e.g. [1, 46]). Here, though, a particular investment could be put into exploring ways to track the relative location and distance between a user and a guide. For instance, AI-enabled systems may provide information about a guide's proximity when letting go occurs. Computer vision and machine learning techniques could be adopted to identify the guide and provide information about orientation and relative distance between pairs. Feedback representing this information would provide a user with the resources to orient themselves towards a guide who has left their side and possibly even allow them to walk together without physical contact. This proposal is again tentative, but shows my aim to support the ongoing and emerging relations between people with vision impairments and their guides, and presents a perspective that makes for richer interdependencies and an expansion of collective capacities.

My study gathered video recordings of 4 people with visual impairments working with their sighted guides to navigate during routine journeys. I analysed 40 segments of video in detail and used 6 of these to illustrate the collaborative and interdependent work involved in navigation.

My findings reveal how people with visual impairments and sighted guides use multiple resources, such as *talk*, *body gestures and movements*, and *objects* to co-constitute a common space that can be navigated together. These resources do not always explicitly describe the physical environment, but they are employed by people to inform how to move their bodies in relation to one another and to space. Here, timings and rhythms play an important role to coordinate their (inter)actions. Additionally, I showed the interdependence work during navigation and the continuous shifting between agencies. Sighted guides and guided people with visual impairments actively take and respond to actions through resources, building up and negotiating a common space of interactions and understanding. This interdependent production allows them to accomplish navigation successfully. Finally, my findings also depict moments of rupture. These ruptures occur when people fail in the negotiation and coordination of actions

through multiple resources, leading them to deploy talk, gestures and body movements, and objects to repair such breakdowns.

I have demonstrated that there is a rich tapestry of highly collaborative work and mutual agency in sighted guiding that constitutes a prime example of interdependence. Taking this perspective allows us to question current approaches to AI-enabled assistive technology. In particular, I suggest a reorientation towards (1) augmenting the sighted guiding relationship rather than replacing it; (2) focusing on identifying the mutual use and sequence of talk, bodies and objects as resources that constitute a common space rather than simply providing a description of the environment; (3) identifying new opportunities for AI-enabled interventions that complement the existing resources; and (4) enable and support repair activities when interaction ruptures are detected.

This initial research provides a step toward the next research study on investigating the *design space* of AI assistive technology that extends the ways companions walk and navigate together. Specifically, the next Chapter will focus on situations in which ruptures occur when pairs *"let go"* of one another. I will further investigate the *problem space*, looking at body movements and their meanings to understand their limitations in the physical disengagement scenario. As above, my aim is to draw attention to the use of situational resources by pairs in sighted guide partnerships. Based on this work, I then intend to approach the design space and hope to demonstrate that AI can have a role in easing the transitions between common and personal spaces, and potentially extending the ways common spaces are co-constituted.

4 APPROACHING A DESIGN SPACE AT THE INTERSECTION OF AI AND INTERDEPENDENCE (STUDY 2)

4.1 MOTIVATION AND RESEARCH QUESTIONS

The first study (Chapter 3) shows the importance of body movements and gestures in sighted guiding. Being physically connected allows companions to convey important information, helping them to accomplish navigation together. Although study 1 also demonstrates that non-verbal utterances (such as changes in voice and pitch, pauses, "huh", "uhmm", "errr" expressions, and so on) constitute how companions coordinate their interactions, they represent micro-adjustments and very subtle interactions which are very challenging to recognise in a conversation by people. Moreover, they represent significant challenges for future AI-enabled AT because of the mixture of interactions, and the highly variable contexts they are set in. For these reasons, I decided to focus on body movements and gestures. These are more manageable in terms of both detectable actions by AI systems, and mutual and recognisable resources by companions. The analysis of study 1 also highlights ruptures while people navigate together. I define ruptures as a troubled co-production or negotiation of a common space of navigation and the asynchronous realisation of this space of actions (see section 3.3). For instance, this may occur when companions have to physically disengage from one another for any reason. In these situations, there is a transition from a common space of navigation to a more personal space of actions and this transition may not be equally perceived or realised by both companions at the same time.

Gaining a deeper understanding of body movements in sighted guiding and their limitations in moments of physical disengagement will help to approach the design space at the intersection of AI and interdependence. Specifically, I am interested in investigating how AI technology can support these moments of physical disengagement during navigation.

The study presented in this chapter is comprised of 2 parts.

Part A (4.3) further investigates the problem space and aims to explore body movements in the sighted guide configuration to deeply understand how companions use body movements, gestures and orientation to build a sense of one another. Furthermore, unpacking the body language will help to identify the strengths and limitations of these gestures when people have

to disengage from one another, leading to a scenario of study for approaching the design space investigation.

Part A addresses the following research question:

> **RQ2.A:** In a deeper exploration of the problem space, **how do companions use body movements in sighted guiding?**
>
> RQ2.A.1: How do companions build a sense of one another using body movements?
>
> RQ2.A.2: When do they continue to use body movements in the transition from being in physical contact to standing/moving independently?

Part B (4.4) turns the focus to the design space, narrowing the research to the physical disengagement context. Current research in designing AI technology uses the UCD approach to iteratively design and build rapid prototypes, refining and evaluating them with users. Following this method, the second part of study 2 aims to introduce to companions a preliminary AI prototype designed for enhancing moments of physical disengagement and ask for some initial feedback and input from companions.

Part B addresses the following research question:

> **RQ2.B:** In an exploration of the design space, **how can an AI prototype extend body language when companions physically disengage in sighted guiding?**
>
> RQ2.B.1: How might AI and audible feedback be used to support moments of physical disengagement, and extend capabilities between a person with visual impairment and a guide?
>
> RQ2.B.2: How do pairs adjust their sighted guide relationship in response to preliminary interventions, which capture the basic ideas of what AI could achieve?

The remainder of this chapter will first describe the method, and then I will detail Part A and Part B. For each part, I will present the study procedure, participants, data collection and analysis, and findings. A final discussion will conclude the chapter.

4.2 METHOD

To address the research questions I conducted a study adopting a user-centered design approach. The chosen method was a consequence of the beginning of the COVID-19 pandemic (more

details are reported in the COVID-19 statement, included at the beginning of this thesis). This approach allowed me to follow the University guidelines on taking into account the impact of the pandemic and consequently adapting my own research plan. Moreover, when the lockdown started, UK Government imposed restrictions on travel and meetings, consequently, face-to-face was banned indefinitely, and people were isolated in their home. Despite having some difficulty in involving the participants, the user-centered design approach and unexpected results (see section 4.5) have been an opportunity to reflect on the design process itself and turn my attention on design methods at the intersection of AI and interdependence for the remainder of my PhD.

The research study was conducted in 2 parts over a period of 4 months. Figure 4.1 shows how the research was carried out. In part A I address RQ2.A, where I focused on an exploration of body movements during sighted guiding, and their limitations (see section 4.3). In part B I address RQ2.B designing and implementing a preliminary AI prototype narrowing the research space to the context of physical disengagement. I introduced the AI prototype to pairs, asking for their input and initial feedback on the application. The following sections will describe in detail both parts of the study, and in the final section, I will present a discussion towards the next step.

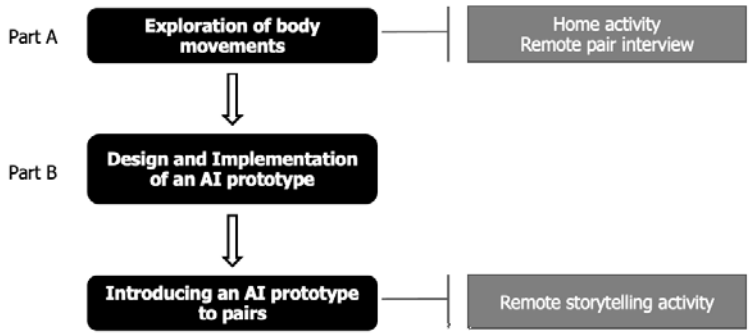


Figure 4.1: Study 2: research procedure.

4.3 PART A: EXPLORING BODY MOVEMENTS

4.3.1 *Part A study procedure*

Figure 4.2 illustrates study procedure of Part A. Participants took part in a *home activity*, and a remote *follow-up interview*. In the *home activity* pairs completed 3 short walks. Walks were

different in terms of task and sighted guiding configuration. Their aims were to (i) observe and discuss the use of gestures, body movements, and orientation in the sighted guiding experience, and (ii) reflect on the transition from being guided to not being in physical contact (physical disengagement from one another), and how gestures, body movements, and orientation help or do not in this transition.

Observations and reflections were audio recorded through a retrospective think-aloud technique at the end of each walk and they were guided by provided questions (Appendix B.6 reports a list of suggested questions per each walk). Participants audio-recorded their reflections using a smartphone application, and all recordings were sent back by email. I provided in advance participants with accessible instructions about how to make a recording and send it using their smartphones (see the end of Appendix B.6). The following describes each walk in detail.

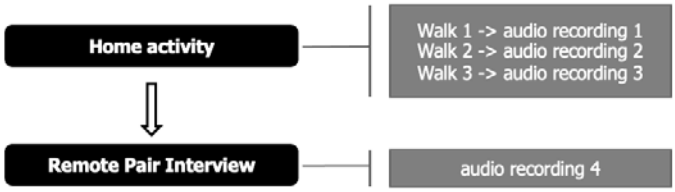


Figure 4.2: Study 2: Exploration of body movements.

WALK 1. I asked pairs to plan a walk at home which started and ended in the same location. They navigated from one room to another (e.g., from the bedroom to the kitchen) using the sighted guide configuration they were familiar with (e.g., holding the elbow). During the retrospective think-aloud, I asked them to reflect on what they had observed: what gestures, movements and body orientation of the guide or person being guided they felt helped them to move through space; why they did those movements, and how those movements helped them.

WALK 2. Pairs repeated Walk 1, but this time holding a different part of the guide's body that they usually do not hold (e.g., the shoulder). Changing the holding allowed participants to see differences, as well as what people might take for granted. Guiding questions were similar to Walk 1, but I also asked them to describe any difference they had noticed compared to the previous walk. These observations were captured in an audio recording after the walk.

WALK 3. I asked pairs to take a walk in their home using the sighted guiding configuration while acting a script. The script was aimed to experience the physical disengagement scenario, I was interested in. Through the script, I asked them to act on three different tasks which required the pair to re-position themselves temporarily in the space while they were walking together (i.e., serving a drink in the kitchen, opening a window, and turning off the phone's timer). After acting out the script, I asked them to audio record their reflections on moments where they had to interrupt their physical contact. Specifically, they discussed how the transition between the sighted guide configuration and not being in physical contact and vice versa happened. Pre-structured questions were also related to which body movements, orientation and gesture pairs perceived in this transition and what those movements told them.

Pair interviews instead were about 45 minutes and conducted remotely on Zoom following a pre-structured list of questions. Questions were related to further exploring the walks that participants did at home. Further, we discussed real-life examples of (i) guiding where gestures and movements were particularly important; (ii) physical disengagement situations, how pairs usually disengage and regain contact with each other, use of gestures and limitations in this context; and (iii) moments where visually impaired companions were disoriented (a complete list of interview questions can be found in Appendix B.7).

4.3.2 *Participants*

I recruited 3 pairs of participants composed of a person with visual impairment and a sighted guide. As in the previous study, pairs had an established relationship through guiding for at least 3 months. This allowed us to minimise risk and capture the partnership they have built up since they started their guiding relationship. Further, individuals needed to be adults and be able to give informed consent. Since I was approaching a remote study I extended the recruitment to people living in the UK, not only in London. However, pairs needed to live together to adhere to the UK Government restrictions at that time.

Firstly, I approached participants who took part in the first user study, underlining that there was no obligation to take part in this new research. Since I already knew participant pairs from the previous study and their ways of managing sighted guiding, I thought it was a good opportunity to continue analysing in detail their natural way to use body movements in their partnership. However, they did not accept to take part in this research, so I recruited

participant pairs through advertisements on RNIB's Facebook group, and on Twitter, and by sending emails to existing contacts of supervisors and other colleagues within the HCID Centre at City, University of London.

I created and emailed a recruitment advertisement. Interested pairs also received the participant information sheet. I gave them 5 days to read and ask any questions and/or concerns. All materials were made accessible through screen readers. Interested participant pairs signed up the informed consent online, through Qualtrics service, offered by City. The platform offers a service to create online forms, which are formatted to meet WCAG 2.0 guidelines. Participants indeed appreciated being able to navigate through the online form without raising any issues.

Approval for this study was granted by the Computer Science Research Ethics Committee at City, University of London. In appreciation of the participant's contribution to the research, I offered a £25 Amazon voucher per person. Names used throughout this study are pseudonyms. Some Ethical issues in common with the previous study have been identified in conducting this research. Specifically, I considered (i) people's vulnerability and (ii) the confidentiality of data.

(i) I recruited people who are independent and capable in their life. For this study, I excluded participants with mobility problems to reduce the risk of harm and excluded participants with any cognitive impairment who are not able to give informed consent.

(ii) Audio recordings sent by email have been cancelled permanently from the email provider of the researcher. All data is kept confidential and secure. Digital data was transcribed, anonymised, encrypted and stored in a folder protected by a password on an external hard drive and is currently managed by the researcher.

As mentioned, all participant pairs had an established relationship through guiding for at least 3 months. Specifically, all pairs had a long partnership relationship as Table 4.1 reports. For each participant pair, Table 4.1 also shows the standard configuration companions usually have while walking together. Each pair had a different sighted guiding configuration (i.e., holding the elbow, holding the shoulder, and holding the hand). During walk 2 in the home activity, pairs were asked to use a different configuration. Two pairs decided to practice walk 2 holding the shoulder, and one pair walked holding the elbow.

Pair *Person with VI	Relationship	Sighted Guiding Technique	Holding in Walk 2
Ryan* and Charlie	partners	Ryan holds Charlie's shoulder	Ryan holds Charlie's elbow
Alice* and Stuart	partners	Alice holds Stuart's elbow	Alice holds Stuart's shoulder
Noah* and Grace	partners	Noah holds Grace's hand	Noah holds Grace's shoulder

Table 4.1: Study 2: Demographic Information.

4.3.3 *Data Collection and Analysis*

I collected a total of 12 audio files. 9 audio recordings of about 5 minutes each, made by participants during the *home activity*, and 3 audio recordings of about 45 minutes from the *follow-up interview*. Firstly, I transcribed and anonymised all collected audio files in full. I analysed audio data qualitatively through Thematic Analysis [18], using NVivo 12 [60]. Overall, I conducted the analysis, following the 4 steps proposed by Clarke and Braun [19]:

1. *Familiarisation with the data* - I started familiarising with data as soon as I collected audio recordings of the *home activity*. Indeed, I scheduled the interview 4 days after receiving the audio to have enough time to transcribe all audio data and customise the interview questions upon what participants reported in the recordings.

2. *Defining initial codes* - Based on previous findings (study 1), I defined an initial set of codes for both body movements and meanings (initial codes are reported in Appendix B.8).

3. *Developing codes and sub-codes through deductive and inductive analysis* - After the interviews, I proceeded with the analysis of body language, considering the initial codes related to body movements and meanings. I started with the transcriptions of the *home activity*. At this stage, I was also open to possible new codes that might have emerged from the collected data. Codes developed at this stage are reported in Appendix B.8. I read through both home activity and interview transcripts several times to define and refine codes, and their definitions.

4. *Identify summary domain through grouping* - Clarifications and conversations with pairs during the interview helped me to better identify body movement and meaning associations. As a result, I was able to group the final list of codes into themes and sub-themes. Towards the end of the analysis, I created a spreadsheet for making sense of themes, codes and when they were applied to. The final list of codes is reported in Tables 4.2-4.7

Essentially, a coding unit is a sentence that contains a body movement and/or a meaning. A unit could contain one or more body movements and meanings, therefore multiple codes were allowed. Sometimes companions came back several times to a specific situation or context they illustrated earlier. Consequently, two instances with the same body movement code, and the same meaning code, but differing by a situation or journey context, were both coded. The following is an example from the data:

"I found the initial tap on the shoulder to ask me to stand up helping me to understand that the journey was starting."

Where *"the initial tap"* was coded with "G tapping VI's body part" as body movement, and *"to understand that the journey was starting"* was coded with "new journey" as meaning.

Throughout the remaining part of the chapter, I will use (G) to indicate the sighted guide, and the placeholder (VIP) to replace "visually impaired person".

BODY MOVEMENTS. I grouped codes of *body movements* theme in 3 main sub-themes: *lower body*, *holding*, *other body parts*. Tables 4.3, 4.4, and 4.2 illustrate codes for each sub-theme, providing a description about what each code means, when it is applied, and an example from the collected data. Body movement includes all codes which describe a body movement or gesture done by either the guide or the person with visual impairment during sighted guiding (e.g., *"I tap on the shoulder [...]"*, *"I moved my arm behind"*, *"I lift up my shoulder"* etc.).

Body movements related to the LOWER BODY		
Code	Description	Example
G Slowing down	The guide decreases the walking speed without stopping.	VIP: *"And then she would also, yeah, just slow down her body speeds."*
G Stopping the walk	The guide stops walking and the journey ends.	VIP: *"so, from my side of it, G actually put a hand back behind her back, we're going to slow down and then stopped, so I knew what it was going to happen"*
G Pausing the walk	The guide pauses, hesitates for few seconds the walk in the sighted guide configuration. It does not include long pauses such as ending the walk. In this case, companions maintain the sighted guiding configuration.	G: *"At the bottom of the staircase we paused on the lower step"*
VIP Standing still	VIP stands still on their own somewhere.	G: *"Sometimes we go in a shop and he is really really busy [...] instead of bringing VIP around throughout all shop I tend to put him someplace, so I do stand him someplace away from people, or in a corner [...]."*

Table 4.2: Body movements related to the LOWER BODY sub-theme.

Body movements related to the HOLDING		
Code	Description	Example
G Gripping hand	The guide and VIP person are hand by hand and the guide grips the hand of the VIP tighter.	VIP: *"So, G holds my hand and when we slowed down she gripped my hand tighter to know we were slowing down."*
G Lifting up/down shoulder	The guide lifts up/down the linking shoulder quickly	G: *"Sometimes we are walking on the road, and we are stepping up from one level to another, like a cab, stepping on the cab I will lift my shoulder so he knows he has to go up as well."*
G Lifting up/down arm/elbow	The guide lifts the linking arm/elbow.	G: *"Ehm, towards the window I gently lifted my arm so as to indicate to her that she can let go of my arm."*
G Moving arm/elbow behind	The guide moves the linking arm, elbow or hand behind toward their back.	VIP: *"[...] moved his elbow behind him so we could walk through the bedroom door into the passageway."*
G Pushing/pulling arm/elbow	The guide moves closer or further away the arm/hand/elbow to their body.	G: *"If there's like a very small obstacle, like a cow poo on the path, [...] I might sort of gently pull him toward me in case he needs to come to the right a little bit."*

Table 4.3: Body movements related to HOLDING (shoulder, elbow, or hand) sub-themes.

MEANINGS. In the same way, I grouped in *meanings* theme 3 different sub-themes: *pre-journey*, *journey*, and *post-journey*. Meanings include all codes which describe what a person within the pair perceives, or wants to indicate through a body movement, but also through other multimodal resources (e.g., talk) in sighted guiding. This allowed me to better identify limitations. In the context of body language I consider limitations situations and reasons why pairs do not use body movements to indicate relevant information. An example would be when relevant information is conveyed through a different resource rather than a body movement. It does not follow, however, that expressing meaning through a resource other than body movement leads to a negative outcome. On the other hand, by identifying limitations, one can better highlight the vocabulary and the language of a particular resource, such as body movements and gestures. Meaning instances are easily recognised by utterances such as *"to indicate [...]"*, *"that helps me to understand [...]"*, *"it allows me to [...]"*, *"he/she does that to know [...] and I know that [...]"*, etc. Tables 4.5, 4.6 and 4.7 illustrate all final codes for each sub-theme, a description of when it is applied, and an example from the collected data.

Body movement related to the OTHER BODY PARTS		
Code	**Description**	**Example**
G Tapping VI's body part	The guide touches or taps with their hand, elbow, or forearm a part of the VIP's body such as a shoulder, hand, or hip for a short time.	VIP: *"I found the initial tap on the shoulder to ask me to stand up helping me to understand that the journey was starting."*
G Guiding (with hands) to an object/space	The guide uses their hands to guide VIP's hand or body to an object (e.g., a chair, or sideboard), or to extra guide the VIP to a space (e.g., close to a corner),	G: *"[...] I usually put his hand on the back of the chair and he knows from there how to work out, where to sit which part of the chair he needs to be able to sit safely."*
G Guiding (with hands) to a body part	The guide uses their hands to guide the VIP's hand and put the hand on a body part of the guide (e.g., elbow, shoulder). Self-initiated hand movements by the VIP are not included.	G: *"[...] I used my hand to place his left hand on my right elbow and then we walked through the bedroom door."*
G Moving arm in front of VIP	The guide moves the free arm out in front of VIP.	G: *"We go down three steps turn the corner and as we are turning the corner, I put my right arm out in front of him in case he slips.*
G Twisting (the upper body)	The guide angles, twists, or turns the upper body (chest and shoulder) behind or forward. The twist of the arm is not included here.	VIP: *"G angles his body as a way to indicate that you have to go to a single file/one behind the other because of a narrow gap [...]."*
VIP Moving out the hand	VIP moves out or has got the hand out. The arm they usually use in the sighted guiding configuration	G: *"[...] I'd either be led my partner putting his hand out to say, to indicate I am ready to be guided or I would say we're going to move now please can you give me your hand [...]."*

Table 4.4: Body movement related to the OTHER BODY PARTS sub-theme.

PRE-JOURNEY		
Code	**Description**	**Example**
New journey	Indication that the guide is ready to guide, or the journey is about to start.	VIP: *"G would tap me on the arm if she was ready to guide me again."*
Making contact	A signal to establish or re-establish contact once the pair is apart. For example, this helps to locate the guide in space, but it does not include indications for setting up the guide configuration.	VIP: *"She says my name to know she's talking to me and that I know it's her [...]. I've been guided by others in the past and they just expect me to know they're there. Sometimes. That can be quite frustrating."*
Setting up	Indication that allows companions to understand it is time to set up the guide configuration.	G: *"and when it ended, I stopped my phone I tapped VIP on the shoulder and he then clutch onto my right shoulder which is where he normally holds when I guide him."*

Table 4.5: Meanings codes related to PRE-JOURNEY sub-themes.

JOURNEY		
Code	Description	Example
Bodies reconfiguration	Signal which indicates a reorientation of the bodies' position. This includes a single file, which means the pair moves from side by side to one behind the other while walking, or a more general adjustment of their bodies' position in relation to one another (e.g., come closer, orient beside).	VIP: *"G angles his body as a way to indicate that you have to go to a single file/one behind the other because of a narrow gap and you have to get through it."*
Change in direction	Indication of changes in direction, for example, turn left or right, turn a corner, or step back.	G: *"At the bottom of the staircase we paused on the lower step, turned right, step off that and turn right again into the kitchen."*
Change in height	Indication of a change in height between the pair. Often this meaning is associated with situations which involve stairs and escalators. For instance, going up/down stairs and starting/ending a stairway imply a change in height between the pair.	G: *"When we reached the first step down, I paused ehm I stepped down and I paused so VIP knows that we are going down the stairs."*
Danger	Indications that something is coming up and requires further attention in navigation. "something" can represent anything, from an escalator (high danger) to stairs (less danger), some obstacles, hazards, curbs, obstructions, etc. on the way	VIP: *"I guess if it's that bad on their own, but I suppose a hesitation if you are using non-verbal yeah would be that there is something coming up. Yes."*

Table 4.6: Meanings codes related to JOURNEY sub-themes.

POST-JOURNEY		
CODE	DESCRIPTION	EXAMPLE
Orientation to the space	Indication where a VIP is in relation to the space, so they can take the next action independently.	G: *"and at the end of the walk I placed his hand on the back of the kitchen's chair, so he knows where the chair is and he can orient himself and sit down there safely."*
Letting go	A signal which is an indication of physical disengagement from the sighted guide configuration.	G: *"Another indication which I give sometimes is I tap his hand with my hand, the hand is on my shoulder I tap it and I just disengage, sometimes I don't use very many words to disengage."*
Next Direction	Signal to indicate which direction to follow once the pair has disengaged from one another.	VIP: *"[...] I might just need to know where the other person has gone so I know which direction to follow or something like that."*
Motivation	Indication about the context (e.g., what is happening around, and why).	VIP: *"[...] because you can't see how long the queue is you get a little bit frustrated. So sometimes I will ask how many people are ahead of us or whatever because you just want that sort of information."*

Table 4.7: Meanings codes related to POST-JOURNEY sub-themes.

4.3.4 *Findings*

In this section, I will present the findings of study 2 part A. I will start with an overview of the most frequent body movements and meanings participants highlighted (see sections 4.3.4.1, and 4.3.4.2), then I will detail the body language in sighted guiding and limitations in section 4.3.4.3. Through this analysis, I will show that companions establish a body language which plays an important role in building a sense of one another in space during navigation. Body language is also strongly related to the type of physical connection participants adopt. Finally, I will present limitations related to both body movements and moments in sighted guiding, such as physical disengagement.

4.3.4.1 *Frequent body movements*

Table 4.8 illustrates the list of body movements I analysed divided by sub-theme (i.e., Lower Body, Holding, and Other Body Parts). To represent how frequently a body movement was mentioned by participants, I used three criteria: (i) whether the body movement was coded in at least half of the transcription files I analysed, (ii) whether the body movement was identified

by all pairs, and (iii) how many references were coded with that body movement. These three criteria are reported in the last three columns in Table 4.8. Cells in the "references" column have a red gradient in accordance with the references' number. The higher the number of references, the darker the colour is. A gradient was assigned to better highlight the most frequent body movements. Overall, in the Table, we can notice that the majority of body movements identified by pairs are initiated and enacted mainly by the sighted guide. These body movements are codes that start with the "G" letter which is the abbreviation for "guide". Furthermore, half of the body movements are about movements which involve the guide only (e.g., twisting the upper body, pausing walk, etc.), and the other half instead are movements interacting with VIP (e.g., guiding to an object-space, gripping the hand).

BODY MOVEMENT				
Sub-Theme	Code	6 out of 12 files	All 3 pairs	References
Lower Body	G pausing the walk	X	X	32
	G slowing down			5
	G steps up-down		X	4
	G stopping the walk		X	6
	VI standing still		X	14
Holding	G gripping the hand			4
	G lifting arm-elbow			1
	G lifting up-down shoulder			2
	G moving arm behind	X	X	15
	G pushing-pulling			5
Other Body Part	G guiding to a body part			5
	G guiding to an object-space	X	X	19
	G moving arm in front of VIP			3
	G tapping VI's body part	X	X	25
	G twisting UB	X	X	15
	VI moving out hand			7

Table 4.8: Body movements frequency according to data files, pairs and references.

Table 4.8 also highlights in yellow the most frequent body movements, those meeting the three criteria reported in the first paragraph of this section. Specifically, the most frequent body

movements are those with a high number of references, identified at least once by all pairs, and appeared at least in half of the transcription files I analysed. Specifically, in *lower body* sub-theme we have *"G pausing the walk"*, in *holding* sub-theme we have *"G moving arm behind"*, and finally *"G guiding to an object-space"*, *"G tapping VIP's body part"*, and *"G twisting upper body"* in *other body part*. All the most frequent body movements were initiated by the guide.

The type of holding acted by a pair played a relevant role in which movements the pair found familiar and natural to perform. For instance, *"moving the arm behind"* gesture consists of the guide moving the holding arm toward their back. Since the information was conveyed through the physical connection point, this body movement was especially frequent when pairs were holding the hand or the elbow. Alternatively, *"twisting the upper body"* became more common when companions were connected through the shoulder. In twisting the upper body, the guide angled or turned their torso behind or forward instead of moving the arm behind. For instance, *Alice* described moving the elbow behind gesture while *Ryan* highlighted twisting the upper body while holding *Charlie*'s shoulder:

> *Alice-VIP: "At the top of the stairs he stops I feel his body turn to the left and his elbow behind him I know it is a single file then the walk is completed."*
> *Ryan-VIP: "Charlie angled his body so I could turn the corner walk to the kitchen toward the kitchen island and return journey upstairs."*

Another peculiarity we can notice from the data is that in *"tapping VIP's body part"* movement there is a correlation between which body part was touched and the body part participants were holding during the walk. Here below, I report two examples. In the former, *Ryan* (VIP) held *Charlie*'s (G) right shoulder and indeed *Charlie* used to tap *Ryan*'s shoulder. In the latter, instead, *Grace* (G) explained she touched Noah's forearm before setting up a hand-by-hand configuration.

> *Charlie-G: "So, I touched R on his shoulder when he was sitting at his desk to indicate that we are going to start walking."*
> *Grace-G: "If I was going to do that, I needed to make physical contact quickly I would tend to do that by touching the forearm with the back of my hand or something like that rather than grabbing."*

The most frequent body movement identified by participants was *"pausing the walk"*. This movement represented hesitations and standing still together for a few seconds during the walk. Yet, the guide was declared as the initiator of this pause. For instance, *Charlie* (G) exemplified a common situation while travelling where he paused the walk while they were approaching an escalator:

> *Charlie-G: "Because obviously, in an escalator the steps are moving very quickly and if he goes on the wrong step we can easily fall, so I would stop, we will both stay there in the standing position until it is safe."*

Table 4.8 also illustrates less frequent body movements. Among these, I would like to mention gestures initiated by people with visual impairments, which were *"moving out the hand"* and *"standing still"*. The former represented the person with visual impairment moving out their arm and hand when the companions were physically disconnected. Usually in this context, people tended to use the hand which was used in their sighted guiding configuration. For instance, *Noah* (VIP) described this gesture:

> *"Noah-VIP: I am just trying to think, so I think it was I kinda knew when we were about to go again and I put my hand out and she took my hand."*

The latter instead (standing still) was a movement done by people with visual impairments, typically when pairs were physically disengaged from the sighted guide configuration. In these moments the guided person stood still on their own somewhere for an undefined period of time. Sometimes they were aware of where they were, some other times instead they were more disoriented. For instance, *Ryan* (VIP) described how he feels when he stood still on his own:

> *Ryan-VIP: "Charlie disengages and goes off to do things while I wait and I learnt to be... to wait very patiently and I don't really feel abandoned, so I always feel pretty secure knowing that Charlie will return and we will continue doing whatever we were doing, shopping, walking, just taking exercises or going to see a friend."*

Although body movements initiated by the participants with visual impairments represented a minority of the instances, what these examples started revealing is that there is a strong association between body movements and the context where they were performed (e.g., when and why the body movement is enacted, and how people feel), and so their meanings.

4.3.4.2 *Frequent meanings*

Participants identified meanings associated with 3 different moments in navigation: meanings which refer to the *"journey"* itself, and those associated with *"pre-journey"* and *"post-journey* contexts. Table 4.9 illustrates the list of meanings divided by these sub-themes. As in the previous section, to represent how frequently a meaning was mentioned by participants, I used three criteria: (i) whether the meaning was coded in at least half of the transcription files I analysed, (ii) whether the meaning was identified by all pairs, and (iii) how many references

were coded with that meaning. These three criteria are reported in the last three columns in Table 4.9. Cells in the "references" column have a red gradient in accordance with the references' number. The higher the number of references, the darker the colour is. A gradient was assigned to better highlight the most frequent meanings. Table 4.9 also highlights in yellow the most frequent meanings, those meeting the three criteria reported above. Specifically, the most frequent meanings are those with a high number of references, identified at least once by all pairs, and which appeared at least in half of the transcription files I analysed.

MEANING				
SUB-THEME	CODE	6 OUT OF 12 FILES	ALL 3 PAIRS	REFERENCES
Pre-journey	Making contact	X	X	28
	New journey			7
	Setting-up	X	X	16
Journey	Bodies reconfiguration	X	X	29
	Change in direction	X	X	34
	Change in height	X		31
	Danger	X	X	21
Post-journey	Motivation			3
	Letting go	X	X	28
	Next Direction			3
	Orientation to the space	X	X	29

Table 4.9: Meanings frequency according to data files, pairs and references.

Looking at the codes for each sub-them, we can realise that *"journey"*, *"pre-journey"* and *"post-journey* reveal important overall meanings. Specifically, in the *pre-journey* context participants often talked about the need of establishing a connection before taking off. Establishing connection certainly includes a physical connection (i.e., *"setting-up"* the sighted guiding configuration), but also "making contact", namely locating each other in space, and finally making sure that both companions knew that the journey was about to start (e.g., *"new journey"*). As we can see from the table, *making contact*, and *setting-up* were the most frequent meanings identified by all participants.

In the *Journey* sub-theme, the most frequent signals were related to the change of both space and bodies' position during the walk. Indeed, participants frequently provided indications

about *"bodies reconfiguration"*, *"change in direction"*, and *"danger"* which they might approach ahead. All pairs described signals to reconfigure and change their bodies' position in relation to one another without stopping their walk. For instance, in *"bodies reconfiguration"* we can find indications such as "going to a single file" (i.e., moving from side by side to one behind the other while walking), but also a more general adjustment of companions' bodies position in relation to one another (e.g., getting closer or moving beside the guide).

In the *post-journey* sub-theme participants described which information they considered relevant when the journey stopped for a long time. There was usually a physical disengagement during this phase of the walk, and a subsequent re-orientation to the new space. Indeed, As Table 4.9 reports, in the post-journey sub-theme the most important meanings are "letting go", and "orientation to the space". This last meaning indicates that guides oriented their companions to the space to guarantee they were in a safe location when the journey stopped. Orientation to the space helped the transition to personal space, indicating to the VIP where they were in relation to the space. As a consequence, this helped visually impaired companions to take the next action independently. For instance, the guide *Charlie* said:

> *"Because guiding a totally blind person is important to understand that you can easily lose the sense of direction or the precise location and orientation within the space."*

4.3.4.3 *Body language and limitations*

In this section, I describe the body language in sighted guiding I discovered through my analysis. Figure 4.3 illustrates the body language broken down by meaning sub-theme (the inner circle). Colours in the Figure are used to highlight the different sub-themes in the body language. For each meaning sub-theme, the Figure maps a meaning (middle circle) against body movements (outer circle). More specifically, for each meaning (middle circle) the map shows which body movements (outer circle) have been associated with that meaning. The width of each body movement section represents the frequency of instances which have been paired with that body movement and the underlying meaning. Frequency increases with the width of the body movement section.

The map was created using both NVivo and Microsoft Excel after coding body movements and meanings. Firstly, in NVivo I computed a matrix (i.e., a two-dimensional array) where I allocated body movements in rows, and meanings in columns (for more details, the matrix has been reported in Appendix B.9). The matrix was populated through a NVivo function that counts

associations between body movements and meanings in all instances I coded previously. As a result, each cell in the matrix reported how many references have been coded under a specific body movement that belonged to a specific meaning. For instance, in Figure 4.3, we have the association 'change in direction'-'G pausing the walk' in the 'journey' sub-theme, meaning that the matrix reported how many references under the coding 'change in direction' belonged to 'G pausing the walk'.

In order to make sense of the body language, and relevant associations between body movements and meanings participants expressed, I imported the matrix into Microsoft Excel and created a visual representation through a sunburst chart (i.e., Figure 4.3). In this visualisation, I reported only existing associations and the rarest body movements associated with meanings are outer sections with no names.

When pairing body movements with meanings, findings revealed that there were a few body movements with no meaning and some meanings associated with other multimodal resources in addition to the body. Instances with meanings which referred to other resources were four times more than the instances of body movements with no meaning. This high occurrence confirmed what I have seen in the previous study, that is the presence of other modalities such as talk, and objects as ways of communication which are as important as bodily communication, and are intertwined in people interactions 3.3.

Since I found few instances of body movements with no meaning, those could be considered outliers for two reasons. Firstly, the body movements identified here were not completely new. Indeed, frequently participants associated these body movements with common meanings well-described in other similar instances (e.g., *pausing the walk*). Secondly, often the context of a body movement with no meaning was similar to other contexts described by participants, where pairs described relevant meanings to these body movements. So, throughout the following presentation, I only take into account *"no-movement"* label to highlight meanings that were not associated with any body movement, and in turn how this might reveal body language limitations.

Overall, from the Figure, we can notice that there is not a one-to-one mapping between body movements and meanings. Indeed, multiple times a body movement is mapped to different meanings in the same sub-theme. *"G pausing the walk"* in *journey* sub-theme is an example. Indeed, *Pausing the walk* is used by participants to indicate *change in direction, bodies reconfiguration, change in height,* and *danger* ahead.

Figure 4.3 also highlights a difference between associations in the journey sub-theme and associations in the other 2 sub-themes. On the one hand, for each meaning in *journey* sub-theme there is a clear predominant body movement, which is performed by participants. For instance, when a guide wants to indicate a change in direction, they pause the walk for a few

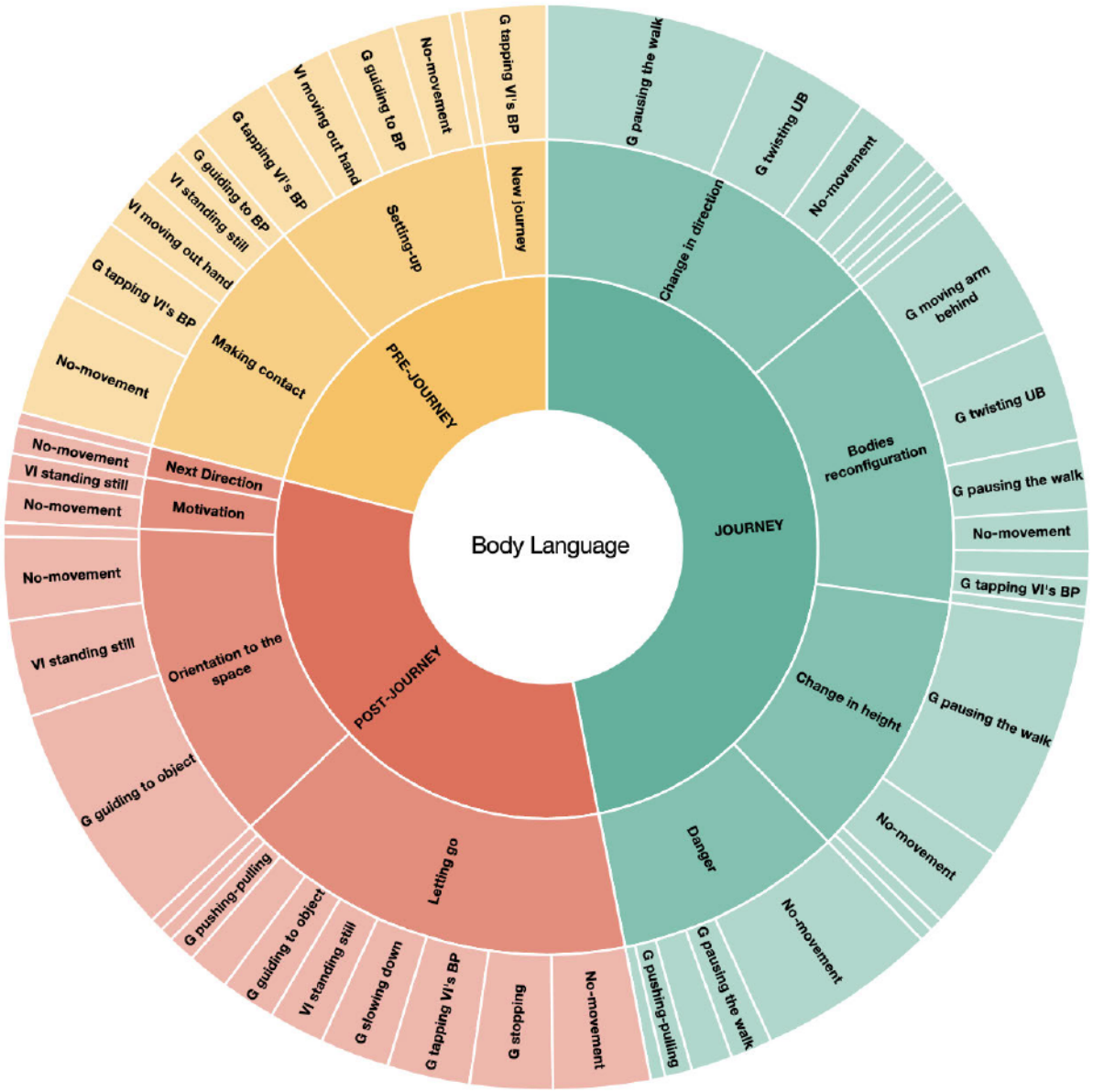


Figure 4.3: Study 2: The body language map is broken down by meaning sub-theme (the inner circle). Colours in the Figure highlight the different sub-themes in the body language (i.e., yellow represents the pre-journey sub-theme, green represents the journey sub-theme, and red the post-journey sub-theme). The Figure maps a meaning (middle circle) against body movements (outer circle) for each meaning sub-theme to represent the most frequent associations. The width of a body movement section increases with the associations between that body movement and its meaning.

seconds. An exception might be *bodies reconfiguration* since the map shows two frequent body movements: (*"moving the arm behind"*, and *"twisting the upper body"*). However, these 2 body movements depend on the type of holding pairs set at the beginning of their walk, as described in section 4.3.4.1.

On the other hand, what happens in the other 2 sub-themes is different and interesting. In *pre-journey*, and *post-journey* there is not a main body movement associated with each meaning. Body movements are more equally spread in each meaning. This highlights that there is no clear and shared body language across pairs to alert companions about these changes. Furthermore, we can imagine that body language can vary depending on the context of the walk (e.g., if pairs are in a crowded place, if they are starting from a seated position, etc.). Physical disengagement and engagement represent gentle passages where other resources (e.g., talk) become more or less of a priority. Thus, *pre-journey* and *post-journey* are challenging moments where body movements might have some limitations and other resources might play in to better negotiate these situations.

In the following, I present a more in-depth analysis of the body language for each journey phase: *journey*, *pre-journey* and *post-journey* respectively.

JORUNEY. As said in the previous section, *"pausing the walk"* movement reveals to have many meanings while companions walk together. For instance, an hesitation of a few seconds during the walk—while the pair is physically connected—can help companions to better understand their relative position, and reorient themselves to a new space. In the following example, *Ryan* (VIP), and *Grace* (G) described how they used to pause the walk to indicate *"bodies reconfiguration"*, and *"change in direction"* respectively:

> *Ryan: "My hand was then placed on Charlie's (G) elbow and he turned left and paused, so I could orient myself beside him."*
> *Grace: "[...] so if I was turning a corner I would stop and turn and then walk rather than sorting of moving diagonally, so it's more angular 'cause it is a kind of indication where we're going to go next."*

In this example, pauses seem important during the walk to indicate how companions have to change their position in relation to one another—*I could orient myself beside him*, and to give an indication on the direction—*I would stop and turn and then walk*. However, communication of more complex information appears to be limited in the use of body movements. Indeed, looking at Figure 4.3, in the journey sub-theme, *"No-movement"* is more frequent in *"danger"*, compared to the other meanings. As a reminder, *"danger"* takes a broader sense, from escalators (high

danger) to some other kind of obstacles (less danger), hazards, curbs, obstructions, etc. on the way. Therefore, when guides need to indicate that there is an upcoming danger and the pair requires further attention in navigation, they prefer to change the way of communication or add an explanation to the performed gesture. In this case, a performed gesture would help the person with visual impairment to quickly react to the obstacle ahead. For instance, *Grace* (G) described how she used to pull or push the companion to divert their trajectory:

> *Grace-G: "If there's like a very small obstacle, like a dog poo on the path, I will, I'll either sort of just nudge Noah (VIP) with the sort of back of my left hand and sort of—encouraging—him to take a bigger step to the left, or I might sort of gently pull him towards me in case he needs to come to the right a little bit. Or I just say it I just say—-yeah, take a big step—you know, quick—go left, hard left or right—And it's less and kind of intrusive than if we were in a more enclosed environment. This is very specific to when we're out in a big open space."*

As Grace reported, the modality used to provide information often depends on the current situation and context (e.g., indoor versus outdoor space), kind of obstacles, crowded places, etc. Indeed, in the *Grace*'s example, we can see that she interchanges gesture (i.e., "sort of just nudge Noah") with talk (i.e., "take a big step") to say the same thing. What is also clear from participants is that talk is often used in combination with body movements to provide more information about the context. For example, *Grace* continued the previous conversation, highlighting that contextual information such as why guides are doing some actions, or what is happening around are important complementary information:

> *"I will tend to tell him when to do something like sort of subtly, you know, saying—-go left go right—- without actually explaining why we're doing that. And, you know, Noah (VIP) will ask why what was that? What did I miss? What was there? And then I'll say—Oh, it was a bin—or—-a hole there—and having that context."*

In sum, as we can see from these examples and the body language map, during the journey bodily communication is highly rich and recognised by participants. Although it is complex and subtle, there are some frequent and common associations between body movements and meanings. Moreover, we have started to see how a danger in navigation (i.e., challenging situations, such as obstacles ahead, crowded places, uneven terrain, etc.) represents the most frequent situation where other multimodal resources (i.e., talk) come in. Indeed, in these situations, body movements are extended using a combination of other resources to further note a body movement's meaning, and to add new information about the context where a gesture is performed.

While in the journey sub-theme participants identified only body movements initiated by the sighted guide, in pre- and post-journey sub-themes we can also observe body movements which involve the visually impaired companion. Likely, this happens because during pre- and post-journey participants commonly identified meanings related to physical engagement and disengagement. Since these situations might result to be more critical, there is a more direct interaction between companions and a more careful negotiation of needs. For instance, *Ryan* (VIP) said:

> *"I guess the beginning and the end are the most important. Starting off the movement, moving from the chair, standing up, going out the room and then getting back to my chair and being able to sit down safely."*

PRE-JOURNEY. In the pre-journey sub-theme all participants identified the gesture of *tapping a body part* as an indication that the guide is ready to guide, and the journey is about to start. As *Ryan* (VIP) phrased it:

> *Ryan-VIP: "Charlie (G) tapped at my shoulder while I was sitting at the desk to indicate the walk was starting. I stood up next to him, he touched my shoulder again and I put my left hand on his right shoulder."*

In this example, *Charlie* touched a body part, which *Ryan* (VIP) holds during their journeys (i.e., the shoulder). As mentioned in section 4.3.4.1, if companions are used to holding the elbow or the hand is likely that sighted guides tap the elbow or the arm rather than the shoulder. For instance, *Noah* (VIP) usually holds *Grace*'s (G) hand, and he described that *Grace* touched his arm to start the walk:

> *"Grace (G) would tap me on the arm if she was ready to guide me again."*

These two examples show that tapping is a shared movement among participants, and also demonstrate how the body part that pairs hold during sighted guiding encloses an implicit meaning for participants. This confirms that the body language in sighted guiding varies from pair to pair, it is quite subtle, and each pair learn and refine their way of communication through practice.

As we can notice from Figure 4.3 in *pre-journey*, "tapping VI's body part" is the most frequent body movement associated with both "Setting-up", and "New journey" meanings. Other modalities, such as talk, have also been frequently identified by participants as a way to gently ask permission for setting up the guiding configuration:

> *Grace-G: "I would say—we're going to move now, please can you give me your hand?—it is not a grabbing thing."*

This example starts revealing that body movements are not always the best approach for setting up the physical connection. The transition from being on their own to moving together is particularly delicate and body movements are not always well accepted by participants even when companions have known each other for a long time. Since companions need to approach each other, often a gesture such as tapping, or guiding the hand towards the elbow/shoulder is considered an invasive and intimate gesture.

In support of this case, we can pay attention to the various body movements associated with "making contact" in Figure 4.3. In this slice of the map, pairs illustrated the presence of (*"No-movement"*) as a predominant modality when they had to make contact. As a reminder, "making contact" refers to signals for establishing or re-establishing contact once a pair is apart. It differs from "setting-up" because it does not include explicit indications to set up the sighted guiding configuration. Indeed, before physically engaging, it is also important making first contact by locating each other in space when for instance, pairs have been separated for a long time. As an example, *Grace* (SG) described how she made contact with her companion through voice rather than gestures:

> *Grace-G: "[...] and then sort of having that, you know—I will meet you here—And when we come back together, you know, I'll speak his name I'll sort of make sure that he knows I'm there. I don't want to just sort of touch him and scare him."*

Making contact is considered a more delicate moment which requires soft permission. As we can read from *Grace*'s words, this permission is not given through the use of body movements. *Noah* (VIP) agreed and interrupted *Grace* saying: *"I generally find quite shocking making contact without saying something, to be honest."*. Therefore, people preferred to orient themselves to each other using voices. Here, the use of body movements would mean forcing the guide's agency on the companion's ability to locate the guide in space.

POST-JOURNEY. Various meanings emerged in relation to the post-journey sub-theme. Participants referred to signals of *"letting go"*, *"orientation to the space"*, *"motivation"*, and *"next direction"* information.

Associations between *"letting go"* and body movements reveal some interesting insights. As a reminder, *"Letting go"* refers to indications of the need to physically disengage from one another.

As we can see in Figure 4.3, "Letting go" is evenly associated with various body movements described by participants with non-strong prevalence.

Some pairs described the use of walking speed (e.g., stopping the walk or slowing down and stopping the walk) and tapping VI's body part as indications of letting go. Indeed, pairs tended not to physically lose contact if they were still walking, so slowing down and stopping were already a signal that something (i.e., disengagement) was about to happen. For instance, this situation was described by *Alice* (VIP):

> *Alice-VIP: "As we walked diagonally across the dining room Stuart (G) stopped and gently disengaged his arm, and moved forward to open the window."*

The wide umbrella (see Fig. 4.3) of body movements associated with "letting go" does not only include gestures but also the "no-movement" modality. The variety and wide umbrella represented in the figure highlights that "letting go", and more generally post-journey moments might be featured as challenging by participants Through the following examples, I will illustrate how participants experienced these moments to identify some limitations. For instance, the context in which the disengagement is performed by pairs can play an important role. In the following examples, we can notice that what happens after physical disengagement might influence how participants indicated "letting go". When companions disengage and remain in close proximity, they often do not use clear and explicit body movement. For instance, *Alice* (VIP) described what happened when Stuart had to pick up something from the shop's self:

> *Alice-VIP: "To disengage safely in the shops, it might be just summarised on losing, losing your hand now, he will just gently move his arm and I'll lose it automatically."*

When companions remain in proximity and physically disengage, they are still connected through voice and presence. In this case, letting go is negotiated easily. In contrast, when companions physically disengage and move apart, guides tend to position their companions somewhere in space to guarantee their safety, and make sure they know where they are, and consequently, visually impaired companions can take the next move independently. Thus, *"orientation to the space"* becomes extremely important to people when guides are moving apart. All pairs identified that body movements such as guiding the visually impaired person to an object or space help to realise where they are and indeed not to get disoriented. For instance, *Charlie* (G) described how he used to guide *Ryan* (VIP) to an object when they were in a new space and about to disengage:

> *Charlie-G: "Normally when I really help Ryan to put him in a new space for example, I usually put his hand on the back of the chair and he knows from there how to work out, where to sit which part of the chair that he needs to be to be able to sit safety."*

Figure 4.3 also shows that apart from *"letting go"*, the other meanings in the post-journey sub-theme are mainly associated with other modalities (*"no-movement"*). Indeed, after disengagement, the physical link between the pair is lost, and likely other modalities (such as talk) need to replace information previously perceived through gestures (such as direction, and orientation to one another). Therefore during the post-journey body movements become irrelevant once pairs have disengaged. Following this perspective, letting go represents the crucial moment of this transition.

In sum, through this analysis, we have seen the complexity of the body language in sighted guiding, where indeed there is not a one-to-one mapping between body movements and their meanings. Further, the findings have revealed: (i) the body language can change from pair to pair depending on the type of physical connection (e.g., holding the elbow, or shoulder) people have established; (ii) the body language results be clearer and better defined during the journey, and more ambiguous and vague during pre- and post-journey moments. According to this, we can draw some limitations in body language. Specifically, (i) during the journey the body language fails to describe contextual information; (ii) the body language is perceived by participants as too intrusive when pairs have to establish their first contact, adopting other modalities for orienting to each other; (iii) there is no clear body language during moments of physical disengagement, and all information perceived through the body language is removed during post-journey moments.

The analysis of the body language in sighted guiding reveals that physical disengagement seems the most ambiguous and challenging moment in sighted guiding. Therefore, through part B of study 2, I decided to focus on physical disengagement as a context of exploration of the design space.

4.4 PART B: INTRODUCING AN AI PROTOTYPE

4.4.1 *Design and Implementation of an AI prototype*

The initial plan was to design a preliminary AI computer vision prototype, narrowing the research to the context of physical disengagement in sighted guiding as during my previous studies, I found physical disengagement to be a challenging moment during navigation. Indeed, the aim was to implement some ideas based on findings from part A and then introduce this AI prototype to participant pairs in part B for investigating the design space. Initially, I planned to hand the prototype to pairs during a workshop session and to involve people in discussions around benefits, limitations, and whether they might have a more enjoyable guiding experience. Specifically, I was interested in receiving some initial feedback, and insights on how sound could be deployed to complement and extend the sense pairs develop of each other, exploring the relative location and distance between a person with visual impairment and a guide when companions have to physically disengage and move apart. The use of sound was introduced in study 2 part B as an attempt to involve people in discussions. Also, previous study methods (study 1 and study 2 part A) did not allow for analysing in detail sound as another resource in the interdependent work (i.e., external, and environmental sound). In study 1, for instance, using cameras, it was difficult to distinguish sound from the environment and how it intertwined with the pair's interactions.

This approach allowed me to incorporate what I learned from the previous study while carrying on my research during the COVID-19 pandemic. The design and implementation lasted approximately 2 months. At the end of the implementation, COVID-19 restrictions on travel and meetings were still in place, and then I had to revise my initial study plan on how to introduce the prototype to pairs (see Section 4.4.2 for more details about how the study procedure and data collection changed).

The preliminary AI computer vision prototype comprises two main elements: a smartphone and a physical marker. The former is worn on the VIP's upper arm, in a running armband. The latter is attached to the back shoulder of the guide. Figure 4.4 represents the configuration set-up. The prototype uses an iOS application installed on the smartphone to access the phone's camera and detect the marker worn by the guide. The prototype was designed to be used during sighted guiding. Specifically, a pair needs to set up the configuration shown in Figure 4.4 before taking off. The guide wears the marker on their shoulder using a Velcro strap. The guided

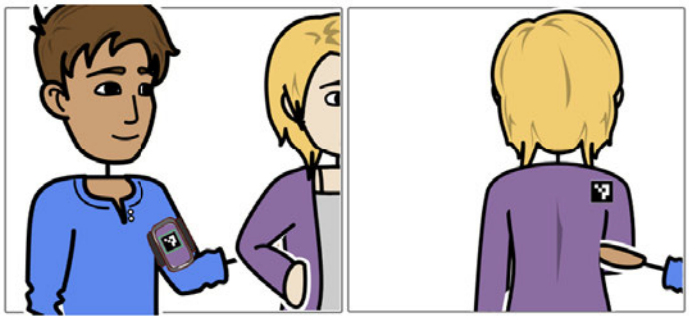


Figure 4.4: Study 2: AI application set up.

person instead wears the smartphone with the application installed in an armband on their upper's arm, the arm used for guidance. The guided person wears the smartphone so that the camera is pointing toward the companion, as shown in Figure 4.4. As soon as the application is launched, the smartphone turns on the front camera, and the application starts processing the image frames captured by the camera. The application searches for the marker worn by the guided companion. After the detection, the application tracks and estimates the relative distance between companions using the marker and provides audible feedback (i.e., a continuous "blip") in real-time. The audible feedback represents the tag's distance from the phone. The sound changes in volume. It gets louder as the tag is moved closer to the camera.

The application has been built in iOS mobile operating system, supporting iOS 13.x and above. It is written in both Swift 5 and C++ languages, using the XCode IDE (Integrated Development Environment). It is also based on a popular computer vision library called OpenCV [154], which is cross-platform and free for use under the open-source Apache 2 License. I have employed OpenCV core functionalities, but also ArUco library [37] included in the extra modules package, which supports the detection of a variety of black and white markers dictionaries.

I designed and implemented the prototype in 3 phases:

- Phase 1: I implemented marker detection. I did research in the literature about computer vision libraries. I chose the ArUco library because it was well-integrated with other common computer vision libraries that I needed for implementation (i.e., image frame processing). During this phase, I also implemented the skeleton of the mobile application (i.e., layout, buttons, and navigation). The detection feature was tested using some pre-recorded video where I recorded myself wearing the phone and centring the marker in and out of the camera frame.

- Phase 2: I implemented the audible feedback and the change in pitch based on the marker's distance. I estimated the marker's distance from the camera and implemented functions to handle audio events. I tested the audio feedback features by pre-recording some videos of myself wearing the phone and walking closer and further away from the marker. Testing helped me to understand and modify the audio feedback implementation.
- Phase 3: I tested the application in a realistic scenario. Since COVID-19 restrictions were still in place, I adopted the empathic modelling technique to test the application. Specifically, a colleague and I took several walks in my neighbourhood using a sleeping mask to mimic the low vision condition. We set the sighted guiding configuration and we started the application before starting the walk. This allowed me to see that the application was not working as expected: (i) the marker detection was unstable because during the walk the arm and therefore the camera was bouncing a lot; (ii) the change in pitch was too slow in relation to the marker's distance. I proceeded to refine the application to correct these two problems before a final test.

4.4.2 *Part B study procedure*

The aim of this study was to introduce a preliminary AI prototype for enhancing moments of physical disengagement and ask for initial feedback and input from participants. AT the beginning of part B, COVID-19 restrictions on travels and meetings had not been lifted yet. I had to approach this stage completely in a remote setting. I invited pairs from the previous stage to a co-design workshop on Zoom of about 1 hour and a half. The session was video, and audio recorded, and it was structured as follow:

- Workshop introduction (15 minutes)
- Computer vision prototype introduction (25 minutes)
- Co-design storytelling activity (45 minutes)

WORKSHOP INTRODUCTION. A few days before the workshop I sent to participants an audio recording of about 2 minutes in which I illustrated the workshop's aim, and emphasised the perspective I was looking for. Thus, I gave them time to understand that my intent was to acknowledge that sighted guiding works very well and that I was not seeking to replace it, but instead, I was looking for their input on how the proposed story could be extended using

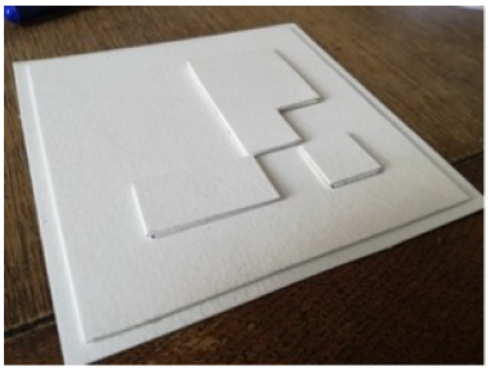


Figure 4.5: Study 2: Tactile tag version.

technology. The workshop introduction was a further opportunity to underline this perspective and to highlight that the AI prototype was very much preliminary, and it provided some of the basic ingredients to a new system that will support particular interactions between people who are blind and their guides.

COMPUTER VISION PROTOTYPE INTRODUCTION. Firstly, I presented the different prototype components. The concept of computer vision application was conveyed through a conversation on similar applications blind people might use in their daily lives and be familiar with (e.g., SeeingAI [84], and TapTapSee [59]). The physical marker used in the application is a paper-based binary drawing composed of different geometric shapes, similar to a barcode. To help people with visual impairment to make sense of the marker I sent them a tactile version illustrated in Figure 4.5 so that they could touch and feel it during the session.

The AI prototype was then introduced through a Wizard of Oz (WoZ) approach. For giving them an idea of how the application works, the three of us acted in different roles. The guide was holding the marker, the visually impaired person was holding their smartphone, and I was playing the role of the technology. Specifically, in the video call, on my side of the screen, I had the same set-up. I was holding my phone with the AI application open and running, and I had a digital marker on the screen. I asked the visually impaired person to do some movements simulating the use of the front camera. For instance, finding the marker moving the smartphone left to right or forward and backwards. While they were doing these movements, I mirrored their gestures using the real application, so that they could hear through the screen the audible feedback every time the digital marker was detected by my phone.

CO-DESIGN STORYTELLING ACTIVITY. After participants had a good sense of the prototype, I presented a story of a couple of friends Alice and Stuart having a daily walk in their neighbourhood using the sighted guiding configuration. Stuart (VIP) is holding Alice's elbow (G) and in this story, the 2 friends have to physically disengage for some reason. As illustrated in Figure 4.6, the story was presented through an audio-visual storyboard in PowerPoint. To make the visual content accessible to the participants with visual impairment, at each scene or slide I associated an audio track which describes and enhances the scene of the story and its visual representation in the slide. In Figure 4.6 the right column represents the shown slide, and the left column reports the audio script participants listened to. The audio file was designed to be from the perspective of the blind person and the visual representation from the guide's perspective. After listening to the audio file together, I asked pairs to undertake activities related to that scene of the story.

I stepped through the scenario with participants, helping them to reflect on their experiences, generating ideas and discussing the strengths and weaknesses of the proposed prototype. Participants envisioned how the AI assistive technology interplays in sighted guiding and specifically in moments where the guide needs to suddenly leave the visually impaired person's proximity. I prompted for feedback on:

- Benefits and limitations of the scenario of use.
- Missing or redundant steps in the scenario.
- Positive and negative aspects of the proposed technical solution, e.g., starting/stopping the system, auditory feedback, camera placement, etc.
- Potential impact of everyday use, such as security, and user experience.

4.4.3 *Data collection and Analysis*

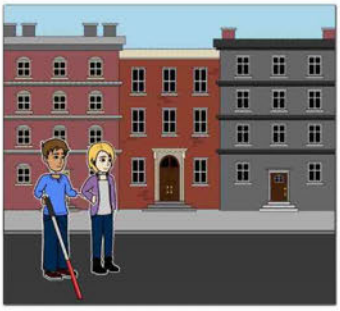
2 pairs out of 3 were happy to continue the research, so I had 2 remote meetings of about 1 hour and a half. Video recordings containing participants' faces were reviewed only by the research Team (supervisors and myself). Ethical approval for part B was gained as an extension of the Ethics application of part A (see section 4.3.2, and Appendix B.1 for more information). After the 2 remote meetings with pairs, I transcribed both the prototype introduction and the co-design storytelling activity. Using these transcriptions, I performed a qualitative analysis of the data through thematic analysis [18]. I applied an inductive and deductive approach. I went

SCENE 01: Introduction

Audio file: *SB-scene01.mp3*
Bell ring
Music on the background
N: Alice and Stuart daily walk is an audio storyboard. When you hear this sound "*whoosh*" The scene has ended.
This is a story of a couple of good friends, Stuart and Alice. They live nearby and they met for the first time 10 years ago. Stuart is blind and is also an independent traveller. When with Alice, he holds her right elbow with his left hand and his long cane on his right hand. Having daily walks together have helped them to build up both their friendship and a good relationship through guiding.
Whoosh

SCENE 02: the walk starts

Audio file: SB-scene02.mp3
Bell ring
Ambient sounds of urban city
N: Today, Alice will pick up Stuart at 3pm for a walk in their neighbourhood. It is a spring, sunny day in London.
Knock knock
A: Hi Stuart it is Alice
Open the door, close the door
S: Hi Alice, how are you?
A: Good thanks, shall we go to the park? Are you ready?
S: yeah, I am ready. Great idea, it is very nice day
N: To start the walk Alice bends the right arm parallel to the ground and taps with her right elbow Stuart's left arm. This is a sign for Stuart to take Alice's right elbow while holding the white cane on his right. This body movement helps them to physical engage and set up the guide configuration.
The couple of friends is now walking together side by side at regular speed.
Ambient sounds of urban city + people walking + sweeping of the cane.
Whoosh

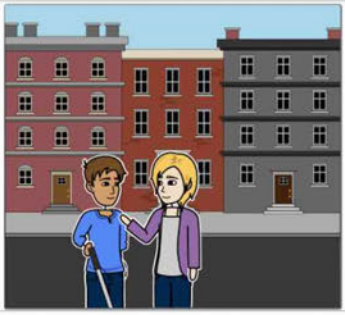


SCENE 03: letting go

Audio file: SB-scene03.mp3
Bell ring
People walking
N: While walking, suddenly, Alice slows down and physically disengages the arm from Stuart. She has no time to alert Stuart about what it is happening.
A: hold on
Walking steps from close to far.
Steps stop
S thinks: where has she gone?
N: Alice has moved away, and Stuart is left on his own and stands still, waiting for Alice to come back.
Whoosh

SCENE 04: coming back

Audio file: SB-scene04.mp3
Bell ring
Ambient city sounds
N: Alice is coming back to Stuart. She is approaching him.
Walking steps from far to closer. From low to high.
Street noise
N: Stuart stands still while Alice taps with her right hand on Stuart's left shoulder. the pair re-establishes the usual configuration.
A: "Sorry Stuart. I had to rush off to help a lady who had fallen to the ground. Shall we continue our walk?"
Whoosh



SCENE 5: continue the walk together

Audio file: SB-scene05.mp3
Bell ring
People walking
N: Alice and Stuart are now walking together toward the park nearby.
S: "Shall we stop by a coffee shop?"
A: "Yeah, we can try the new one in the park."
Whoosh

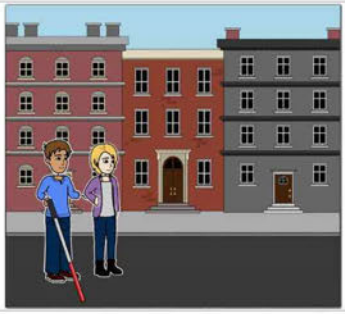


Figure 4.6: Study 2: Storyboard.

through the data the first time, during which I noted some possible emergent themes relating to how audible feedback might support moments of physical disengagement, and how pairs might adjust/negotiate their interactions with a preliminary AI prototype. In a second review pass of the data, I performed a more in-depth coding process. I refined codes while focusing more on the participants' feedback and interactions I noticed in the interviews. Finally, I readjusted my initial list of emergent themes which are reported here below:

- Audible feedback exploration: How did participants envision the use of audible feedback to support the scenario of study? Were there any challenges?
- Digital marker: How did participants adjust the digital marker to the context of exploration?
- Use of the camera: How did participants adjust the use of the smartphone's camera?
- AI prototype feedback: How did participants react to the AI prototype?

4.4.4 *Findings*

Through the analysis of collected data from part B, I wish to present some preliminary feedback participants expressed in relation to the AI prototype (see section 4.4.1) that I have introduced in the workshop session. Participants provided practical inputs and engaged with enthusiasm during the workshop session, holding a lively discussion and conversation. However, their reaction was negative overall. Indeed, participants found the AI prototype was not supporting their partnership, and it did not extend their body language in moments of physical disengagement. Instead of proceeding with further refinements and evaluation of the prototype, I decided to step back and reflect on the reasons (reflections are reported in discussion section 4.5).

AUDIBLE FEEDBACK EXPLORATION. During the storytelling activity I explored with participants the use of sounds as a way to indicate their relative position and orientation. Specifically, through audio files, we discussed four different sound features which could be used to augment what was happening in the scenario: pitch, tone, rhythm, and spatial audio. Participants proposed a change in pitch as an indication of pointing towards the right direction: *"It pitched loudly when it is pointing at the right direction and it fades away when I move the camera away from the digital marker"*. However, both pairs pointed out that a quiet sound may be difficult to hear in the background, especially in noisy places, therefore in the scenario—I proposed—sound feedback needs to be louder.

Participants' preference around tone was to have a sound like a *sonar* or a *"blip"*. Indeed, a crescendo might be easier to perceive having a repeated tone rather than a continuous sound. However, pair 01 also illustrated the idea that the tone is a personal choice, and so the application should have a setting to personalise their sound preference. Further, participants pointed out that many people with visual impairments might also have difficulty hearing some tone range. Pair 01 suggested providing an option where people can set their tone range.

The rhythm was appreciated by both pairs. Pair 01 pointed out that rhythm can be used in combination with a pitch to indicate relative direction. In this case, a high rhythm combined with a loud pitch sound indicates that the person is pointing the application in the right direction. Pair 02 instead suggested different rhythms to indicate different directions. However, they also proposed a different audible feedback: *"why not just to say—-10 yards ahead, 10 yards behind—rather than a blip, or clockwise—partner 10 yards 2 o'clock position—So 12 o'clock is straight, 6 o'clock is behind you"*.

Spatial audio to indicate direction and orientation was not appreciated by any participant because of the necessity of wearing headphones, suggesting that spatial audio would not add anything more to pitch and rhythm.

DIGITAL MARKER. During the workshop I described the digital marker shape, but I allowed participants to express how and where the tag should be worn. The marker or tag was intentionally designed roughly because one objective was to explore better its design. Both pairs preferred to wear the marker on the upper arm used for guiding. Participants suggested attaching the marker on a stretchy armband, not too heavy. However, the designed marker was too large and both pairs agreed on resizing the tag to fit the arm's size. Their preference on where to position the digital marker suggests that the arm represents an anchor point during the navigation, an important reference which may need to be explored further in the design of future computer vision systems. As we have also seen in the findings of part A (see 4.3.4.3), many body movements participants expressed to be important start from their "socket". Further, a pair was concerned about wearing the marker on the back or shoulder using Velcro or another strap attachment. They were afraid of falling, or someone pulling it off. A pair also suggested repeating the pattern all around the band to have multiple tags instead of one. This would help the smartphone's camera to detect the tag continuously, improving cases where the tag is out of the camera's frame. This highlights that people might be interested in knowing the relative distance, but also orientation.

USE OF THE CAMERA. Although both blind participants said they usually carry their smartphone when travelling with sighted guides, the use of the smartphone's camera raised different concerns, adding new constraints to the design space. Firstly, participants usually keep the smartphone in their jacket's pocket (chest height), trousers' pocket, or in a pouch, therefore they were worried and they found challenging holding the smartphone in their hands: *"because I hold the white cane on one hand and Charlie's shoulder on the other hand"*. They suggested keeping the smartphone in their pocket and taking it out when they need to use the application. This imposes constraints on the design space, specifically on the scenario of study, and consequently what can be captured by the AI prototype. Participants also raised concerns about having a running application in their pocket all the time, because the smartphone's screen is much more sensitive when using accessibility features. Therefore, if an app is running inside the pocket, some fabric might touch the screen and change the app's status easily. Pair 02 was also very sceptic about the use of a camera in public places. Privacy and ethical concerns were raised (e.g., capturing of sensitive information, and negative perception by passersby) which made the conversation beyond practical issues challenging.

INTERPLAYING WITH THE AI APPLICATION. Visually impaired participants had different design ideas about how and when the AI application should be integrated into companions' interactions. Specifically, in the discussed scenario of study, the second pair would start the AI application before taking off, so they do not have to think about it later. The first pair instead suggested starting the application when they need to. They proposed to run the application once companions are already apart, and the person with visual impairment would like to find out the companion's direction. *"When the app starts, I would be instinctively in camera mode and I have to just point it around me to find where the guide might have gone"*. Both pairs agreed on using speech as a common way to start an application: *"I would say something like—launch sighted guide app—-and then it comes up."*. The visually impaired participant continued saying: *"If I have to use the application and speak to it, I think it would be better to use the back camera instead of the front camera"*. AI interactions described by participants are similar to other common AI smartphone applications the blind community uses in their everyday lives for completing practical tasks.

AI PROTOTYPE FEEDBACK. Pair 01 had a slightly positive reaction compared to pair 02 around how audible feedback might extend their body language when physical disengagement

happens. Firstly, pair 01 identified themselves in the scenario of study: *"something very similar happened to us"*. They then expressed their interest in knowing which movement the guide was doing (e.i., running, falling, and standing still) as relevant information they would like to know after relative location. Further, while reflecting on the use of the AI prototype in other contexts (e.g., shopping/grocery, theatre, and restaurant), pair 01 also highlighted the interest in knowing whether the guide is returning to their side. For them, this seemed to be important when they have been far away for a long time, and the visually impaired companion stands still, waiting for the guide to come back.

Pair 02 was very sceptical instead, especially since the participant with visual impairment did not see any value in the preliminary AI prototype I introduced. The pair had concerns about several design aspects I was exploring during the workshop. For instance, the pair pointed out that the scenario of study was rare and not realistic since the sighted guide does not move too far or leave the companion's proximity. Moreover, they described that the guide always says something about what is happening around them and why they have to move apart. Other issues were related to the AI prototype itself. For instance, participants said that audible feedback would not work outdoors in crowded places, and with many obstructions, also adding that person's reactions are quicker than technology. Finally, as said above pair 02 also pointed out concerns about the use of smartphone camera in a public place: *"and there's a little child over there a parent might think—why are you filming my child—why are you filming us wearing this around?"*

The pair was limiting the discussion during the workshop, closing the possibility to explore the design space. Although participants provided some practical design features related to the prototype, moving beyond the current focus of solving discrete tasks was difficult, and in some cases, participants' abilities were diminished unintentionally during the session (see Discussion section 4.5). Indeed, the discussion of the prototype through the storyboard and the use of audible feedback provoked a negative reaction from a participant: *"blind persons aren't useless, I would go and help anyway. If someone falls off the bike, even if the person can hardly see, they might be able to do something while the guide is helping them, they could call an ambulance or something like that. A blind person is not just stuck there like garbage, you know, they would want to help as well within their ability."*. This negative reaction from pair 02 let me stand back and reconsider the design process. In the following discussion, I will come back to some of these points to reflect on why the adopted design method did not fully help companions to explore ways in which AI could support the collaborative work that takes place in sighted guiding.

4.5 DISCUSSION

In study 2 I have given the focus on both the *problem space*, exploring the body language in part A and the *design space*, introducing to sighted guiding companions a preliminary AI prototype to extend moments of physical disengagements. Findings from part A revealed the body language in sighted guiding. They also highlighted limitations of the body language and the presence of other multimodal resources which have been highly used when companions physically disengage moments. This helped to identify the scenario of study for approaching the design space in part B. The findings from part B showed the practical design of AI prototype features participants suggested. They also showed their initial negative and limited feedback about the role of the proposed AI prototype. Therefore, in the following, I wish to re-consider the design process I adopted in study 2. Due, to COVID-19, The study had a limited number of participant pairs. Only two pairs took part in the remote workshop, however, participants provided initial practical design features. To involve people in the design process, the study employed a set of techniques commonly used in the (re)design phase of the UCD approach (i.e., introducing AI prototypes through the WoZ approach and storytelling through accessible storyboards). I acknowledge that UCD approach as described by Preece et al. [64] was not put fully into practice in this thesis. One outcome is that the techniques I adopted did not fully help participants to explore ways in which AI could support the collaborative work that takes place in sighted guiding. Moreover, as Morrison et al. argue, inviting people with vision impairments to speculate on AI-based assistive technology can be difficult [89]. For example, it is common for people to rehearse cliched ideas of assistive agents or unhelpful and exaggerated roles for computer vision. Therefore I decided to take this opportunity to stand back and reflect on the reasons, presenting some design method considerations in this Discussion. Considerations suggest the introduction of methods not standard in UCD, as an attempt to open up a space that is grounded and at the same time provides a basis for people's imagination.

4.5.1 *Storytelling activity*

A REDUCTIVE AND NOT SITUATED SCENARIO OF STUDY. The proposed scenario tells us about Alice and Stuart's daily walk. While walking together the pair experiences an unexpected event happening nearby: an elderly person is falling on the ground (see storyboard in Figure 4.6). In this situation the pair physically disengages and the guide goes away to help the person.

As findings report, both pairs pointed out that a sighted guide moves too far rarely. If the pair get separated, firstly the guide will make sure the blind person is safe. It might happen that they get separated accidentally, but in this case pair 02 observed people's reactions are much quicker than technology, cutting out any possibility for technology to have a role. Therefore, pair 02 was very sceptical about the proposed scenario, and described it as not realistic.

Instead of being not realistic, I argue that the scenario was too reductive and not situated. Indeed, it did not consider the variety of social interactions which might happen when people have to disengage. As we have seen from previous findings pairs manage these situations well, using interactional resources, for instance, intertwined talk and saying what is happening and why they have to disengage (see 3.3, and 4.3.4.3). In this regard, it does not build on people's capacities, but physical disengagement is perceived as a problem to solve, where the person with visual impairment needs some missing information.

An example which builds on people's capacities instead is the recent design work done by Morrison et al. [89]. The authors explore human-AI interaction through the design of an AI open-ended technology with a blind child to provide information about people in their proximity. Similarly, the scenario of my study quickly changes while the pair walks together and the end-to-end use cannot be easily defined, despite my attempt to do so through the storytelling activity. Pair 01 had a much more positive response compared to pair 02 because companions identified themselves in the story. They have experienced a similar situation, and they had suggestions on how the AI prototype might proactively empower people who are blind in sighted guiding: asking for help, and knowing the guide's posture.

In sum, the scenario of the study was situated for one pair, but too far from the other pair. This opposite reaction of the participants demonstrates that the scenario was overly constrained, leaving no space to explore alternatives. Therefore, new exploratory methods that aim to investigate alternatives in the design of future AI assistive technology might bring greater benefit.

4.5.2 *AI prototype introduction*

AI PROTOTYPE AS A PRACTICAL, BUT NOT ENOUGH EVOCATIVE TOOL. At the beginning of the session, as described in 4.4, the AI prototype was presented using references to similar smartphone applications participants were familiar with in their everyday lives (e.g., SeeingAI [84]). These applications are used by the blind community to achieve practical and individual

tasks. For instance, a visually impaired user can take a picture of a letter and the application reads out the sender's address. Driven by their everyday experience, participants had some pre-established ideas of how a new AI smartphone application for people with visual impairments should work. Accordingly—as we have seen in the findings section—participants provided practical suggestions on how to launch the application. For instance, *Ryan* (VIP) from pair 01 said: *"launch sighted guide"*, and then *"I have to just point it around me to find where my guide has gone"*. These expressions and gestures mimic the current ways of interacting with applications which aim to accomplish pragmatic and individual tasks.

Despite the attempt to present my perspective, using an audio recording sent few days before the online session (see Section 4.4), I believe the AI application was perceived by participants as a practical, but not enough evocative tool. By evocative tool, I mean that the application did not give space for participants to reflect beyond the current use of AI in the context of assistive technology. Recent work in HCI highlights the importance of balancing these 2 features when we want to open up the design space and creativity. For instance, Ghajargar and Bardzell in their work state: *"designing everyday use objects for reflection requires a synthesis of two apparently opposite forms: conventionally practical forms since they are everyday use objects, and evocative forms since they make users think."* [41]. Instead of narrowing down onto a *"solution"* in research, research through design and speculative approach might be more appropriate for making alternative designs and speculate on possible future, where AI might play a different role [102].

4.5.3 *Participation and Engagement*

ENGAGING PEOPLE WITH MIXED ABILITIES IN A REMOTE SETTING. The two pairs responded differently to the user experience of an AI prototype. Pair 01 suggested some nice insights about the role that AI technology might play in sighted guiding. For instance, *Ryan* (VIP) said: *"It increases in sound when I am pointing in the right direction. So, I know where to look and maybe where to shout out for help or say—–are you ok? What's happening—-so ask for verbal feedback"*. As reported in the findings, pair 02 was instead much more sceptical, indeed *Alice* (VIP) pointed out that people's reaction is much quicker than technology, leaving limited space for an alternative role of AI technology to emerge.

Participants were involved in a lively discussion, the storytelling activity was accessible using a mixed media of visual and audible tools, and the scenario of the study was well understood.

However, it is clear that for some the technology was perceived as a solution for their visual disability, and therefore being perceived as less able than a sighted person. For instance, the visually impaired participant from pair 02 said: *"Blind persons aren't useless, I would go and help anyway. If someone falls off the bike, even if the person can hardly see, they might be able to do something while the guide is helping them, they could call an ambulance or something like that. A blind person is not just stuck there like garbage, you know, they would want to help as well within their ability."*

Their reflection let me think that the adopted method and setting failed in engaging people with different abilities to think about interdependence. In this regard, the adopted method was not completely accessible in understanding the role of the prototype, and including people in the design journey. Begel et al. [7] recently highlighted the difficulties authors had in engaging with the autistic population when designing AI technology. They show that building prototypes that leverage AI functionality can be very challenging, and traditional design methods can be overly optimistic in presenting AI functionalities to people. Driven by this research, it is clear that participants' abilities were "diminished" unintentionally, and therefore it is essential to acknowledge the need to re-think how to further engage with the population.

Furthermore, due to the remote setting in which I conducted the study, participants did not engage with the AI prototype on their own. The WoZ method was good to have a sense of how the application might work, but there was not a hands-on activity. In this case, a rapid prototype did not allow for deeply engage with a mixed abilities population.

Through this study I approached the design space at the interaction of interdependence and AI, narrowing the research to the context of physical disengagement in sighted guiding.

Firstly, I explored body movements and their meanings. Findings revealed the body language in sighted guiding, understanding their limitations when people physically disengage and move apart. Secondly, I introduced a preliminary AI prototype to extend moments of physical disengagement and asked for some initial inputs from sighted guiding companions. My experience approaching the design of an AI prototype with sighted guiding companions taught me more about my design process and how common UCD techniques I used may not be sufficient when involving both complex systems, and people with mixed abilities.

This research study provides a next step towards the final study, aiming to better explore the *design space* at the intersection of AI and interdependence. Specifically, the next Chapter

focuses on developing a new design method for helping sighted guiding companions to creatively think about interdependence and AI aiming to strengthen their partnership.

5 MAKING DESIGN SPACE FOR AI AND INTERDEPENDENCE (STUDY 3)

5.1 MOTIVATION AND RESEARCH QUESTIONS

In the previous Chapter, I explain how I struggled to employ a user-centred design method that accounted for the collaborative work that takes place in sighted guiding (see Chapter 4). For instance, the prototype I introduced did not help companions to think beyond the practical functionality of the AI application.

Through this final study, I reconsider my design process and my exploration of the design space. My intention here is to rethink the design process I had followed so that it might allow both designers and participants to move beyond the idea of AI as a solution to blindness and sight impairment and to develop the basis for new design methods which help to involve people in the design process and pay special attention to their collaborative achievements and competencies.

The aim of this study is to answer the following overarching research question:

> **RQ3:** In an exploration of the design space, **how can we employ design methods to help people creatively think about AI and interdependence?**

Design workbooks [40] and cultural probes [38, 39] are exploratory methods developed to collect inspirational data for the purposes of defining a design space, and setting a design trajectory (e.g., *"How do people describe their real-world experiences?"*, *"How do people make sense of diverse scenarios?"*, and *"What are people's responses to a range of technological proposals or provocations?"*). Given my interest in exploring the design space for AI and interdependence, workbooks and cultural probes will be of inspiration in this research study. I develop my own design method and work with sighted guiding companions to stimulate their creative thinking. The aforementioned research question is broken down into the following two sub-questions:

> RQ3.1: How can we make workbooks an accessible interactive design tool for people with different abilities?

RQ3.2: How do people engage with a design space which attends to the sighted guiding partnership, interdependence, and AI?

The remainder of this chapter will first describe the study method, presenting the workbook, study procedure, the participants, data collection and analysis. This will be followed by the findings section where I will present how workbook components helped pairs (i) to creatively think about interdependence and AI assistive technology, and (ii) to participate and engage in the workshop. In the final section of this chapter, I will discuss some emerging themes to consider in future design methods and reflect on my involvement as a researcher in the design process.

5.2 METHOD

To address these research questions, firstly, I developed an accessible and interactive design method to better engage with sighted guiding companions and think, creatively, about interdependence and AI. The method—an extension of design workbooks and cultural probes—was put into practice in a participatory workshop with pairs of participants. The workshop was conducted online, and I took a qualitative and interpretative approach to analyse the collected data. The core of the analysis was to examine how the workbook enabled participants' creative thinking and opened up the design space towards interdependence and AI. Through this examination, I also revealed interdependence insights and participants' reflections on how AI assistive technology might extend their partnership in the future.

Below, I provide details on the workbook, participants in the study, how the workshop was initially structured, and then carried out, and how I collected and analysed the data.

5.2.1 *Motivation*

The workbook I designed is an extension of design workbooks and cultural probes. As mentioned in Chapter 1, workbooks and cultural probes are intentionally set against quantitative methods and forms of analysis that seek one correct representation of people's experiences and needs [38, 39]. On the opposite, probes and workbooks embrace subjectivity, interpretation, and uncertainty, instead of being an instrumental tool which seeks objectivity, and produces a set of user

requirements: *"cultural probes are not simply 'another technique' for getting data but rather frame an alternative account of knowledge production in HCI design"* [15, p.1078].

So, the methodology grounded in cultural probe might help to bypass issues I have encountered in the previous study (see section 4.4.4). Adopting a more critical interpretive frame will resist the analysis to result in a list of system requirements and elicit design inspiration. Here, there is much in common with ethnography and what Dourish discusses in *"Implication for Design"* article [29]. One point is the recognition of the researcher as an interpreter instead of an objective observer. Data is *"generated through an encounter between that setting and the ethnographer"* or researcher, and *"shaped by ones' subject position"* [29]. Thus, in HCI practice the common conceptualisation of a rational and objective set of implications for design as the main final goal in research is disputed and limited.

Workbooks were introduced to present a collection of provocative design proposals, aiming to create a space where participants can engage with and expand upon initial ideas and reflections [40]. As they are presented in the literature, workbook proposals are largely visual, made of sketches with brief texts. This has benefits and costs. For example, visual materials can help to bypass some barriers to creative thinking (e.g., language) [39]. However, at the same time, they are inaccessible to visually impaired people. Research work shows that they have been used with different sighted user groups so far [13, 28, 51], and not applied to collaborative work in sighted guiding involving AI. Indeed, little work has explored the use of workbooks to investigate AI technology design [91]. Alongside this, recent work shows the difficulty of employing traditional methods when designing AI technology for and with people with special needs. For instance, Begel et al. [7] reflect on the challenges around using a Wizard of Oz design process to incorporate an AI prototype for supporting an autistic population. My previous study also led to negative feedback, highlighting the difficulty of involving people in the design process and adopting traditional tools such as storytelling and rapid prototype to think about possible AI assistive technology future alternatives (see Section 4.4.4). This raises an urgent call to rethink the design process and develop new methods which take into account AI, its complexity, and uncertainty. In the following, I seek to appropriate and build on design workbooks as a method in order to provoke questions surrounding the role of AI and in particular the AI's role in assistive technologies.

Another influence on the work I present has been cultural probes. Introduced by Gaver and colleagues for the first time in 1999 [38], probes are often made up of tangible objects, physical packets containing open-ended tools and tasks to support early participant engagement with

the design process. Over time, they have been transformed to accommodate different settings and purposes in HCI research (e.g., cultural, technological, etc.). Compared to workbooks, probes have the potential to be more accessible to a wider population, therefore a combination of these exploratory methods may help sighted guiding companions to think about what AI might offer in their partnership.

5.2.2 *Design Process: The Workbook Components*

The workbook[1] I developed was presented to companions through an accessible website. Figure 5.1 shows the starting page. The workbook was comprised of 2 sections, each including 4 activities. The first section is called *"Strengthening connections"*, and the second *"The role technology might play"*. The first section proposed activities to explore the physical connection and relationship as sighted guiding companions. The second section explored some basic ingredients of AI technology to begin thinking about the possible roles AI could play to enhance people's partnerships.

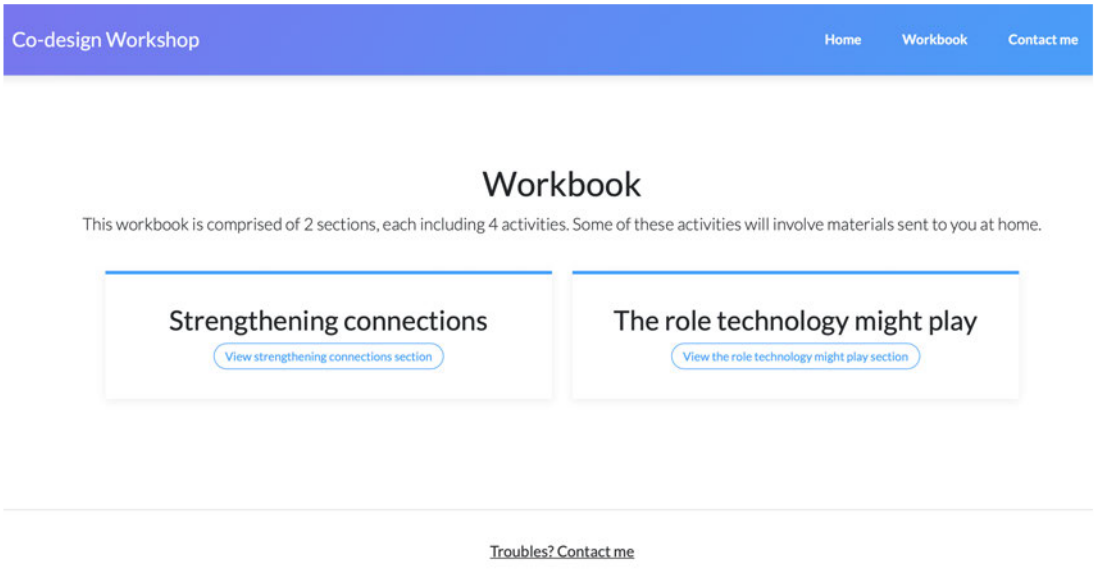


Figure 5.1: Workbook sections page.

I approached the design of the workbook building on several components. In the following, I describe how these components shaped the workbook, and then I illustrate in detail each

1 Workbook website: https://violetta010607.github.io/workshop/index.html

activity in section 5.2.3. Figure 5.2 depicts a visual representation of workbook components. The first component I considered is the *activity ordering*. Indeed, the workbook was created following a narrative which puts the emphasis on pairs' partnerships first (*"Strengthening connections"* section) and gradually introduces AI technology proposals in sighted guiding situations to invite reflection and creative thinking (*"The role technology might play"* section). To mark the start and the end of the workbook I specifically designed the first and last activity respectively. The former is an ice-breaking activity (see "Activity 1: the sighted guiding technique" for more details in sub-section 5.2.3.1), the latter is a summary activity (see "Activity 4: better together than apart" in sub-section 5.2.3.2). The second component I designed is *sequential activities*, which I considered in the "A sound presence" activity and the "A further sound exploration" activity from the first section. By *sequential activities* I mean, activities which are related to one another. Specifically, I used "A sound presence" to introduce some technological elements, and then the following activity to extend these elements to various scenarios.

<table>
<tr><th colspan="6">Workbook components</th></tr>
<tr><td colspan="4">Section 1: strengthening connetions</td><td colspan="3">Section2: The role technology might play</td></tr>
<tr><td rowspan="4">Activity ordering</td><td>Activty 1:
The sighted guiding technique</td><td colspan="2">Ice-breaking activity</td><td rowspan="4">Activity ordering</td><td>Activity 1:
Sensing a wearable tag</td><td>Independent activity</td><td>Experimental, and collaborative task: use of an web app and tangible materials</td></tr>
<tr><td>Activity 2:
The Ramble tag</td><td>Independent activity</td><td>Provocative, collaborative task: use of tangible materials,
DIY activity</td><td>Activity 2:
How would you teach a machine to learn your body language?</td><td>Independent activity</td><td>Reflective task: use of situated experience to explore body language recognition technology</td></tr>
<tr><td>Activity 3:
A sound presence</td><td rowspan="2">Sequential activities
⇣</td><td>Provocative, Experimental, and collaborative task: use of digital materials</td><td>Activity 3:
Silence is also communication</td><td>Independent activity</td><td>Reflective task: use of situated experience to explore the role of silence and its recognition</td></tr>
<tr><td>Activity 4:
A further sound exploration</td><td>Experimental and collaborative task: use of digital materials in context</td><td>Activity 4:
Better together than apart</td><td colspan="2">Summary activity</td></tr>
</table>

Figure 5.2: Workbook components.

Non-sequential activities can be considered as *standalone* or *independent activities* instead. Indeed, they differ in activity type and/or content, and potentially they could be completed in any order. Each activity within the workbook is composed of an introduction (or preamble) to set the context of exploration, a short task where pairs are asked to work together or complete proposals and some exit questions to deeply reflect on the task itself and open the discussion.

What each activity differs from is the *activity type* and/or its *content*. This constitutes the last component of the workbook. I created provocative, collaborative, experimental, and reflective tasks, which make use of tangible and digital tools, and artefacts. *Provocative tasks* include for instance disrupting companions' usual way of walking together (e.g., "A sound presence" activity). *Collaborative tasks* encourage participants to work together for completing a task (e.g., DIY activity in the "The Ramble tag" activity). An example of *experimental task* instead is the "Sensing a wearable tag" activity from the second section, where participants explore a simple technology prototype. Finally, *reflective tasks* build on the introduction of real-world experiences and current AI features to discuss the role of some future AI assistive technology in context.

The workbook components set the ground for the data analysis, and the presentation of the findings (see sections 5.2.6, and 5.3). I will now give further details on the workbook activities.

5.2.3 *The Workbook*

5.2.3.1 *Section 1: Strengthening connections*

The first section, *"Strengthening connections"*, explores the physical connection and relationship the pair have as sighted guiding companions. It includes the following 4 activities.

ACTIVITY 1: THE SIGHTED GUIDING TECHNIQUE. This activity represents an ice-breaking task. After presenting a quote from a YouTube video on the sighted guiding technique, for getting to know better companions, I ask pairs to reflect on their connections, and small pleasures in sighted guiding, both as a guide and as a person being guided (see Fig. 5.3).

ACTIVITY 2: THE RAMBLE TAG. Inspired by the Ramble Tag [135], I sent to participants a homemade armband, designed to be worn on a guide's upper arm (see Fig. 5.4). I ask participants to take a walk using the provided armband. I then propose a DIY activity where using materials they received at home (e.g., post-it, straps, foam balls, fabrics, blue tack, and pens), the pair had to work together to create a personalised low-tech version of the Ramble Tag. The activity was guided by the following question: what would you add or how would you enhance the Ramble Tag to strengthen your connection?

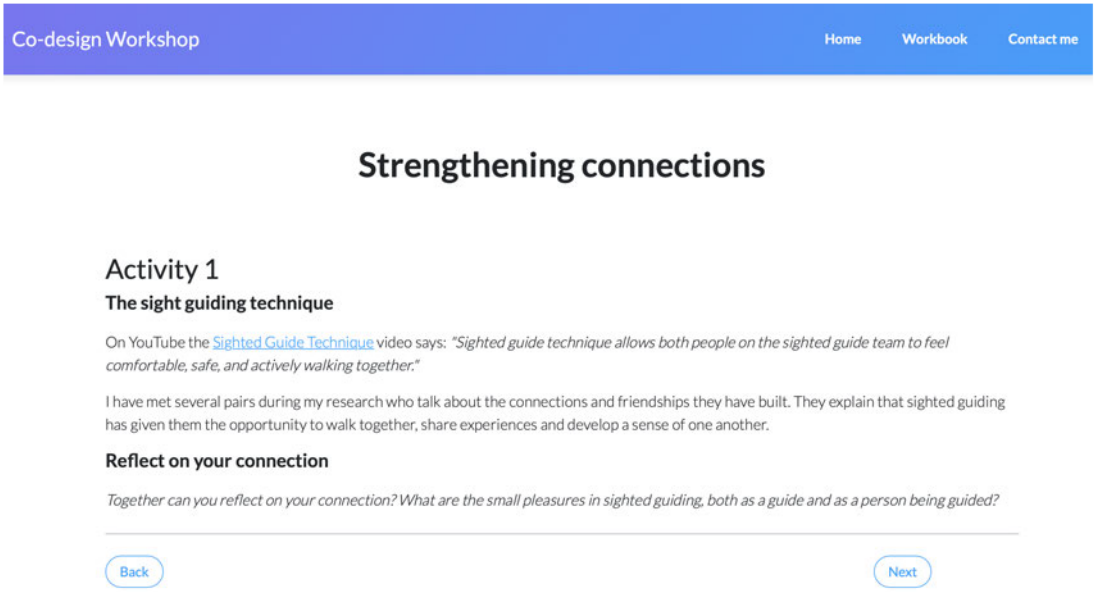


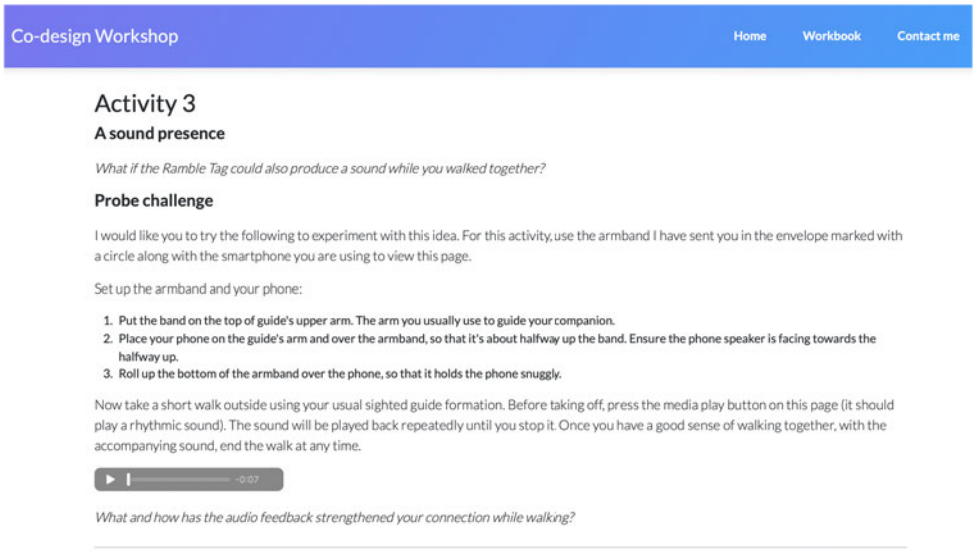
Figure 5.3: The sighted guiding technique activity page.

(a) The Ramble tag armband. (b) Research materials.

Figure 5.4: The Ramble tag activity.

ACTIVITY 3: A SOUND PRESENCE. This activity was designed to provoke reflections on what and how audible feedback might strengthen companions' connection while walking together. I propose a probing challenge where the pair had to take a short walk using their usual sighted guiding configuration while an accompanying sound was played back. The sound was presented through the workbook's activity page, and as described and shown in Figure 5.5, the pair

attached their phone to the provided armband the guide was wearing. The sound was played back through their smartphone repeatedly until they stopped it.



(a) A sound presence activity page.

(b) The activity set up.

Figure 5.5: A sound presence activity.

ACTIVITY 4: A FURTHER SOUND EXPLORATION. As a continuation of the previous activity, here I propose three different sounds. Based on their preference the pair has to choose one and work together to complete the task. Using the same armband of activity 3 and playing back the rhythmic sound, the pair takes short walks moving from close proximity to far away and vice-versa.

5.2.3.2 *Section 2: The role AI might play*

"The role technology might play" section is comprised of 4 activities. They are aiming to explore some basic ingredients of AI technology to begin thinking about the possible roles AI could play to enhance people's partnerships.

ACTIVITY 1: SENSING A WEARABLE TAG. Using two small and slightly different JavaScript applications I ask participants to explore left-to-right movements, and distance. The 2 applications recognise a wearable tag through the use of the smartphone's front camera. The tag is based on geometric shapes and is similar to the one I used in the previous study (see Section 4.4). I made it wearable using a plastic card holder and a strap, I also provide a tactile tag version to be sensed through touch (see Figure 5.6). The companions have to face each other, one person wearing the tag on their arm and the other person holding the smartphone. The companions have to work together to centre the tag on the smartphone's screen.

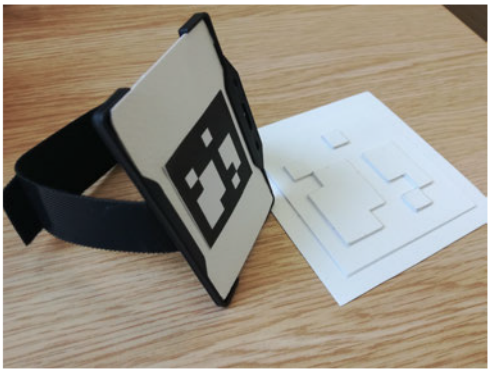


Figure 5.6: The wearable tag and the tactile version.

In exploration left-to-right movement, when the tag is detected the phone plays a sound. The audible feedback has a soft sound when in the middle of the screen and changes in rate (or pitch) when the tag moves to the left or right of the camera's field of view. As previously, in exploring distance instead, the pair detects the tag using the smartphone's front camera. When the tag is detected the phone plays back a sound. This time the audible feedback represents the tag's distance from the phone. The sound changes in volume. It gets louder as the tag is moved closer to the camera.

ACTIVITY 2: HOW WOULD YOU TEACH A MACHINE TO LEARN YOUR BODY LANGUAGE? Through a think-aloud activity, I ask companions to label actions related to sighted guiding for new

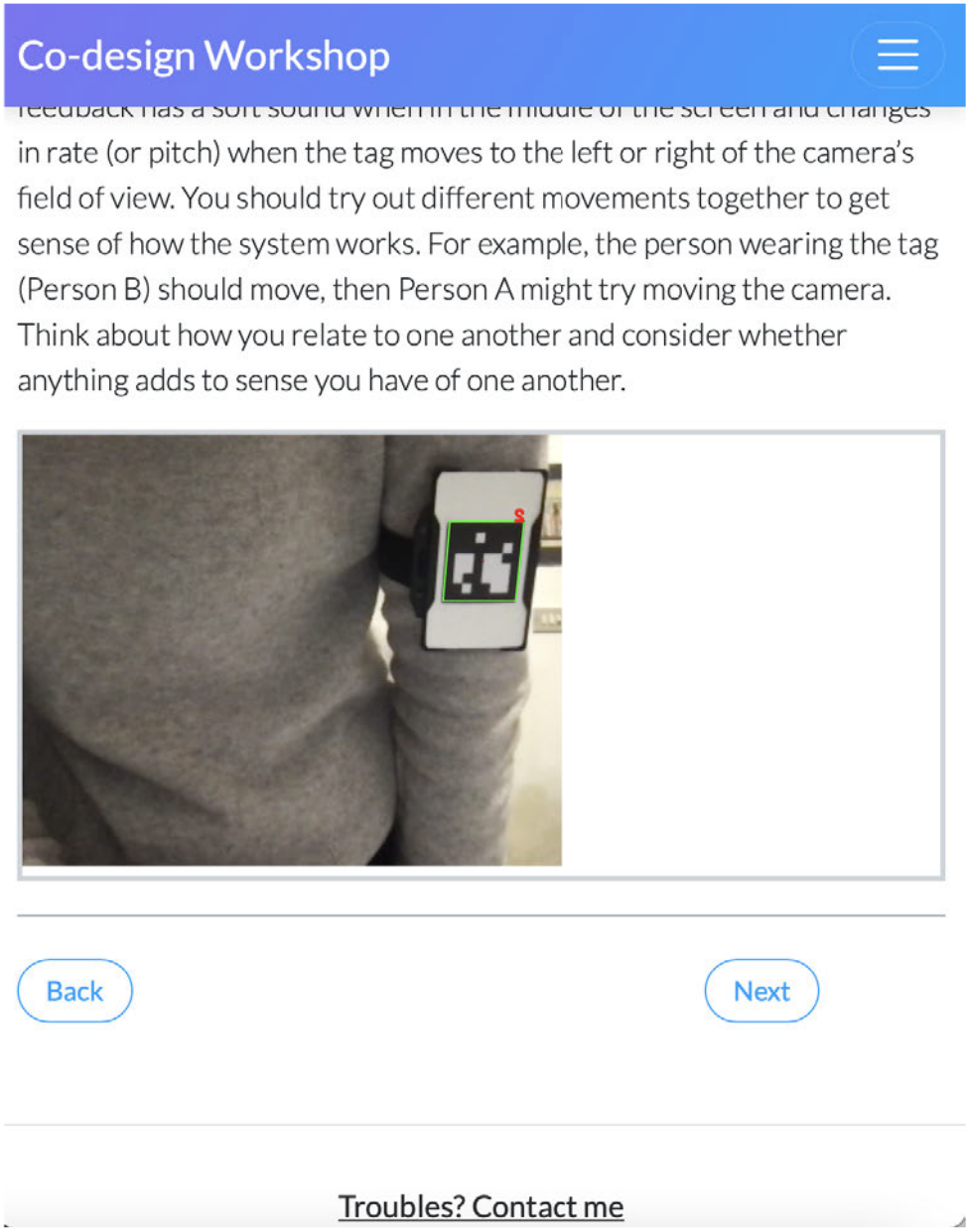


Figure 5.7: The application detects the wearable tag.

assistive technology. The new technology recognises body movements in sighted guiding, and companions have to reflect on which kinds of actions or body movements they would want to teach and how the recognition of these body movements would help them to work together.

ACTIVITY 3: SILENCE IS ALSO COMMUNICATION. I propose an activity to reflect on the role of silence, how silence supports their connection, and in which way. The pairs are invited to discuss and expand their shared experience on how a new assistive technology which detects moments of silence, could potentially support them.

ACTIVITY 4: BETTER TOGETHER THAN APART. I ask companions to think about contexts, situations, or actions during sighted guiding where they have combined their skills to achieve something together. Participants are invited to share something new or to recall some previous situations. This activity has been designed as an exit activity to help pairs synthesise what they have discussed. Starting from situations companions shared, I ask them to complete the following statements. *"If an assistive technology could ... This could enable us to ..."*.

5.2.4 *Study Procedure and COVID-19 impact*

I think it is important to briefly present the COVID-19 impact on conducting this final study. Specifically, the pandemic affected participant recruitment and data collection. As a result, I had to change the study procedure in course of action. Originally, in line with COVID-19 government restrictions in place at the start of the project, the study had been planned to be conducted in a hybrid format. The original plan was to ask the participant pairs their preference on whether they wanted to take part in an in-person or remote workshop. I had chosen this format for several reasons:

1. The hybrid format would have helped me to be flexible to sudden COVID-19 restrictions and changes.
2. Even though in-person meetings would have been allowed, participants may not feel comfortable traveling and/or meeting other people.
3. I believe that in-person workshops provide a more comfortable space and a more active engagement, so if people were willing to meet, I would have given priority to in-person activities.
4. Further, data collection using different approaches could have been of interest for further analysis, for instance, to compare research methods and understand how the format plays a role in the research questions I want to address.

In the end, due to the pandemic, and heightened by the difficulties in recruitment (see Section 5.2.5 for more details), I had to develop and accommodate my study method to be both fully remote and accessible. As we have seen in the previous study, accessibility and remote format—together—can be really challenging when working with people with visual impairments. These challenges can also be intensified when digital AI artefacts and tangible materials are introduced in the process. To minimise these issues, I decided to present the workbook to

participant pairs using an accessible website, and complete activities in a 2-hour Zoom meeting with a pair at a time. During the synchronous meeting, we had two main sessions with a break:

- Introduction to each other, and workshop aim (5 minutes)
- Workbook activities, section 1 – "Strengthening connections" (45 minutes)
- Break (10 minutes)
- Workbook activities, section 2 – "The role technology might play" (45 minutes)
- Exit interview: questions around the adopted approach for this research to understand how accessible the method was, and what can be improved in future studies - (15 minutes)

I created a mixed collection of activities and proposals, comprised of both digital and tangible materials. I carefully made digital materials accessible through screen readers. Instead, other materials were comprised of tangible objects which could be perceived through touch and hands-on activities. For each activity, I asked participants to interact with all material and complete tasks. Activities are summarised in Section 5.2.1

5.2.5 *The Sighted Guiding Companions*

As in the previous studies, I recruited pairs of participants composed of a person with visual impairment and a sighted guide with an established relationship through guiding for at least 3 months. Since I was still interested in investigating their relationship with each other and the multiple facets in terms of harmony, care, and mutual understanding, the target population did not change.

Firstly, I approached past participants from the first and second studies seeking their interest in continuing the research journey, but I was unsuccessful. The workshop was then advertised online through several Facebook groups, on Twitter, and by contacting several organisations in London and UK. Overall, I had no or few responses which did not meet the criteria of the study (see Appendix C.3 for a full detailed list of inclusion and exclusion criteria). Finally, participants were recruited via emails to existing contacts, and through the help of a volunteer specialist and sight guide trainer at BlindAid charity in London [152]. Even though recruitment was conducted after COVID-19 restrictions were lifted, it was very difficult to find interested pairs compared to the previous studies. A participant pair and the volunteer specialist reported that while sighted people were already coming back to a normal life, the visually impaired were still much isolated

in their homes, highlighting the difficulty of regular meetings with their sighted guides and having daily walks outdoors.

Participant information sheet, informed consent and emails shared with participants were in an accessible format (see Appendix C.1 for a full list of the Ethics application and documents). Informed consent was obtained online through Qualtrics system offered by City, University of London. Approval for this study was granted by the Computer Science Research Ethics Committee at City, University of London. In appreciation of the participant's contribution to the research, I offered a £50 voucher per person. Names used throughout this study are pseudonyms. I identified similar ethical issues to the first and second studies, associated with conducting this research. Specifically, I considered (i) people's vulnerability and (ii) the confidentiality of data.

(i) I recruited people who are independent and capable in their life. For this study, I excluded participants with mobility problems to reduce risk and exclude participants with any cognitive impairment who were not able to give informed consent.

(ii) All data is kept confidential and secure. Digital data was transcribed, anonymized, encrypted and stored in a folder protected by a password on an external hard drive and is managed by the main researcher. Tangible materials are kept in a locked cabinet at City University of London.

Four participant pairs took part in the study. Two pairs were family members and the other two had a long friendship relationship. Table 5.1 reports some demographic details about the age of participants, how long pairs have known each other, the actual vision of visually impaired participants, and their sighted guiding technique. All pairs had a very established relationship and different ways to perform the sighted guide technique. For instance, Vincent and Harold are the only pair where the guide holds the visually impaired shoulder, instead of the opposite. The variety of holding helped to investigate the different creative ways people communicate during navigation which are also an expression of intimacy and care.

5.2.6 *Data Collection and Analysis*

Data collection changed during the study. The initial plan was to hand the online workbook to participant pairs for a period of a week. During this week pairs would have been asked to use a smartphone to navigate the website and complete all activities. Each activity within the original workbook had a digital way to collect data, for instance through audio recordings,

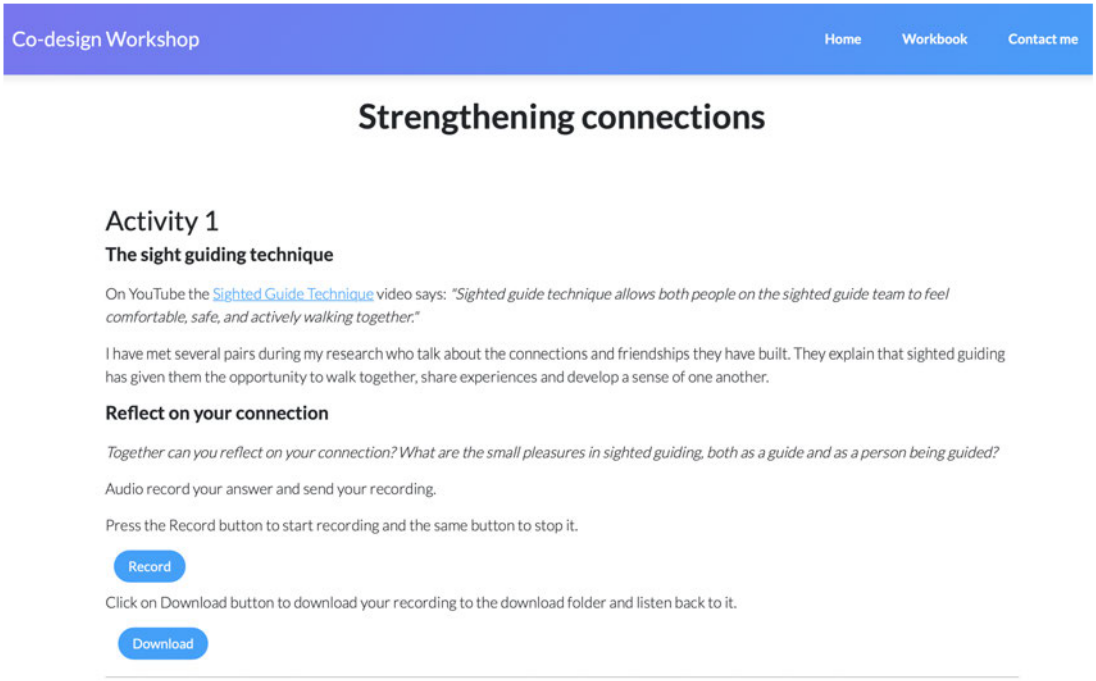
Pair *Person with VI	Age	Relationship	Info about their vision	Sight Guiding Technique
Vincent* and Harold	34 - 47	10 yr - Family members	10% of sight colorblind	Harold holds Vincent's shoulder
John* and Nick	56 - 52	3 yr - Close friends	No vision since birth	John holds Nick's shoulder
Henry * and Mary	77 - 36	15 yr - Family members	No vision since birth	Henry holds Mary's arm
Emily* and Lisa	69 - 73	10 yr - Close friends	Aniridia since birth	Emily holds Lisa's elbow

Table 5.1: Study 3: Demographic Information.

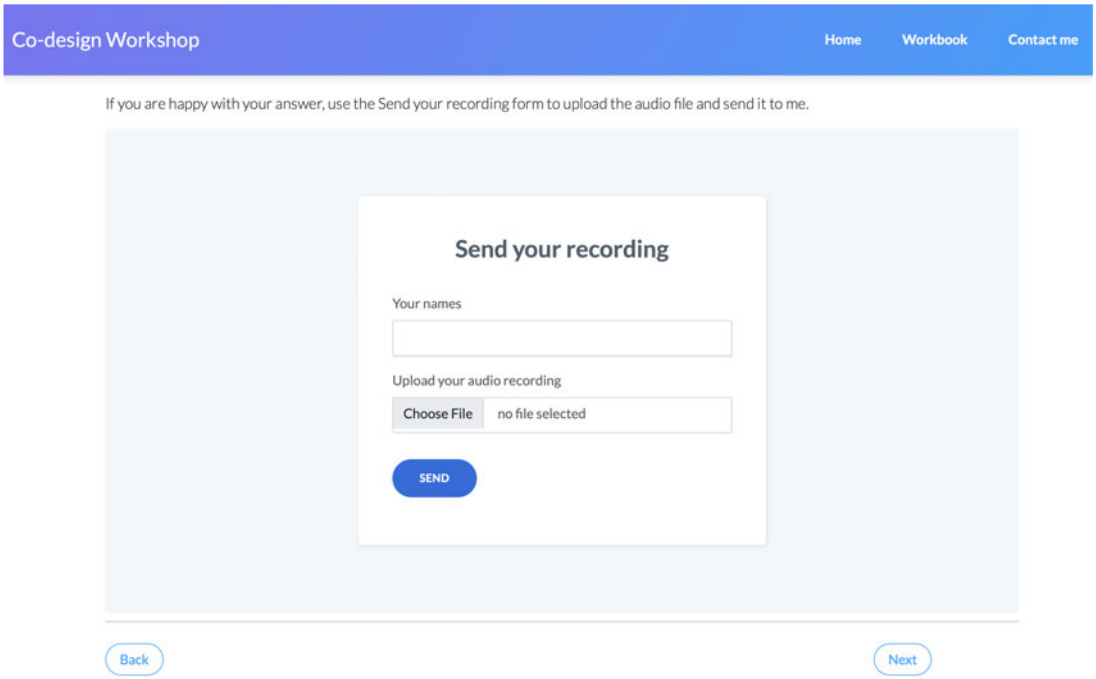
taking pictures, and filling in forms. Figure 5.8 reports an example from the initial workbook about how the audio collection data would have been presented to participants.

After a conversation with a sighted guide trainer, I came to realise that most of the visually impaired community was still isolated in their homes, and therefore asking to meet their sighted guide in person for a long period was not trivial for them. This may be one of the reasons why the recruitment was not straightforward. Due to the lack of participants, I changed the data collection. In the end, data were collected over a 2-hour Zoom workshop with a pair at a time. I asked participants to complete all workbook activities with me in the scheduled time, reducing their face-to-face meetings from a week to a couple of hours. I audio-recorded their conversation, instead of using the different tools provided by the original workbook. During the workshop, pairs navigated the website using their smartphone, completing the proposed activities. I made the website accessible through screen readers. Two visually impaired volunteers (a past participant and a video blogger) tested the website in advance using their smartphones and provided useful feedback on how screen readers read out page elements (e.g., text, and buttons), and what the reading order was. This helped me to improve the final accessibility of the workbook.

Previous work in HCI (e.g., [28, 118, 126, 136]) recognises probes methodology and builds forms of analysis which embrace subjectivity and interpretation to tell inspirational stories about participants' responses which might inform the design in the future. Instead of using probes as a method technique to collect data for more analytical analysis, I decided to take a similar collaborative and interpretative analysis approach. Specifically, I followed these steps:



(a) Activity 1 and audio recording.

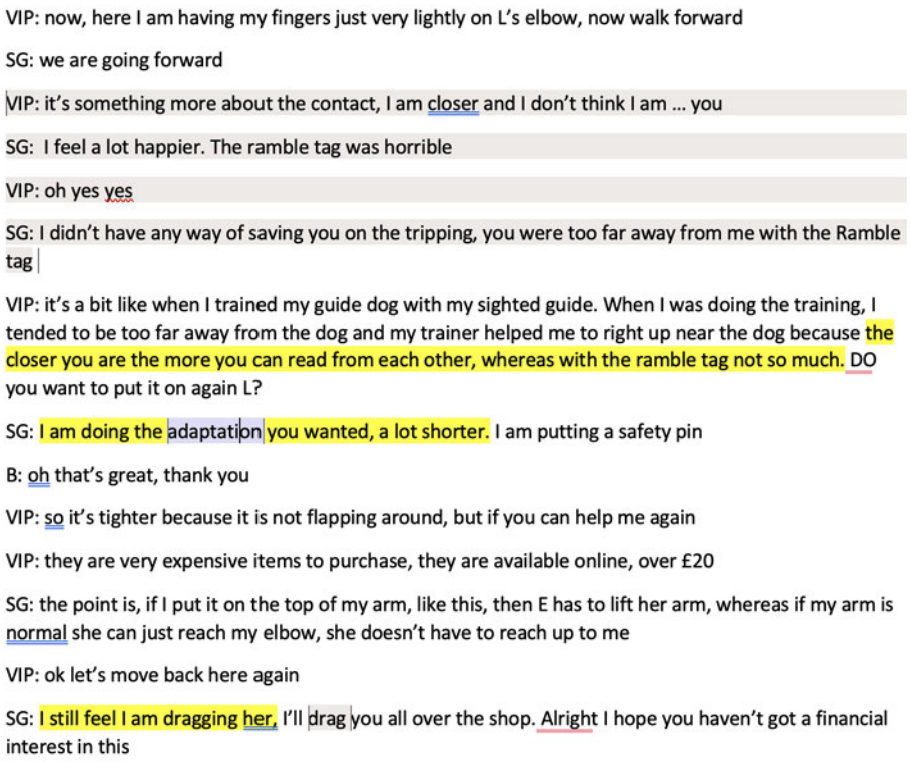


(b) "Send your recording" form.

Figure 5.8: Activity 1 and data collection.

STEP 1 – VIDEO TRIMMING AND TRANSCRIPTION. After each workshop with participant pairs, I trimmed the video recording into several clips. Each clip represents an activity in the workshop. After that, I created a new document for each pair where I transcribed all clips in full.

STEP 2 – IDENTIFICATION OF EXAMPLES. I started working on my own, looking openly at participants' responses and reflecting on their conversations. As Figure 5.9 depicts, at this stage, I highlighted part of the data conversations I found interesting in yellow. As a follow-up, I discussed what captured my attention with one of my supervisors to discuss whether the selected examples represented meaningful reflections and actions which showed the creative thinking around pairs' partnership and the role AI assistive technology might have.


VIP: now, here I am having my fingers just very lightly on L's elbow, now walk forward

SG: we are going forward

VIP: it's something more about the contact, I am closer and I don't think I am ... you

SG: I feel a lot happier. The ramble tag was horrible

VIP: oh yes yes

SG: I didn't have any way of saving you on the tripping, you were too far away from me with the Ramble tag

VIP: it's a bit like when I trained my guide dog with my sighted guide. When I was doing the training, I tended to be too far away from the dog and my trainer helped me to right up near the dog because the closer you are the more you can read from each other, whereas with the ramble tag not so much. DO you want to put it on again L?

SG: I am doing the adaptation you wanted, a lot shorter. I am putting a safety pin

B: oh that's great, thank you

VIP: so it's tighter because it is not flapping around, but if you can help me again

VIP: they are very expensive items to purchase, they are available online, over £20

SG: the point is, if I put it on the top of my arm, like this, then E has to lift her arm, whereas if my arm is normal she can just reach my elbow, she doesn't have to reach up to me

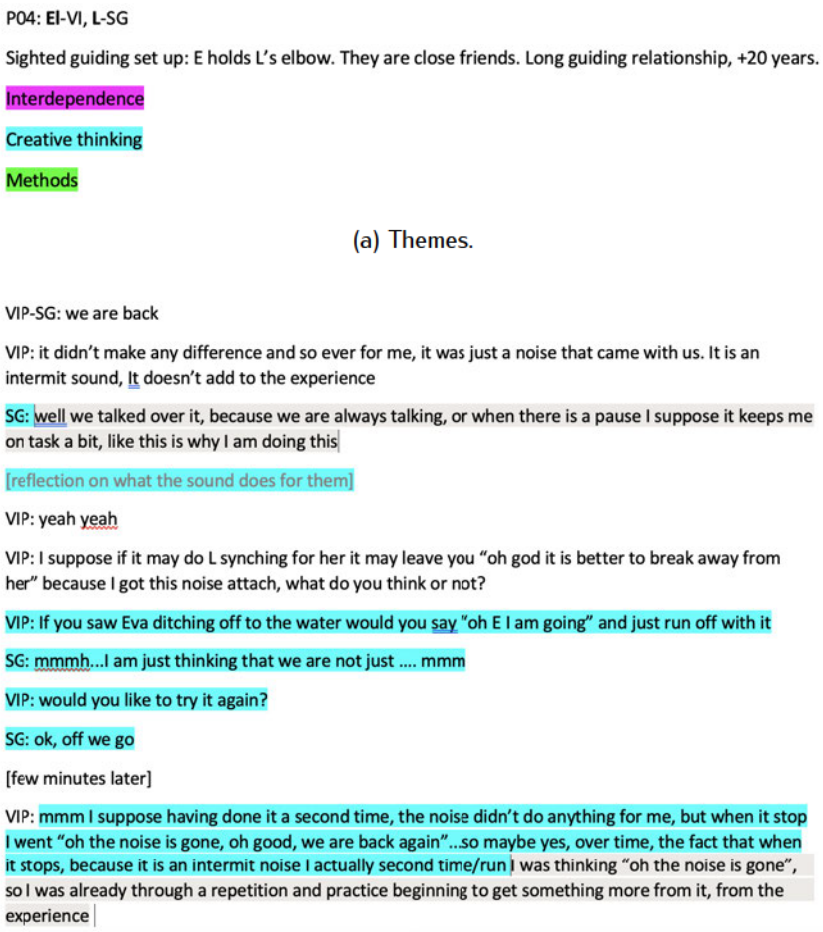
VIP: ok let's move back here again

SG: I still feel I am dragging her, I'll drag you all over the shop. Alright I hope you haven't got a financial interest in this

Figure 5.9: Analysis step 2 - Identification of Examples.

STEP 3 – IDENTIFICATION OF DOMINANT THEMES. Since activities were designed and built on several workbook components (see Section 5.2.1), I came back to the examples I selected. I looked for meaningful examples of how and to what extent these components helped participants to engage and participate in reflections, adapt and generate new ideas. I focused on 3 different themes (i.e., examples related to interdependence, creative thinking, and method) shown in

Figure 5.10 (a). Figure 5.10 (b) illustrates an example of a "creative thinking" theme from the data.



P04: EI-VI, L-SG

Sighted guiding set up: E holds L's elbow. They are close friends. Long guiding relationship, +20 years.

Interdependence

Creative thinking

Methods

(a) Themes.

VIP-SG: we are back

VIP: it didn't make any difference and so ever for me, it was just a noise that came with us. It is an intermit sound, It doesn't add to the experience

SG: well we talked over it, because we are always talking, or when there is a pause I suppose it keeps me on task a bit, like this is why I am doing this

[reflection on what the sound does for them]

VIP: yeah yeah

VIP: I suppose if it may do L synching for her it may leave you "oh god it is better to break away from her" because I got this noise attach, what do you think or not?

VIP: If you saw Eva ditching off to the water would you say "oh E I am going" and just run off with it

SG: mmmh...I am just thinking that we are not just .... mmm

VIP: would you like to try it again?

SG: ok, off we go

[few minutes later]

VIP: mmm I suppose having done it a second time, the noise didn't do anything for me, but when it stop I went "oh the noise is gone, oh good, we are back again"...so maybe yes, over time, the fact that when it stops, because it is an intermit noise I actually second time/run I was thinking "oh the noise is gone", so I was already through a repetition and practice beginning to get something more from it, from the experience

(b) Example of theme assignment.

Figure 5.10: Analysis step 3 - identification of Dominant Themes.

STEP 4 - DISCUSSION. Important reflections, adaptations, and ideas were then presented and discussed in weekly meetings with one of my supervisors. We discussed this through video call meetings, but also asynchronously using shared transcripts of the data. Figure 5.11 shows an excerpt from the data at this stage.

I iterated steps 3 and 4 several times to develop and refine dominant themes and check the consistency of the data interpretation. Because of the components underpinning the workbook, output data from the workshop was sometimes ambiguous, incomplete, and biased. Regular

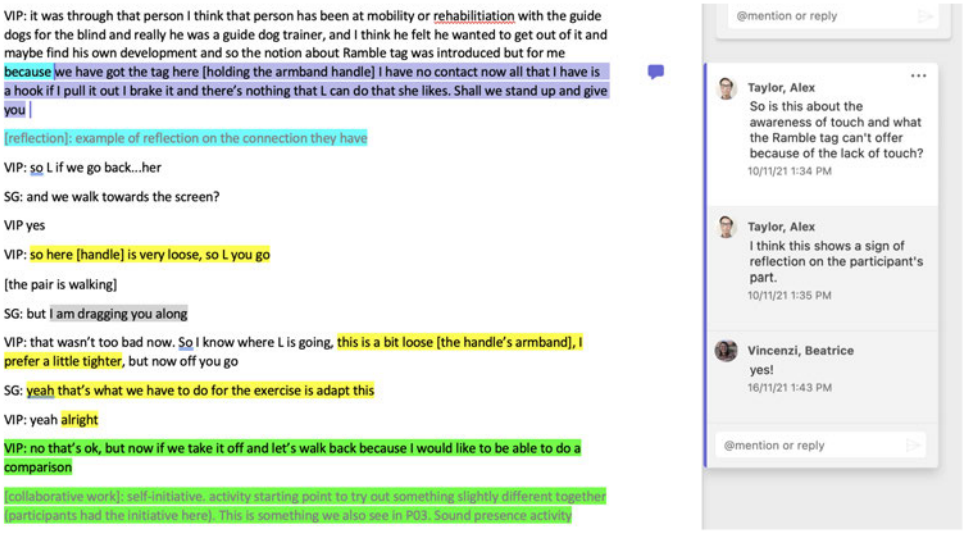


Figure 5.11: Analysis step 4 - Discussion.

meetings with one of my supervisors helped me to embrace these qualities and subjectivity in the research process.

5.3 FINDINGS

In this section, running through the workbook activities, I present illustrative examples of how the workbook—as a method—provided pairs with components to (i) think openly and creatively about future assistive technology and in some cases, the role of AI, and (ii) actively participate and engage in the workshop. Although tasks and proposals worked differently for each pair, participants engaged well in the activities and showed they were able to reflect on and propose adaptations to potential future AI systems.

In presenting the findings, I will use the Sighted Guide (SG) acronym to indicate the sighted companion, and VIP to replace Visually Impaired Person.

5.3.1 *Creatively thinking about AT and the role of AI*

5.3.1.1 *Examining the role of activity type and its content in creative thinking*

This sub-section examines how different activity types helped participants to reflect on their partnerships and the role of assistive technology, and also generated some initial ideas for AI's role in future systems. Specifically, I show (i) how provocative tasks and tangible speculation

helped participants to make comparisons, and in turn, revealed more about their interdependence and possibilities for ATs; (ii) how experimental tasks involving digital materials (e.g., sound feedback) did not always offer easy design prompts to interpret or extend the design space; and (iii) how co-speculation helped to move beyond technological and practical features and maintained an openness to thinking about design.

PROVOCATIVE TASKS. Some activities were designed to be provocative. For example, the "Ramble tag" and "A sound presence" activities invited participants to speculate on interventions in sighted guiding meant to disrupt established ways of pairs working together (section 5.2.1). In the "Ramble tag" activity, a tangible object (an armband with a handle, see Fig. 5.4) was introduced to replace the physical connection people usually have. In the "A sound presence" activity, novel sounds were introduced to accompany companions walking together. This disruption of usual practice was intended to help pairs reflect, to reveal more about their connections and interdependencies, and in turn to consider the ways in which they might further complement one another. For instance, after the "Ramble tag" activity, *Nick* (SG) described what the physical connection did for his companion, and how it supported his abilities.

> *"What's nice in sighted guiding with the elbow I become like radar, it is complicated, it is quite subtle. Which means that the sight impaired person is dignified in their movements."*

As a mediating object, the Ramble Tag also helped participants make comparisons between their familiar and established interactions.

> *Henry (VIP): "I felt a little bit insecure because when I am holding there [guide's arm] I feel more safe and secure. While I was holding it [the armband's handle], it was a bit lose."*
> *Emily (VIP): "It's something more about the contact...the closer you are the more you can read from each other, whereas with the RambleTag not so much."*

The comparison drawn out here reveals the importance of feeling secure and also of physical closeness or proximity to each other. *Emily*'s words suggest the two-way interactions that are important in this proximity. Crucially this points to a question of control.

In another case, *Harold* (SG) described how the Ramble Tag invites an unintended "grabbing" of his partner leading him to reflect: *"They [guides] don't have 100% control of the other person"*. Here, then, we see how control is recognised and negotiated by both parties. For *Harold*, the activity from the workbook creates the space for him to make a comparison and to reveal how the physical arrangement between him and his partner distributes agency. What we see, in short, is that the use of activities involving provocations and tangible speculation with physical

objects and interaction provided participants with the resources to draw out comparisons and highlight both what works in current practices and where interventions might offer benefits.

EXPERIMENTAL TASKS. Activities 3 and 4 from the first section ("A sound presence", and "A further sound exploration"), and activity 1 from the second section ("Sensing a wearable tag") were experimental tasks. For instance, in "A further sound exploration", I let participants experiment with how sound might offer a layer of communication for pairs. Aside from using the smartphone to play back sounds, the technology itself was not well defined in the activity. This was intended to give pairs the space to explore and imagine. However, some participants tended to discuss practical design or technical features. For instance, *Vincent* (VIP) and *Harold* (SG) became preoccupied with the ways audible feedback would be produced and spent little time considering how sound could be used to complement their interactions. *Harold* pointed out that continuous audible feedback can be annoying and might distract the blind companion from the environmental sounds surrounding them. For them, a continuous sound was thought to be a source of interference; that is it would intrude on a blind person's abilities to listen to and recognise their surroundings, and also be audible to others. This way of approaching a scenario has similarities to the results from study 2 part B (4.4.4), where participants struggled to think beyond the practicalities of future technologies.

Results such as this illustrate the difficulty people can have imagining new AI technology, and this confirms findings reported elsewhere (i.e., in Morrison et al. [88] work). As with technological and design futures being necessarily ambiguous and incomplete, the experimental activities with sighted-guiding pairs showed how prompts for future designs can be difficult to interpret and respond to. This has important implications for future design methods that will be discussed in section 5.4.

The "Sensing a wearable tag" experiment yielded more promising results. In this case, some pairs were open about their thinking on how sound feedback might support them. The following examples illustrate that providing information about a guide's location, and relative distance/orientation can serve to strengthen and *maintain a companion's connection* in challenging situations.

While experimenting with tag recognition using the phone's camera and the wearable tag (in the "Sensing a wearable tag" activity), *Nick* (SG) described sound giving information about his location in relation to his companion, *John* (VIP). As he phrases it:

> *"[...] the sound does work if you [John] want to know where I am [...] I am trying to imagine how it would be in the field while walking outside. It will tell John I am near to him and then further away".*

As we can see, *Nick* was able to consider the possibility of receiving information about the relative distance between him and John in a real-world situation without dwelling on practical technical features.

Similarly, both *John* and *Nick* and *Emily* and *Lisa* highlighted the importance of being aware that the guide has left their side. For instance, *John* (VIP) and *Lisa* (SG) explained:

> *John: "yes, maybe in the future that would be a bit useful, you know, because sometimes I am not aware of where Nick (SG) is, I am not sure where he is, because he goes off and I don't know if he is on my left, or right, or in front of me, you know".*
> *Lisa: "for me it was nice because it kept the connection and I know she went over to my wardrobe and she's trying one of my clothes".*

This reinforces the idea that AI technology should not be designed to mimic or replace the guide's agency, but in this case to maintain continuity, a connection between people when they disengage, and they are not physically in contact. Furthermore, *Emily* extended her imagination towards ideas of how this might enhance her capabilities. She explained:

> *"For me the plunk, I could tell Lisa's gone far away, she went into the garden, so if I—Hey Lisa I need something—I would have known where to shout".*

In sum, the experimentation with the use of phones, tags and sound in the "Sensing a wearable tag" activity allowed participants to explore new possibilities for their interactions. In *Emily*'s case, it was to consider how a richer sense of distance from those around her might enable new orientations towards interaction to happen, such as how to *call for attention*.

COLLABORATIVE TASKS. As I will describe later in the findings (see section 5.3.2), collaborative tasks played a relevant role in how pairs participated in the workshop. Additionally, collaborative tasks also offered a space where pairs were able to reflect and think openly about interaction. What seemed crucial was the grounding of ideas in experience (see the end of section 5.3.2) and, in addition, the role I played as a facilitator in echoing and amplifying their creative thinking. Indeed, through a back and forth, I actively *co-speculated* with participants on ideas as they progressed through their workbooks. In this way, my involvement helped to maintain the openness to possibilities. For instance, in the "A further sound exploration" activity I illustrated above, where *Vincent* (VIP) and *Harold* (SG) had difficulties in moving beyond their practical concerns, I intervened in their conversation:

> *"so, let's suppose that we have a new wearable device instead of the camera. This wearable device vibrates based on your relative distance, do you think it can give you a greater sense of the person you are with?"*

In response to my suggestion, *Harold* first emphasised again their concerns about using a camera in a public space, but then adapted my original proposal:

> *"If I have a Bluetooth, or wearable [touching and holding the wrist], or watch or something [...] so with that Bluetooth we can tell a lot of things, like distance, how far I am, or I am going next to him very slowly or I am going far to him, so something like that. But the camera... mmmh... How do you call that, is a bit limiting, because he [Vincent (VIP)] can still talk with the watch, you know, he can easily shout or call my name, or ask for help."*

This example shows that my intervention helped *Harold* to think beyond the practical difficulties he raised previously. I introduced a different technology in general terms—a new wearable device instead of the camera—and changed the output modality from audible feedback to vibration. What we can see from *Harold*'s response is that thanks to my suggestion, he firstly adapted my original proposal, and then developed his imagination, considering the role the technology might play in the pair's interactions. More specifically, *Harold* adapted the generic wearable device to be a watch with a Bluetooth sensor built-in to gather input data. As a result relative distance and orientation between companions are identified as salient information for future technology. For instance, distance and orientation information might be augmented with a sense of walking speed—*"next to him very slowly"*. Removing the phone's camera and the audible feedback from the proposal also helped *Harold* to imagine what the watch might enable in their partnership. As we have seen in *Emily*'s case described above, even *Harold* imagined that a richer sense of distance and orientation might afford a *call for attention* from the companion.

5.3.1.2 *Examining how ordering and sequence across activities worked*

In this sub-section, I highlight the role the ordering and sequence of activities played in the workbook. What I will show is how (i) the *sequence of activities* enabled a creative attitude on the part of participants so that pairs began to independently build on ideas without the need for explicit prompts; (ii) the *ordering of activities* helped participants to reveal new insights into interdependence (extending my research on sighted guiding navigation in study 1); and (iii) *stand-alone or independent activities* created the opportunity to make new associations

which were not prescribed by the workbook itself, thus promoting a space for new AI-AT ideas to emerge.

SEQUENTIAL ACTIVITIES. As a reminder, by sequential activities I refer to the way tasks and prompts within activities were intentionally designed to build up a perspective on a design proposal or intervention. This would mean first introducing pairs to a technical concept and then giving them a familiar scenario to think about it. As noted earlier in Method section 5.2.1, "A sound presence" (activity 3) and "A further sound exploration" (activity 4) in the first session are examples. "A sound presence" was designed to reflect on the use of an accompanying sound while companions walk together, and "A further sound exploration" activity extended this idea, providing a scenario where people physically disengage and move from being in close proximity to being distant. The results show that this sequential activity helped participants reflect and think about design possibilities.

For instance, *Henry* (VIP) and *Mary* (SG) changed their views in progressing from activity 3 to activity 4. Initially, they were sceptical about an accompanying sound during their walk.

> *H: I am not sure what the sound was there for.*
> *M: I think, it was not really needed, was it? Probably a little bit annoying, when you try to listen out for it, it's not really adding anything.*

However, after activity 4 they reconsidered their perspective and reflected on how sound feedback might support their connection and in which setting this might be of use.

> *M: That was much better, isn't it?*
> *H: yeah*
> *M: It makes sense to have a sound if I am not holding on because you were able to follow the sound quite well.*
> *H: Yeah, it was much better, it was really good.*
> *M: I suppose if we are in a busy place it can be good, if we are on the Tube you want to make sure you are still holding onto me if you hear the sound I guess you associate it with we are still together. If we are on a quiet road I suppose it is not really necessary.*
> *H: yeah I agree, I agree.*

ACTIVITY ORDERING. Another component I designed is the *activity ordering*. In the following, I consider how the order helped (or hindered) reflections on the role of AI-AT. As a reminder, the activity ordering refers to the overall workbook narrative expressed through the workbook sections. Specifically, I started with an ice-breaking activity ("the sighted guiding technique"

activity 1 from the first section) to get to know pairs. I gradually investigated their partnership and introduced technological proposals in the remaining activities. The workbook ended with a summary activity ("better together than apart" activity 4 from the second section) which aimed to combine and capture some AI future ideas from participants that they discussed in the previous activities.

The first activity worked better than the last one. Specifically, the ice-breaking activity helped participants to reflect on their interdependencies. For instance, *Emily* (VIP) described how she received messages from her companion *Lisa* (SG), highlighting the importance of multimodal resources during sighted guiding:

> *"So, for me, because the technique being used is me holding Lisa's elbow, I am receiving the messages: the non-verbal communications, feeling Lisa's body movements in terms of narrow space. She indicates as we are going through the position of her arm and my hand in relation to that".*

The ice-breaking activity was an opportunity to confirm what I observed constitutes interdependence in study 1 (e.g., see "Go Skinny" segment 1 in section 3.3.1.2).

The last activity instead was more challenging and did not work as expected. Specifically, I proposed a task to help pairs to summarise some ideas people explored throughout the workbook. The idea was to help people make connections with what they discussed previously, and generate some potential AI assistive technology proposals. The activity was intrinsically challenging, and participants found it difficult to reconnect with what they have discussed throughout the workshop. Participants were unable to extend their reflections on future AI assistive technology. However, what seems interesting is that through the last summary, activity pairs reconnected and expanded their ideas around interdependencies. Indeed, while the first activity helped pairs to describe interdependencies in the sighted guiding navigation, the last summary activity promoted a space to extend the problem space. Pairs talked about their daily collaborative practices which go beyond walking together. Below, I report some examples to illustrate their thinking.

In the first activity pairs also engaged in reflections about how they complement each other during navigation. For instance, *Harold* (SG) described *Vincent*'s abilities, and how his abilities and skills helped while walking:

> *"He knows how to come back home. This is where Vincent is very clever. Sometimes he tells me the way, sometimes I take to wrong way, sometimes instead of taking the Jubilee line I take the District line, but he tells me—no we should take the Jubilee line first, it's much quicker..."*

We can also see a nice articulation of reciprocity from *Emily* and *Lisa* (pair 04). Emily and Lisa have established a long friendship, and they demonstrated forms of care through both their descriptions and how they helped each other during the activities. For instance, *Lisa*, the guide, said:

> *"This lady took me to New York and we travelled around New York for 6 days. She's just a wizard on smartphones which I can't manage she helped me not to get lost."*

Later, *Emily* (VIP) added:

> *"Another time would be just for a walking and if Lisa says—oh this is a lovely sunset—and begins to describe the sunset, it would be something I would be interested in hearing as opposed to changing the subject."*

Whereas in the last activity, *Lisa* (SG), and *Emily* (VIP) nicely described two different situations where they worked together in their everyday encounters. First, formatting a document, and second, filling in an online form.

> *Lisa-G: "If I go first when Emily has done a degree recently, she needed my sight for some* [...] *formatting a document, so I have learned so much about formatting"*
> *Emily-VIP: "But also I was doing a bibliography and referencing and I wanted to look, I mean visually, I knew in theory what to do, where to put punctuation, the order in which to put the authors, the title, all of that, so for me, I am not seeing it visually on the page, so although there is very punctuation, it was good that I could look at it and how well it looked. So that can be one situation where we worked together"*

> *Emily-VIP: "like another is just accessing a website where I might not be able to access it and I might say—I can fill this in, but you wanna put a tick in the box, I don't know how to do a tick in the box—but then I might be able to tell Lisa if you do this the tick in the box will happen, so in that way, we are in tune with each other and complementing each other on the task"*

These two examples show that sighted guiding is only one of the many situations in which pairs have to strengthen their relationship. Performing other tasks together helped build their mutual understanding and intimacy. For instance, *Lisa* and *Emily* are aware of each others' abilities and skills. *Emily* is very good with technology, and even though she finds an inaccessible website, she is able to guide *Lisa* to complete the task, which is another example of interdependent work. Doing together establishes a sense of trust, sharing interests, and confidential information, intensifying their partnership when they walk together, but also their relationship as friends or family members.

INDEPENDENT ACTIVITIES. Some activities were designed to be independent. They aimed to encourage reflection about different aspects of sighted guiding. This was the case in, for instance, "The sighted guiding technique" and "Silence is also communication" activities. The former asked pairs to reflect on their connection whereas the latter focused on how silence is used by pairs and where AI might utilise silence recognition in different contexts. What was interesting to see was how pairs implicitly developed their AI assistive technology ideas across these independent activities. It was surprising how each activity opened up their thinking and, in some cases, how discussion and reflection led to the kinds of proposals and enhancements I was looking for. This was the case of *John* (VIP) and *Nick* (SG). In the "sighted guiding technique" activity. *Nick* first described their practice as something enjoyable, where he likes the walking pace while guiding his companion:

> *"I found that the world kind of slows down, and I like that, and I like describing the environment, and it is just a bit different you know, the world is a bit different, I quite like that, and I like the sense of trust that it is shared and yeah, I am just happy really".*

Later, when discussing the role of silence in "Silence is also communication" (from the second section), Nick connected a walking pace to silence:

> *"Because I know he had another guide who was walking too fast, like speedy gonzales and it made him nervous, and he told me—he didn't tell the guy—because people have a different level of confidence"*

Here, the use of silence is related to how established and close pairs can be. The level of confidence determines what the pair is happy to share. Although my intention was to discuss the role of silence in conversational terms, reflecting on silence and sharing more generally helped the pair to come back to their past experiences and to remark that walking pace is a key resource in their partnership.

> *John-VIP: "Yeah, I feel really comfortable walking with Nick, because he has the right pace and says what the steps are: step up, step down, someone on the right, or on the left, keeping simple indication"*
> *Nick-G: "So, the sighted guiding training is very useful I think, the way's been designed because it can be really subtle, unnoticeable to passersby and then there's a certain rhythm to it.* [...] *This is because it is a special relationship, because it takes time, because you want the person to have a nice experience, and not like the speedy gonzales guy"*

In the same activity, Nick built on this idea of walking speed and rhythm in the walk. As a consequence, he described his idea of an AI assistive technology that can help to strengthen their connection: *"It can record his pace and if I have that app on my phone and if I go too fast it would bip because I would be out of sync".* Irrespective of the merits of such an idea, what we

see here is how the workbook as a whole created a space for thinking, not always by intentional sequential activities or activity ordering but sometimes by allowing participants to express and build on their own associations. What this points to is the value of intentional ordering and sequential activities in workbooks, but also ensuring there is the scope for connections and associations that do not seem too scripted or prescribed. What seems important here is to provide the components for making these links, for example providing participants with the ingredients of silence on the one hand and strength of interpersonal relationships on the other and allowing these to seed new associations.

5.3.2 *Participation and engagement*

In this sub-section, I will present examples of how some workbook components helped participants to engage in the activities. Different pairs found some activities more engaging than others. Indeed, what was notable was how partnerships influenced participation dynamics. In the following, I present some workbook components which had an impact on companions' participation during the workshop. Overall, what pairs found engaging was: (i) tangible and collaborative work; (ii) experimentation and self-initiative; and (iii) situated experience that encouraged sharing and closeness with the researcher.

COLLABORATIVE TASKS. Some workbook components—such as collaborative tasks—were intentionally designed to help participation, but these components did not work in the same way for all pairs. For instance, "The Ramble Tag" activity (see section 5.2.1) had pairs collaborate to complete a pre-defined task (i.e., having a walk wearing the armband), and co-create something together using tangible materials (i.e., DIY activity: use materials to enhance the armband). After taking a short walk with the armband, the DIY activity was designed to accommodate non-visual abilities and make the design space accessible. Accessibility of materials, and so the workbook, was seen as the basis for participants' involvement. However, in practice, I found it was not sufficient to foster participation. What seemed more important was the relationship between companions. These relationships influenced participant dynamics; for example: how much each companion was involved in the workshop, in completing tasks, and what pairs found engaging. As an example, *Vincent* (VIP) and *Harold* (SG) did not engage at all with the tangible materials but *Emily* (VIP) and *Lisa* (SG) appeared much more hands-on and exploratory: to them, the

workshop itself appeared as an expression of interdependent work. Through the negotiation of their roles and abilities, the pair showed how they work together.

In the following conversation, we can see *Lisa* (SG), and *Emily* (VIP) working through the second part of the Ramble Tag activity. They take a picture and use the online form to send it to the researcher, adding a description of how the adaptation strengthens their connection.

> *Lisa-SG: "You do photos because I can't do photos. So, E will send this to you [the researcher] because she is good with technology, I can just spend a week to get in the mood"*
> *L: "Describe your creation and how to strengthen your partnership, I can type that in. You do the photo and I do the typing"*
> *Emily-VIP: "So, we have the visually impaired person taking a photo"*
> *L: "Of course, unless you get it [phone] ready for a selfie"*
> *E: "yeah, I can do that [voiceover instructions], it is ready for the selfie"*
> *[taking a photo]*
> *L: "ok done"*
> *E: "have you checked if it's fine?"*
> *L: "Yeah, it is a bit awkward because I have a black cardigan, but it is ok"*
> *L: "So, we shortened the strap to have a closer position and the guide needed something to cover the irritation..."*
> *E: "against the skin"*
> *L: "yeah, against the skin"*
> *E: "so, it needs a protection"*
> *L: "yeah, a better one will be a padded one"*

This example shows that expressions of care and intimacy are entwined in the conversation. Having sight loss does not prevent *Emily* from completing a visual task, such as taking a photo. Being 'good at technology' (as *Lisa* puts it), she can help out her guide with the task, demonstrating her own agency, and her ability to be flexible and skilled when changing the camera set-up. Towards the end of the conversation, we also see how *Lisa* and *Emily* seek to complement each other. Using forms of repair of troubles in talks that were also observed in study 1 (see section 3.3), *Emily* repairs the utterance *"[...] to cover the irritation..."*, showing how the task is achieved turn-by-turn coordinated through a mutual exchange of verbal signals.

In sum, the workbook study revealed how participants, such as *Lisa* and *Emily*, worked well together not only because of the workbook (and how I designed it) but how it was set against the relationships between pairs. The nature of the relationships was integral to both how the activities were approached and what outcomes were achieved. Although this may not be entirely surprising, it does seem to be important given the focus of my PhD research, that of the interdependencies between sighted guide pairs. What is evident here is that the success

of guiding and also in activities like those in the workbook go well beyond the functional partnership between people, and is dependent on the quality of the relationship between pairs.

EXPERIMENTAL TASKS. Participants also approached experimental tasks in the workbook with enthusiasm. What I noticed is that doing an experiment makes space for participants' self-initiative. For instance, in the "A sound presence" activity *Nick* (SG) described how he extended the activity to instigate an experiment with his partner *John*:

> *Nick-SG: "I totally tried a couple of things where I would lead John (VIP) just for the sound and he took off his hand from my shoulder, but he didn't like that experience, so he could walk freely guided by the sound, but he didn't like that. And the other one was turning without saying anything and obviously the phone moves ...personally I found it quite irritating... you know, normally when we are out, we talk, or we don't talk but we can hear the world around us and it is nice to have no noises actually, I think."*

Regardless of the perceived benefits or even irritations, Nick's comments show engagement through extending the proposals with self-motivated changes and additions to the tasks. This kind of self-initiative helped participants investigate thoughts and ideas, and in turn, opened up the design space to new and emerging ideas. In Nick's case, then, we can notice that their initiative in extending the activity helped to reflect on the importance of the physical connection, and on the inadequacy of sound feedback.

REFLECTIVE TASKS. As a reminder, reflective tasks were built on real-world scenarios and current AI features to explore how future technology might extend people's collaboration. While participants had difficulty discussing the future roles of AI systems using reflective tasks, they did contribute to participation in some way. Something that appeared to work well in the presentations of the reflective tasks was situating the activities in real-world examples. The grounding of the activities in what I had learnt in earlier research and through related studies provided a way for participants to engage with the ideas. For instance "How would you teach a machine to learn your body language?" (activity 2 from the second section) might have felt far-fetched and difficult to comprehend. Indeed, *Nick* (SG) said as much:

> *"Oh this seems very far out, it seems like a sci-fiction movie, like Terminator or something, we can create a liquid man who can travel between walls".*

However, I used the preamble to this activity to recount what I had learnt from my research (presented in Chapter 3): *"a sighted guide I've worked with often says—go skinny—and bends*

her arm back to indicate to her blind companion to move behind her, for instance, because the street ahead has narrowed".

While reading this activity, *Nick* (SG) reacted with enthusiasm:

> *Nick-G: "Oh this is what I was, I say this—one sighted guide says go skinny—I was doing that along the canal, it's kind of command, it is a dignify look out* [...]*—go skinny go skinny—and everyone knows where they are".*

Presenting a situated experience, and similar situations participants experienced in their lives helped to set a common ground and a better understanding between the researcher and the participants. As a consequence *Nick* (SG) and *John* (VIP) were more involved in the activity compared with other pairs. The "Body language recognition" activity was a challenging task, and pairs did not engage in the proposed task. Only *Nick* (SG) and *John* (VIP) responded positively, and started reflecting openly about the use of body recognition technology to complement information about relative orientation when physical disengagement might happen:

> *Nick-G: "Because you are using the shoulder you wanna teach that, so whenever you know* [...] *because he can say when I am turning without me saying anything so he can feel the shoulder and the socket, so you can feel that way. So like a 360 degrees tone, so if I turn right around and you take your hand off, you know I am turning right around because something may happen, it can be anything, some kind of emergency".*

In sum, the grounding of the activities in real-world, situated experiences seemed key to the role of the workbook and, in particular, to how engaged participants were. An important component of this was my own role in fine-tuning the presentation of the activities to do this grounding work. Importantly, then (and as I have noted already), my own presence and sensitivity to the ways participants' engaged with the activities and my efforts to establish common frames of reference played an important role in the workbook as a method.

5.4 DISCUSSION

The study presented in this chapter was focused on developing an accessible and interactive design method inspired by workbooks and cultural probes and putting this method into practice in a participatory workshop with pairs of participants (i.e., visually impaired participants and their guides). Above, I have presented the workbook method and examined specific components (presented in section 5.2.1) that I considered in the method's design. I have set this in the context of reflections on interdependence, future AI assistive technology and participants' engagement.

Overall, I found the workbook highlighted the diversity in pairs' relationships. Findings show how pairs experimented with concepts, scenarios and technological proposals; regularly situated their discussions in their lived experiences, and reflected on future AI-AT through co-speculative acts. Further, results reveal that activity ordering, and both sequential and independent activities helped participants to build their thinking around interdependence and future AI-AT, and created a space for new spontaneous associations to emerge. Finally, pairs also collaborated, responding to the form of the activities as well as employing their own initiative.

From the findings, several common themes emerged. Specifically, from the examination of the activity type and its content (section 5.3.1.1) emerges the importance of slowing the design process, setting a common ground around AI and its possibilities, and implementing (co)-speculative tools for free exploration. The examination of the ordering and sequence across activities (section 5.3.1.2) highlights the importance of slowing down the design process, setting a common ground around AI and its possibilities, and building a degree of ambiguity into proposals. Finally, participation and engagement (section 5.3.2) echo some of the previous themes but also underline the need for greater involvement in co-creating proposals with participants.

In this last section of this Chapter, I discuss in detail these common themes and how they might be taken into account in future design methods. Specifically, future design methods should draw further attention to:

(i) Building on situated experiences: a greater involvement from participants for co-creating scenarios and technology proposals themselves;

(ii) Establishing a common ground: setting a common ground around AI and its possibilities;

(iii) Scaffolding the slow progression of creative thinking: slowing the design process;

(iv) Ambiguity and making connections: intentionally building in a degree of ambiguity into proposals;

(v) (Co-)speculation for maintaining an open design space: implementing speculative tools for free exploration as well as promoting co-speculative mechanisms.

The chapter closes with some reflections on my involvement as a researcher in the design process.

5.4.1 *Considerations for Future Design Methods*

Responding to the results of the study I have presented in this chapter, I propose five points that aim to refine the workbook method described above and might also inform similar participatory methods targeting future AI assistive technology.

BUILDING ON SITUATED EXPERIENCES. The examination of the workbook method highlights a more open and collaborative engagement compared to study 2 (see section 4.4.4) and this, in turn, led to a more thoughtful and extended discussion of future technologies between participant pairs. Attention to the dynamics of participation and collaboration would thus seem crucial in improving creative design methods. As I have noted in section 5.3.2, one important aspect of pairs' participation in the workshops hinged on the shared reference to situated experiences of sighted guiding. Particularly important to this were discussions of partnerships and working together. Designing activities which are more situated in lived experiences can be challenging as relationships and established practices can vary. The risk here is a failure to capture and represent a plurality of cases and situations that speak to all participant pairs.

Beyond increasing the number and variety of proposals, it would I believe be worth extending the participatory qualities of the workbook method presented above. By this, I mean having a greater involvement from participants in designing the scenarios and technology proposals themselves. As with the work from Neate et al. [95], who combined personas and participatory techniques in working with people with aphasia, the aim here would not only be to better capture the range of possible cases but also to deepen and enrich the representation and reflection of experiences. What appeared to be salient for the participant pairs in the workbook method I developed was not just how a scenario or proposal captured actual experiences but how it triggered a depth of discussion and reflection. Thus, the goal of a greater degree of participation would be to further foster engagement, collaboration and creative thinking in the workbook method.

ESTABLISHING A COMMON GROUND. Situated experiences also promoted a common ground between the participants and the researcher, and so fostered participation in the workbook activities. For instance, *Nick* became more engaged when I referred to an experience he had also encountered (see the end of sub-section 5.3.2). Also, other activities provided a basis for shared talk, for example in "The sighted guiding technique" activity, thanks to what participants

described, I had the opportunity to link what they experienced in sighted guiding to what I had seen constitute interdependence in the previous studies (see sub-section 5.3.1.2).

Also instructive were those occasions where activities did not always provide a basis for common ground. For instance, in sub-section 5.3.2, *Nick*—initially—saw ideas for an AI system (e.g., body movement recognition) to be impossible and too far removed from the real world. This demonstrates resistance to the imagination. While there is literature that looks at helping people imagine novel ideas through structured ideation methods [45], Morrison et al. work [88] show the difficulties people can face when trying to imagine new AI assistive technology addressed to people with visual impairments. Authors report that people struggle to think beyond familiar technologies and clichés. I suggest that future design methods should consider these difficulties and should seek to employ a mixture of new techniques that directly target establishing a common ground around the possibilities and potential of current and future AI-AT. This would help people to acknowledge what is possible and establish the basis for reflecting and imagining future AI systems. For instance, one suggestion might be to include multiple proposals which incorporate different AI technology features and levels of expertise. Accordingly, scaffolding mechanisms and situated experience might help to introduce AI basic ingredients and knowledge to participants (e.g., what AI is, how it is built, and how it is deployed), moving the focus away from the rapid prototyping technique.

SCAFFOLDING THE SLOW PROGRESSION OF CREATIVE THINKING. Building on the goal of fostering engagement, collaboration and creative thinking, I believe greater attention should also be given to the way workbooks and similar creative methods order and organise participatory materials. Above, I have suggested the combination of the ordering and sequence of activities provided the ingredients for scaffolding thinking. As noted, where the workbook succeeded to engage participants in critical and creative thinking, it was often apparent that scenarios, concepts and technology proposals were developed across a series of activities. Intentionally, in parts of the workbook, I introduced the basis for an idea through, for example, the basic ingredients of a technology, and then added additional details and a scenario around this in successive activities. The "A sound presence" activity and the "A further sound exploration" activity from the first section are illustrative. In contrast to study 2, part B (see Chapter 4), this provided a more deliberate and gradual entry point into a way of thinking about future AI assistive technology.

I want to suggest this slow as opposed to rapid progression through a series of steps to be a central focus for developing workbooks and other, similar AI assistive technology methods. This intentionally diverges from the rapid prototyping methodology prevalent in many areas of design, providing a counter position that emphasises a deeper and more process-focused engagement with creative thinking. For future methods, I believe what should be especially important is how the different elements or ingredients to a technology, concept or scenario are staged and ordered to create a space for this depth in imagining *together*. Care would be needed here not to focus participants' attention on the functionality of technology or to overly constrain thinking, but rather to provide the resources for collective co-creation.

AMBIGUITY AND MAKING CONNECTIONS. The fourth area of focus for methods in designing AI assistive technology I want to propose stems from the observations of pairs connecting and building on seemingly unrelated and independent activities in their workbooks. This may seem at odds with the idea of scaffolding. However, I want to suggest that in combination the scaffolding between activities and the use of standalone activities are complimentary.

Above, in the last part of sub-section 5.3.1.2, we have seen how pairs made connections between activities to reflect and develop their ideas. For example, we saw how *John* (VIP) and *Nick* (SG) used an activity about silence to think about the importance of the closeness of relationships between visually impaired people and their guides. I believe the way in which the workbook was organised and ordered may have supported making connections in this way. That is, unintentionally, the mixture of standalone activities and those that served to scaffold a concept or scenario provided a 'license' for participants to build their own connections between activities. Furthermore, I believe that a degree of ambiguity in some of the activities whilst difficult for some also invited pairs to make sense of them by drawing out the connections. It is possible that the scaffolding and ambiguity together triggered a form of sense-making through connection.

I am more tentative about this possibility for future design methods, but I believe it presents an area worthy of research. The intentional combination of scaffolding across activities with ambiguity within activities, aiming to promote unexpected connections between concepts and scenarios, could be a promising dimension to build into future design methods.

(CO-)SPECULATION FOR MAINTAINING AN OPEN DESIGN SPACE. As we have seen in sub-section 5.3.1.1, provocative and experimental tasks helped participants to reveal more about

their connections and interdependencies, and in turn to consider the ways in which they might further complement one another. Specifically, content and both tangible and digital objects in the activities served as speculative artefacts, that inspired people to both make comparisons and to self-initiate tests to reflect on aspects of sighted guiding as well as AI's future role. This demonstrates that speculation opens creative thinking, and that future design methods should consider employing a diverse set—in term of material and form—of tools/prototypes.

What could be challenging here is to introduce and present these tools as research materials rather than intermediate prototypes of a final solution. The risk again is to have participants feeling constrained by the practicalities of the final AI solution, as I observed in study 2, chapter 4. In contrast, what seemed especially important in the workbook method was my active involvement as a facilitator in the workshop. As mentioned in sub-section 5.3.1.1, co-speculating with participants helped to echo and amplify the creative thinking, and draw them away from more functional challenges of the technology. In addition, I think it is fair to say that co-speculative acts were possible thanks to how the workshop was carried out (i.e., through synchronous co-presence in a Zoom meeting). What I want to suggest, in short, is that co-speculation has the potential to maintain an openness to the design space. In this regard, I believe it would be worth considering how to extend the workbook method to support co-speculation in asynchronous as well as synchronous settings.

5.4.2 *Reflections on my involvement*

Through the planning and running of this last research study, I have become more aware of the subjective role of the researcher, and the importance of more reflexive practice in research. Indeed, the interpretive analysis I conducted has helped me to see there are times to resist a crude notion of objectivity and to lessen the emphasis on producing a set of practical technology requirements. This emerged from a need to bypass the issues I encountered in Chapter 4. In contrast to this previous study, my involvement and positioning were taken into account from the beginning. The narrative I created through the workbook activities allowed me to introduce myself to participants and present the perspective I was looking for. I came to see there are methods that can be less about objective observation and that can be more focused on engagement and opening up the design imagination.

Moreover, while conducting the study remotely on Zoom, and presenting the activities in first person I had a direct involvement throughout the research. As described in the findings in

sub-section 5.3.1.1 and discussed later in sub-section 5.4.1, my co-presence in the setting and involvement enabled co-speculative acts and helped participants in some cases to think beyond practical AI functionality. This was also confirmed during the workshop by different participants. For instance, *Harold* (SG) at the end of the workshop mentioned: *"as I said earlier you made it very clear and then we knew what we were doing, why we were doing it, and what you wanted to know about the exercise"*. What Harold I think recognises in his words is the change in my own investment in the research, of how I have learnt to relate with my participants. Through this work, I have thus come to see how research can be about a process of discovery, as much about what to know as how to know it.

Finally, I believe this shift in my approach to research methods played a key role in my efforts to seek common ground with my participants. These efforts did not go unnoticed. At the end of the session I participated in *Emily*'s (VIP) generous assessment of the activities: *"I know a lot about myself, I wondered what could I learn. And I have learnt a lot* [...], *I have found it informative. I came with an open mind but wondered how much would you know from your studies that I know having lived with visual impairment. But you have opened up a lot of avenues for me to think about, and I am very positive and pleased"*. Words such as *Emily*'s show the importance of creating an accessible environment as a researcher, not only in terms of having materials presented in an accessible format but also in building a space which encourages sharing and closeness with the participants.

6 CONCLUSION

This thesis provides a detailed account of designing AI assistive technology aiming to support the sighted guiding partnerships through an interdependence lens. In this final chapter, I will first come back to the contributions and research questions I highlighted in Chapter 1. I will then outline some limitations, and suggestions for future work.

6.1 CONTRIBUTIONS

The overarching contribution of this research is a reframing of designing at the intersection of AI assistive technology for people with visual impairments and interdependence. This is done through a specific and intentionally narrow focus, so looking at the sighted guiding partnership (see section 2.1.1). This contribution is comprised of smaller ones, which are achieved by addressing the research questions outlined at the beginning of this thesis (see section 1.2).

Research questions have been addressed conducting two predominant types of exploration: study 1 (Chapter 3) and study 2 part A (Chapter 4, section 4.3) which explored the *problem space*, and study 2 part B (Chapter 4, section 4.4) and study 3 (Chapter 5) which investigated the *design space*. The research journey is explained in more detail at the beginning of the thesis in Introduction Chapter 1.

> **RQ1:** As an exploration of the problem space, **how do people with visual impairments and their sighted guides accomplish navigation together?** (study 1, Chapter 3)

The contribution of study 1 is an empirical understanding of the theoretical concept of interdependence in the sighted guiding partnership. While previous design perspectives have paid attention to the social features of settings, for instance highlighting mismatches between the different ways sighted and non-sighted people interact with their surroundings, and thus how appropriate feedback is important in navigation, they did not explore how people collaboratively work. Moreover, AI assistive technology for navigational aid has been approached from the perspective of autonomous travel, reducing the "problem" of navigation to a sequence of steps and movements from one place to another. Therefore, the interdependence concept had not

previously been considered in understanding how people with VI navigate, and in the design of AI systems.

Chapter 3 includes details of how sighted guiding companions accomplish navigation together. Findings reveal (i) how multimodal resources, such as talks, body movements, gestures, and objects are used in concert to co-constitute a common space between people with vision impairments and their guides; (ii) how this work together is intertwined into the ordinary and unfolding sequence of interactions, which is a form of interdependence; and (iii) how the unfolding relations through space are subjected to ruptures and repairs.

Through the findings, I suggest that an AI's goal might be to support these partnerships rather than assume they can be replaced with technology. This reduces the emphasis on the problem of recognising the environmental details, focusing instead on how AI might relate to multiple resources, without disrupting the temporal concurrence or sequence in action. One case of AI interventions might be represented by rupture moments where the shift from a common space of interaction to a more personal one might not be equally perceived, for instance during physical disengagement.

> **RQ2.A:** In a deeper exploration of the *problem space*, **how do companions use body movements in sighted guiding?** (study 2 part A, Chapter 4)

The results of study 1 highlighted the importance of body movements and gestures in sighted guiding. Being physically connected allowed companions to convey important information, helping them to accomplish navigation together. The contribution from part A of study 2 is an extension of the empirical contribution gained in study 1. After analysing body movements and meanings during sighted guiding of 3 participant pairs, RQ2.A has been answered providing a detailed illustration of the body language and its limitations in sighted guiding. More specifically, the findings reveal: (i) the complexity of body language, the most frequent and common associations between body movements and meanings, and the importance of the type of holding in defining the body language; (ii) body language limitations in describing contextual information during the journey, in resulting too intrusive during pre-journey moments, and in being ambiguous and challenging during post-journey moments.

Gaining a deeper understanding of the body language in sighted guiding and its limitations in moments of physical disengagement helped me to approach the design space at the intersection of AI and interdependence in part B of study 2.

> **RQ2.B:** In a preliminary exploration of the *design space*, **how can an AI prototype extend body language when companions physically disengage in sighted guiding?** (study 2 part B, Chapter 4)

After introducing a preliminary AI prototype to sighted guiding companions as an exploration tool at the intersection of AI and interdependence, the above research questions have been addressed revealing the following findings: (i) insights about audible feedback and its features (i.e., how audible feedback features might be employed to extend body language); (ii) AI prototype inputs on how the user experience can be refined; and (ii) overall negative feedback on the scenario of study, and the design of the preliminary AI prototype.

The contribution of part B is a methodological one. It concerns the re-framing of the design space to attend to interdependence and AI. Indeed, part B was approached following common design methods which are used when designing AI technology (i.e., UCD method). Findings offer important reflections and insights. Participants' negative feedback, and the impoverished idea of independence that the prototype enabled taught me more about the design process, and how traditional methods are insufficient when involving both complex systems, and people with mixed abilities (see section 4.5). The literature demonstrates that there is no HCI research looking at how to design AI assistive technology for interdependence. On the one hand, traditional approaches such as PD and co-design methods [92, 112, 113] have been naturally adopted with people with visual impairments. These approaches foreground the lived experience of people and inclusion in the design process. On the other hand, working with AI results to be complicated, and the typical approach is adopting user-centred techniques. The interdependence concept in assistive technology has been introduced recently in the HCI area, and so there is no research on how to design AI assistive technology for interdependence.

> **RQ3:** In an exploration of the *design space*, **how can we employ design methods to help people creatively think about AI and interdependence?** (study 3, Chapter 5)

The final study of this thesis reconsidered the design process and the exploration of the design space. Thus, to move beyond the idea of AI as a solution and blindness as a disability, I developed a new method to involve people in the design process and pay special attention to their collaborative achievements and competencies. The workbook presented in section 5.2.1 was inspired by workbooks and cultural probes [38–40], and extended through the design of new components.

The overarching contribution of study 3 is a method contribution in extending current design methods at the intersection of workbooks and cultural probes. Through a reflexive analysis of the data findings show: (i) how pairs experimented with concepts, scenarios and technological proposals; regularly situated their discussions in their lived experiences, and reflected on future AI-AT through co-speculative acts; (ii) how activity ordering, and both sequential and independent activities helped participants to build their thinking around interdependence and future AI-AT, and created a space for new spontaneous associations to emerge; (iii) how pairs also collaborated, responding to the form of the activities as well as employing their own initiative.

In the last section of the Chapter, I suggest that future design methods should draw further attention to:

(i) A greater involvement from participants in co-creating scenarios and technology proposals themselves;

(ii) Setting a common ground around AI and its possibilities;

(iii) Slowing the design process;

(iv) Intentionally building a degree of ambiguity into proposals;

(v) Implementing speculative tools for free exploration as well as promoting co-speculative mechanisms.

6.2 LIMITATIONS

The work conducted in this research looks at how to design AI assistive technology for interdependence addressed to people with visual impairments.

For conducting this research I adopted a qualitative approach, which was required for developing an empirical understanding of sighted guiding. I am aware that the method I chose authorised a particular understanding of sighted guiding, as previously mentioned in the limitations of study 1 (see section 3.4). Moreover, my research was conducted only in the UK with people who spoke English. The cultural and social-economic context surely has influenced the kind of resources and strategies people establish for accomplishing navigation together. As such, the details around interdependencies might not be representative of other sighted guiding companions around the world. In other countries (e.g., India where people living with visual impairments represent a large proportion of the population) sighted guiding companions

might adopt different technique preferences and strategies because of the differences in culture, gender, and power dynamics. Therefore, the role AI might play in the people's partnerships I studied might be different from other populations and settings (e.g., low and middle-income countries).

Additionally, due to the pandemic, study 2 and study 3 were conducted completely in a remote setting. Specifically, part B of study 2, and study 3 were related to the design space and the exploration of design methods. In part B of study 2, the introduction of a preliminary prototype was entirely online, and as explained in the findings (see section 4.4.4) accessibility and the remote setting resulted to be very challenging. Challenges were related to both the storytelling activity and the WoZ technique. Specifically, the scenario of study followed a sequence of perceived not realistic steps, the prototype did not help to go beyond the practical tasks of AI, and participants' engagement was limited and negative (see Discussion section, in Chapter 4). Consequently, the results should be interpreted in light of the study setting limitation. The UCD techniques I used resulted in being limited in a remote setting but could have provided positive feedback if adopted for in-person workshops. For instance, in-person workshops would allow participants to run the storyboard in a more realistic setting and act different roles while trying the prototype through WoZ technique. A second limitation concerns the sample size. Study 2 was conducted with limited participants (e.g., study 2 part B). Although it allowed me to reflect on my design process, it is difficult to generalise the results more broadly. More participants should be involved to better understand the implications and issues related to these techniques. Moreover, it is fair to say that the study employed a set of techniques commonly used in the (re)design phase of the UCD approach, but the UCD approach as described by Preece et al. [64] was not put fully into practice in this work. I see a space for future research to further explore similar techniques and compare them with other alternative methods investigating design methods' strengths and limitations when designing AI assistive technology for the collaborative work in sighted guiding.

In contrast, study 3 resulted to be more accessible despite the remote setting. A reason might be the co-presence of the researcher that helped participants to engage and participate in creative thinking about future AI assistive technology. Again, it is fair to say, that conducting in-person studies might have helped even better to engage participants in thinking about future AI assistive technology. For instance, conducting study 3 in a hybrid format—as I planned originally—would have helped me to compare research methods, and so understand how the format might play a role in the research questions I wanted to address.

Finally, this PhD research could be understood as an unfair critique of AI. As stated in section 1.1, this work did not aim to develop and evaluate an AI assistive technology, therefore the work only explores the technical side of AI in a very limited way. My rationale here has been two-fold. First, technology-led research risks overemphasising technical goals and accomplishments rather than how the technology can be transformative for its potential users. I referred to the work of Bennett et al. [8, 9] and other scholars [57, 89, 129] to demonstrate that this perception informs activists and researchers at the intersections of AI and HCI. Second, I have argued that alongside technological developments what is needed is new creative methods that invite different ways of thinking about the uses and values of AI. These methods need to allow for experimentation that extends beyond the well-rehearsed ideas in technology-led AI research. However, I recognise that the work I have presented needs to be judged in actual cycles of technical development, combing both creative methods and technological accomplishments. This points to future work described in Section 6.3 where for instance, I refer to Fiebrink's work as inspirational research to train AI systems using user-generated examples, or similarly, Theodorou et al.'s work where authors involve blind users to collect and construct a dataset for teachable object recognition systems [131]. Further, exploring new creative methods such as *soma design* [58] could lead to new insights about both new AI values and generative uses from people which can be incorporated in cycles of technical development.

6.3 FUTURE WORK

As mentioned in Chapter 1, by conducting 3 studies, this research touched 2 areas of the design process: the *problem space*, and the *design space*. Future work might be related to both of these areas. Firstly, there is not much research investigating interdependence as a framework for designing. Future research might focus on exploring interdependence within other underrepresented/marginalised populations, in terms of different impairments or disabilities, but also geographical areas (as noted in the section above). Following this path, we can better understand to what extent the results of my research—which are based on a low sample size—are generalised for people with disabilities or in other social-economic settings. Following this direction, future research will make a contribution in suggesting and improving guidelines around AI assistive technology. The interdependence framework offered a way to study the collaborative work that takes place in sighted guiding. The design surrounding navigation-based AT might then benefit from shifting attention away from the problem of recognising details

in a user's environment to supporting the means by which the world is made meaningful through talk and interaction. Relatedly, such research might question a further presumption: that *independence* is the sought-after goal, that people with vision impairments should, through technology, be given the means of navigating on their own. Again, in examples where AT has been designed to support navigation, it is often the case that it is treated as an individual accomplishment and thus something to be solved for the individual. Where the recognition of other people is addressed, it is either to recognise them as an obstacle [3] or to detail their attributes (e.g. "man, aged 35", etc.). What I want to suggest is that the support for navigation in assistive technologies might instead show concern for how people actively work together, and how they rely on one another to move together.

While investigating the design space, I encountered several challenges that let me reconsider my design process. The five points reported in the previous section can be the starting points for designing AI assistive technology for interdependence in future work. For instance, as suggested in Chapter 5, interactive and accessible workbooks can be further extended toward a greater involvement from participants in co-creating scenarios and technological proposals themselves. Using Fiebrink's work as a guide [32, 34], it is possible to develop a more human-centred approach to machine learning by training systems using situated user-generated examples. This could be a way to both involve participants in co-creating proposals but also establish common ground around AI and its possibilities, which is another point future design methods should draw attention to. Fiebrink has shown considerable success in building digital music instruments that can be trained and respond to real-time embodied interaction by users [33]. Similarly, we could explore how people with visual impairments and their sighted guides might build their own training set for body language recognition, or other resources they would like to augment in sighted guiding.

Another promising area is the exploration of other design methods for making design space for both interdependence and AI. Future work might explore a combination of design methods to better involve people with visual impairments and guides in the co-creation of AI assistive technology. For example, a suggestion could be to slow down (see section 5.4 in Chapter 5) the design process rather than focus on rapid progress (e.g., iteratively rapid prototypes) and to, in turn, emphasise interdependence rather than task completion. More broadly, the exploration of other design methods might be beneficial in future AI systems. For instance, *soma design* might offer an innovative design method to attend to bodily and interpersonal communication and the competencies people develop and tune through navigation. *Soma design* is a *"process that*

allows designers to examine and improve on connections between sensation, feeling, emotion, subjective understanding and values" [58]. By exploring this design method, sighted guiding companions can engage with the body rather than prioritise vision in the design of AI assistive technology for interdependence. This would promote accessibility, diversity and inclusion, resist the idea of a disabled body, and enhance social justice. For instance, we have seen that bodily communication plays a relevant role in understanding spatial configuration when companions are bodily connected. In contrast, physical disengagement might bring challenging changes to spatial configuration such as distance and orientation (e.g., a person with VI might not realise that the companion has left their side). The adaptation of this method could bring important design implications because of the increasing adaptability of AI-AT to contextual, situational and personal factors and the capabilities of people with VI. This differs from the previous approach that has focused on object recognition and discrete tasks where the end-to-end scenario is easily defined.

Future work will help to advance HCI research in AI assistive technology, accessibility, and inclusion. My hope is that new methods will help to investigate alternatives to current trends in AI assistive technology, which prioritise solving perceived problems. My research was a first attempt to think about what human-AI interactions will look like in the future. More research is needed to break current social norms and inspire people to make alternative designs of AI. Potentially, future collaboration between people through/with AI will bring the promotion of both individual and collective empowerment amongst people living with visual impairments (and more generally people with disabilities) in social life.

A INTERDEPENDENCE IN ACTION (STUDY 1)

A.1 ETHICS APPLICATION

Ethics ETH1819-1113: Beatrice Vincenzi (Medium risk)

Date	28 Mar 2019
Researcher	Beatrice Vincenzi
Project	Exploring interpersonal interaction in the sighted guide experience
School	School of Mathematics, Computer Science & Engineering
Department	Computer Science

Ethics application

Risks

R1) Does the project have funding?
No

R2) Does the project involve human participants?
Yes

R3) Will the researcher be located outside of the UK during the conduct of the research?
No

R4) Will any part of the project be carried out under the auspices of an external organisation, involve collaboration between institutions, or involve data collection at an external organisation?
No

R5) Does your project involve access to, or use of, material that could be classified as security sensitive?
No

R6) Does the project involve the use of live animals?
No

R7) Does the project involve the use of animal tissue?
No

R8) Does the project involve accessing obscene materials?
No

R9) Does the project involve access to confidential business data (e.g. commercially sensitive data, trade secrets, minutes of internal meetings)?
No

R10) Does the project involve access to personal data (e.g. personnel or student records) not in the public domain?
No

R11) Does the project involve deviation from standard or routine clinical practice, outside of current guidelines?
No

R12) Will the project involve the potential for adverse impact on employment, social or financial standing?
No

R13) Will the project involve the potential for psychological distress, anxiety, humiliation or pain greater than that of normal life for the participant?
No

R15) Will the project involve research into illegal or criminal activity where there is a risk that the researcher will be placed in physical danger or in legal jeopardy?
No

R16) Will the project specifically recruit individuals who may be involved in illegal or criminal activity?
No

R17) Will the project involve engaging individuals who may be involved in terrorism, radicalisation, extremism or violent activity and other activity that falls within the Counter-Terrorism and Security Act (2015)?
No

Applicant & research team

T1) Principal Applicant

Name
Beatr ce V ncenz

Provide a summary of the researcher's training and experience that is relevant to this research project.
Beatr ce s a PhD student and th s study s re ated to her project. Moreover she s vo unteer ng to B ndA d char ty for he p ng and ass st ng peop e w th v sua mpa rment. She s act ve y nvo ved n events to offer company and conversat on to v sua y mpa red peop e and she s tra ned to be a gu de us ng the s ghted gu de techn que.

T2) Co-Applicant(s) at City

T3) External Co-Applicant(s)

T4) Supervisor(s)
Dr S mone Stumpf

Dr A ex Tay or

T5) Do any of the investigators have direct personal involvement in the organisations sponsoring or funding the research that may give rise to a possible conflict of interest?
No

T6) Will any of the investigators receive any personal benefits or incentives, including payment above normal salary, from undertaking the research or from the results of the research above those normally associated with scholarly activity?
No

T7) List anyone else involved in the project.

Project details

P1) Project title
Exp or ng nterpersona nteract on n the s ghted gu de exper ence

P1.1) Short project title

P2) Provide a lay summary of the background and aims of the research, including the research questions (max 400 words).
Many d fferent techno og es have been bu t to ass st v sua y mpa red and b nd peop e n the r everyday ves. Prev ous research has focused extens ve y on ass st ng nav gat on n the phys ca env ronment, by prov d ng nformat on about surround ngs, through, for examp e, object recogn t on, obstac es avo dance, phys ca d stance, prox m ty of wa s and so on. More recent y, computer v s on, art f c a nte gence and mach ne earn ng have been everaged n these nav gat on systems.

However, what tends to be gnored s that many v sua y mpa red and b nd peop e re y on and work w th others to nav gate n the r da y rout nes, common y re y ng on what s known as a s ghted-gu de (see https://www.rn b.org.uk/ nformat on-everyday- v ng-fam y-fr ends-and-carers/gu d ng-b nd-or-part a y-s ghted-person). Thus, what has been neg ected n techno ogy- ed research are opportun t es for augment ng s ghted gu d ng, address ng both how peop e nav gate the phys ca env ronment n coord nat on w th one another and the soc a or nterpersona nteract ons that often go a ong w th (and ndeed comp ment) these human-to-human nteract ons. G ven th s, we are nterested n study ng the s ghted gu de exper ence and exp or ng the potent a for AI to enhance the mutua nterpersona nteract ons between those who are v sua y mpa red and the r s ghted gu des.

The proposed study has been des gned to answer the fo ow ng research quest ons:

RQ-1: Are there dent f ab e and regu ar features to the nterpersona nteract ons n the gu d ng exper ence?

RQ-2: What const tutes successfu nterpersona nteract ons between a b nd person and the r s ghted gu de?

RQ-3: What prob ems ar se n the nteract ons between the gu de and gu ded?

RQ-4: Where m ght be the opportun t es for an AI system to enhance nterpersona nteract ons n the gu de exper ence?

P4) Provide a summary and brief explanation of the research design, method, and data analysis.

Th s user study s a med at understand ng the nterpersona nteract ons that const tute the exper ence between a s ghted gu de and a person w th a v sua mpa rment. We w exp ore our research quest ons through a qua tat ve study. Th s w be made up of v deo record ngs of v sua y mpa red persons w th the r s ghted gu des (.e. part c pant pa rs), nav gat ng n rea -wor d sett ngs, and, fo ow-up nterv ews w th each part c pant pa r. The former w nvo ve both members of a pa r wear ng body v deo cameras n order to support deta ed qua tat ve nteract on ana ys s at a ater stage of the research (deta s be ow).

We w recru t a max mum of e ght part c pant pa rs of adu ts v ng n London, w th each pa r composed of a s ghted gu de and a person reg stered severe y s ght mpa red (b nd) or s ght mpa red (part a y s ghted). Interested pa rs need to have an estab shed re at onsh p through gu d ng, mean ng that they are used to nav gat ng together us ng the gu de techn que n the r da y ves for at east 3 months. Indeed, th s pre-estab shed re at onsh p a ows us to nvest gate the r 'natura ' behav our as safe y as poss b e.

Pa rs w be recru ted through adverts v a Tw tter, ema s to ex st ng contacts of the student and superv sors and d str but ng f yers (targeted at s ghted gu des).

Once a potent a pa r meets our nc us on/exc us on cr ter a, the part c pant nformat on sheet and consent form (both n access b e formats) w be sent to the part c pants and an n t a meet ng w th the pa r w be arranged.

The f rst meet ng w ast approx mate y one hour, and the researcher w obta n nformed consent at the start of th s meet ng. She w then ask some quest ons about demograph c backgrounds of the pa r (structured nterv ew quest ons attached). The researcher w go on to exp a n to the part c pants how to set up and wear the cameras, how to sw tch them on/off and f na y part c pants w do a m n - demonstrat on to ensure they have understood correct y the set up procedure. We w eave the cameras w th the part c pants for three days and they can dec de to do one or more journeys at any t me dur ng th s per od. The journey w be chosen by the recru ted pa rs and must be a path they usua y do us ng the s ghted gu de techn que, for examp e "go grocery shopp ng, go to a museum, go to the GP appo ntment, go to a coffee for meet ng fr ends etc". The journey shou d ast at east 20 m nutes.

After three days we w meet the pa r aga n to co ect our cameras and the v deo record ngs. Dur ng th s meet ng we w conduct a sem -structured nterv ew w th the pa r, about 30 m nutes ong. The nterv ew w be aud o-recorded for further ana ys s. We w co ect overa nformat on re ated to the s ghted gu de exper ence and some contextua nformat on about the journey s cho ce and the journey exper ence they have done.

The v deo data gathered from the journey w be ana ysed through nteract on ana ys s. Th s qua tat ve research method, we estab shed n stud es of the workp ace [1, 3, 7] and more recent y n everyday and techno ogy-med ated sett ngs [4, 6], re es on recorded v deo and repeated and carefu rewatch ng of the record ngs to produce deta ed transcr pts of spoken and nterpersona nteract ons. The theoret ca underp nn ngs of th s approach (ow ng much to conversat on ana ys s and ethnomethodo ogy) offers a means of understand ng how nteract on s made nte g b e and thus consequent a to the members of a sett ng, so, for examp e, how peop e cross a road at traff c junct ons w thout constant co s ons [5] or mus c ans ach eve synchrony [8].

In the proposed research, v deo w be captured us ng two wearab e cameras, one worn by the gu de and one by the v sua y mpa red person, thus prov d ng the two part c pants' v ewpo nts. These camera v ews w be ana ysed to nspect and deta the nteract ons n numerous v deo segments [2].The method s ant c pated to offer a r cher and deeper understand ng of how part c pant pa rs coord nate the r verba and bod y nteract ons to nav gate spaces. Spec a attent on w be pa d to how bod y and fac a gestures and movements, and spoken utterances and conversat ona turn tak ng he p to produce a wor d n common for b nd and v s on mpa red peop e and the r gu des, and show nav gat on to be a h gh y coord nated and mutua y accomp shed ach evement. In short, how nav gat on can be and often s done by peop e together.

The co ected aud o data from the nterv ew nstead w be transcr bed and summar ze. We w conduct a themat c ana ys s and resu ts w be used as a d mater a and contextua nformat on to the nteract on ana ys s. Th s ana ys s w form the bas s of dent fy ng opportun t es for extend ng or augment ng the s ghted gu de exper ence w th AI-based ass st ve techno ogy.

References

[1] Heath, C., & H ndmarsh, J. (2002). Ana ys ng nteract on. V deo Ethnography.

[2] Heath, C., H ndmarsh, J., & Luff, P. (2010). V deo n qua tat ve research. Sage Pub cat ons.

[3] Heath, C., Knob auch, H., & Luff, P. (2000). Techno ogy and soc a nteract on: the emergence of 'workp ace stud es'. The Br t sh journa of soc o ogy, 51(2), 299-320.

[4] Laur er, E., Lor mer, H., Brown, B., Jones, O., Juh n, O., Nob e, A., ... & Swan, L. (2008). Dr v ng and 'passenger ng': Notes on the ord nary organ zat on of car trave . Mob t es, 3(1), 1-23.

[5] L v ngston, E. 1987. Mak ng sense of ethnomethodo ogy, Rout edge & Kegan Pau .

[6] Mart n Porcheron, Joe E. F scher, Stuart Reeves, and Sarah Sharp es. 2018. Vo ce Interfaces n Everyday L fe. In Proceed ngs of the 2018 CHI Conference on Human Factors n Comput ng Systems (CHI 18). ACM, New York, NY, USA, Paper 640, 12 pages. DOI: https://do .org/10.1145/3173574.3174214

[7] Ment s, H. M., & Tay or, A. S. (2013, Apr). Imag ng the body: embod ed v s on n m n ma y nvas ve surgery. In Proceed ngs of the SIGCHI Conference on Human Factors n Comput ng Systems (pp. 1479-1488). ACM.

[8] Weeks, P. (1996). Synchrony ost, synchrony rega ned: The ach evement of mus ca co-ord nat on. Human Stud es, 19(2), 199-228.

P4.1) If relevant, please upload your research protocol.

P5) What do you consider are the ethical issues associated with conducting this research and how do you propose to address them?

1. Vu nerab e peop e

V sua mpa rment peop e cou d be cons dered vu nerab e. However, we are recru t ng peop e who are ndependent and capab e n the r da y fe. Part c pants who are v sua mpa red are a ready us ng ass st ve techno ogy, such as screen readers, app cat ons and too s to nav gate n the env ronment, for nstance wh te cane, gu de dog or a s ghted gu de. They have an act ve fe and th s research ntends a so to show that v sua mpa red peop e are ab e to nav gate successfu y.

For th s study we are exc uded part c pants w th mob ty prob ems to reduce r sk, and a so exc ude part c pants w th any cogn t ve mpa rment who are not ab e to g ve nformed consent.

2.Conf dent a ty of data

Due to the un que character of the s ghted gu de re at onsh p we p an to study and as our research s focused on deta ed nteract ons, t may be essent a to record and ana yse fac a express ons and gaze d rect on n some contexts (th s s a core e ement of do ng nteract on ana ys s). For th s reason, we be eve that t s essent a not to b ur part c pants faces n the v deo we co ect. We recogn se, however, part c pants cou d be concerned about revea ng the r dent t es through v deo record ngs and there may a so be threats to pr vacy for those who have not agreed to part c pate n the research (e.g., bystanders). To address these ssues, the fo ow ng w be done to secure peop e's r ght to and protect ons of pr vacy:

- A data w be kept conf dent a and secure.

- We w not use the r rea names n any pub cat ons, and use a pseudonym nstead. Add t ona y, the key to the r dent ty w be kept n a password-protected and encrypted f e.

- We w de- dent fy the co ected data, and v deo records may conta n dent f ab e faces on y f part c pants have g ven consent.

- On y the project team, composed of the ma n researcher and superv sors, w rev ew v deo data conta n ng part c pants' dent f ab e faces dur ng the ana ys s phase. Add t ona y, part c pants need to g ve exp c t consent for us ng v deo data segments n academ c pub cat ons, presentat ons and workshops that may conta n faces.

- Any frames conta n ng dent f ab e faces of part c pants who have not g ven nformed consent w be b urred.

- Any frames conta n ng dent f ab e faces of other recorded peop e (e.g. bystanders) w be b urred.

- Aud o data w be rev ewed to f nd dent f ab e data, such as names of part c pants, fr ends, fam y and names of workp ace or ocat ons frequent y v s ted and so on. Th s data w be anonym sed (e.g. aud b e redact on).

- Both aud o and v deo data w be encrypted and stored n a fo der protected by a password on an externa hard dr ve and w be managed by the ma n researcher. The researcher w keep the dr ve n a ocked cab net at C ty, Un vers ty. V deo/aud o records w be kept on the externa hard dr ve dur ng the study and stored on the secure F gshare repos tory after the study. F gshare's "Pr vate Space" fac ty w be used to ensure a v deo s kept secure and w a so prov de a serv ce to manage v deo data segments (w th the appropr ate perm ss ons) for conferences, workshops and n pub cat ons

A these po nts w be covered n the Part c pant Informat on Sheet and Informed Consent and we w g ve these two documents to the part c pants n advance to make sure they have t me to read t, ask quest ons and understand the study.

The procedure we have adopted s based on a precedent set at K ng's Co ege London and spec f ca y an eth cs app cat on made by a PhD student and approved n May 2019 (Prof Jon H ndmarsh at K ng's Bus ness Schoo s the student's superv sor). The PhD researcher has proposed a s m ar study, us ng nteract on ana ys s on co ected v deo data. L ke us, th s research re es on nonverba commun cat on (.e. fac a express ons and gaze d rect on) and thus dent f ab e nformat on (e.g. faces) w be reta ned n the v deo data. Moreover, t s recogn sed, anonym zat on by b urr ng

faces n the v deo wou d m t the capac ty to commun cate resu ts to the sc ent f c and academ c commun ty. We have shared further nformat on about the approved eth cs app cat on from K ng's w th Jason Dykes.

P6) Project start date
04 Jun 2019

P7) Anticipated project end date
30 Sept 2022

P8) Where will the research take place?
The meet ngs before and after the journey w take p ace n C ty Un vers ty or part c pants home. The researcher w ask the part c pants wh ch p ace they wou d rather meet. If the p ace w be the part c pant's home, an estab shed check- n check-out procedure w be used to ensure the researcher s safety. In part cu ar we w fo ow the codes of pract ce estab shed by the Soc a Research Assoc at on. In pract ce, the researcher w be aware n advance of the part c pant's home address, she w p an the route n advance and she w use on y pub c transport to reach the part c pant's home. Add t ona y, she w a ways take a map and a phone dur ng the meet ng to ensure safe routes and to be ab e to contact other researchers or emergency numbers at any t me. The ma n researcher has the respons b ty to ma nta n contact w th the other researchers. She w nform them about each appo ntment, address deta s and the t me of arr va and departure n advance and she w keep them up-to-date dur ng the meet ng.

The ma n researcher nvo ved n the study has the D sc osure and Barr ng (DBS) enhanced check obta ned on the 31st of January 2019 (cert f cate number: 001646045894). App cat on has been made through the B ndA d char ty. Our protoco s n ne w th codes of pract ce reported above, for further deta s, see the fo ow ng nk: http://the-sra.org.uk/sra resources/safety-code/

The journey sess on w take p ace n London and when and where about w be a cho ce by part c pants. The researcher w not be present dur ng th s journey but part c pants w be adv sed to ensure that they are safe dur ng the journey.

P10) Is this application or any part of this research project being submitted to another ethics committee, or has it previously been submitted to an ethics committee?
No

Human participants: information and participation

The options for the following question are one or more of:
'Under 18'; 'Adults at risk'; 'Individuals aged 16 and over potentially without the capacity to consent'; 'None of the above'.

H1) Will persons from any of the following groups be participating in the project?
Adu ts at r sk

H2) How many participants will be recruited?
16

H3) Explain how the sample size has been determined.

Our research s a qua tat ve study and t s focused on soc a nteract on deta s rather than the var ety of the nteract on n nav gat ng phys ca env ronment. Thus, we th nk that e ght pa rs can ensure to w de y cover nterpersona nteract ons that occur natura y.

H4) What is the age group of the participants?

Lower Upper

18

H5) Please specify inclusion and exclusion criteria.

Part c pants w s gn up to the study on y as a pa r. Both peop e w need to:

- ve n London,
- speak Eng sh,
- adu ts over 18 years o d,

must be ab e to g ve consent.

Interested pa rs need to meet these nc us on cr ter a:

- The pa r must be composed by a s ghted person and a person reg stered severe y s ght mpa red (prev ous y "b nd") or s ght mpa red (prev ous y "part a y s ghted").
- Have an estab shed gu d ng re at onsh p for at east 3 months.

We exc ude part c pants who have:

- any cogn t ve mpa rments wh ch w mean that they cannot g ve nformed consent.
- Mob ty mpa rment, because the k nd of gu de exper ence can great y change cons der ng th s cond t on and for th s reason t s not appropr ate for our scenar o.

H6) What are the potential risks and burdens for research participants and how will you minimise them?

Adu ts a r sk

Even though v sua mpa red peop e are cons dered adu ts at r sk, th s research study does not ant c pate cons derab e r sks and burdens. Thanks to the s ghted gu de techn que we are us ng and the stab e re at onsh p we are ook ng for, the study w take p ace n a safe cond t on. Indeed the scope of the gu de techn que s to support v sua mpa red peop e dur ng nav gat on and th s support g ves them more ndependence. Moreover the r stab e re at onsh p guarantees trust and a sense of comfort. Add t ona y, our procedure nvo ves do ng a journey n a natura sett ng, so they w be occup ed w th a task they usua y do n the r da y rout ne.

We a so w m n m se the r sk of hav ng to trave to C ty, when they usua y wou d not, by offer ng to go to the r home.

V deo and aud o capture cou d conta n faces

We be eve that our research w generate a un que and va uab e data set that w be mportant to the research commun ty. To ach eve th s sc ent f c va ue we be eve t s cr t ca to conduct an nteract on ana ys s where the study and ana ys s of part c pants nteract on, nc ud ng verba express ons, gestures, face express ons and gaze, are ntegra to the research. For th s reason, the comp ete de- dent f cat on of part c pants faces n v deo data w m t the ab ty of the researchers to ana yse data and commun cate f nd ngs of our research study at conferences, workshops and n pub cat ons.

S nce there may be a need to show faces of some v deo segments, we w nform part c pants upfront through the part c pant nformat on sheet and we w ask for the r agreement n the nformed consent (see attached documents). Any frame conta n ng dent f ab e faces of externa peop e or part c pants who have not g ven nformed consent w be b urred when shown at conferences, workshops and n pub cat ons nstead (n support of our dec s on we prov de an examp e n P5).

Add t ona y, after nformed consent the recru ted pa r w rece ve a pseudonym and th s name w be used throughout the study to refer to the part c pant.

The mapp ng between any pseudonyms and rea dent t es w be stored n a password-protected and encrypted f e.

Any d rect reference to part c pants name w be rep aced w th the r pseudonym. Any hard or d g ta data w be kept protected us ng the pseudonym and on y the nformed consent w have part c pants name.

Aud o data w be rev ewed to f nd dent f ab e data, such as names of fr ends, fam y and names of workp ace or ocat ons frequent y v s ted and so on. Th s data w be anonym sed.

R sk of data eak ng

In conduct ng the study

A cr t ca stage of potent a data eak ng dur ng the study s the journey sess on. To record these sess ons, we w eave body cameras to the part c pants for three days. There s a r sk the cameras may be sto en dur ng th s per od and dent f ab e nformat on may be seen by strangers and unauthor zed peop e. To m n m se th s r sk we dec de to use two body cameras wh ch prov de a data protect on system wh e part c pants are record ng. Spec f ca y th s k nd of camera uses the AES256 encrypt on protoco . Th s protoco ensures that v deo records cannot be accessed by unauthor zed peop e because they are encrypted. An examp e s the Revea D-ser es camera a so used by UK po ce (https://www.revea med a.co.uk/products/d-ser es). Add t ona y to m t gate the poss b ty of cameras oss the ma n researcher w nform part c pants, they can put on-off cameras on y n pr vate and safe p aces (.e. home), but they can sw tch them on-off wherever they ke and at any t me. We w a so abe our cameras w th st ckers, nd cat ng they are be ng used for research purposes and for them to be returned to the HCID Centre at C ty Un vers ty f found.

Dur ng and after ana ys s

Dur ng the ana ys s a d g ta data w be stored n a encrypted and password-protected fo der n a externa hard dr ve of the ma n researcher. The externa hard dr ve w be kept n a ocked cab net at C ty, Un vers ty. After the ana ys s and pub cat on of the resu ts, re evant v deo data segments conta n ng part c pants faces, who have g ven nformed consent, cou d be shared and showed at conferences, workshops and n pub cat ons. To m n m se the r sk of v deos eak ng and unauthor zed access to them we dec de to pub sh our v deo records on F gshare repos tory. Th s repos tory s offered by C ty, Un vers ty as a space to pub sh and share research resu ts. It s hosted by Amazon Web Serv ce and has the h ghest eve of secur ty for research data https://know edge.f gshare.com/art c es/ tem/how- s-my-data-stored- s- t-secure. Moreover, through a perm ss on sett ng we w def ne wh ch v deo f es cou d be seen by peop e who w have access to our conference presentat ons, workshops and pub cat ons.

A data n the repos tory w be kept for 10 years, fo ow ng Un vers ty's gu de nes on retent on.

H7) Will you specifically recruit pregnant women, women in labour, or women who have had a recent stillbirth or miscarriage (within the last 12 months)?
No

H8) Will you directly recruit any staff and/or students at City?
None of the above

H8.1) If you intend to contact staff/students directly for recruitment purpose, please upload a letter of approval from the respective School(s)/Department(s).

H9) How are participants to be identified, approached and recruited, and by whom?
Pa rs of part c pants w be recru ted through adverts v a Tw tter, ema s to ex st ng contacts of the student and superv sors, hand ng out f yers.

An access b e advert sement w be made to recru t our part c pants. The advert sement w be sent by ema through the char ty n d fferent formats and su tab e for screen reader. The same advert sement w be a so sent to ex st ng contacts of the student and superv sors, and posted on Tw tter. D fferent formats are essent a because we are target ng both s ghted and v sua y mpa red peop e.

A f yer targeted at s ghted gu des w be created and handed out by the ma n researcher.

Peop e who are nterested n the study w be ab e to contact Beatr ce V ncenz v a ema , text, phone or soc a med a for ask ng nformat on and c ar f cat on. The researcher w exp a n them the deta s of the study and determ ne f the pa r f ts the nc us on cr ter a us ng a check st sheet.

H10) Please upload your participant information sheets and consent form, or if they are online (e.g. on Qualtrics) paste the link below.
H11) If appropriate, please upload a copy of the advertisement, including recruitment emails, flyers or letter.
H12) Describe the procedure that will be used when seeking and obtaining consent, including when consent will be obtained.
Once a pa r meets the cr ter a for part c pat ng and both peop e are st nterested, the pr nc pa researcher w send them the part c pant nformat on sheet and the consent form, before arrang ng a date, t me and ocat on for the f rst meet ng. I w set up a per od of 5 work ng days between the rece v ng documents and the meet ng. Th s per od w g ve the part c pants enough t me to read and rev ew the documents. The part c pant nformat on sheet and consent form w made access b e (e.g. we w set up access b ty features for screen reader) and be sent e ectron ca y. Part c pants can contact the researcher at any t me, and ask quest ons.

The f rst meet ng w ast around one hour and the ma n researcher w spend t me ta k ng about the research and study p ans n deta . The researcher w read a oud a summary of the research and she w be ava ab e to d scuss any unc ear sect on. Part c pants w be nv ted to ask quest ons at any t me and the researcher w answer them accord ng y. Once both part c pants have we understood the study, the researcher w rev ew the consent form. As before she w read a oud the consent form to both part c pants and answer to the r quest ons to be sure they have understood the document. Part c pants can dec ne to s gn the consent form at any t me. If one person of the pa r dec des to do not take part n the study, both part c pants w be automat ca y exc uded and the r

contact nformat on w be permanent y de eted. However f the part c pants pa r chooses to cont nue n the study, they w be asked to s gn the consent form. V sua y mpa red part c pants have the poss b ty to s gn the nformed consent us ng a stamp or a s gnature gu de, these are the standard procedure used to s gn documents by v sua mpa rment peop e (https://www.v s onaware.org/ nfo/everyday- v ng/essent a -sk s/read ng-wr t ng-and-v s on-oss/s gn ng-your-name-and-handwr t ng/1235).

If they are not ab e to s gn the nformed consent due to the r v sua mpa rment cond t on, the researcher w get and record verba consent. If the part c pant dec des to g ve ora consent, the researcher w read a oud each consent form statement and w wa t for the part c pant conf rmat on. The ora consent form sess on w be aud o recorded and s gned by the researcher. Fo ow ng the standard procedure nstead the researcher and the part c pant w s gn the consent form, she w keep a copy and g ve back the other to each part c pant.

H13) Are there any pressures that may make it difficult for participants to refuse to take part in the project?
No

H14) Is any part of the research being conducted with participants outside the UK?
No

Human participants: method

The options for the following question are one or more of:
'Invasive procedures (for example medical or surgical)'; 'Intrusive procedures (for example psychological or social)'; 'Potentially harmful procedures of any kind'; 'Drugs, placebos, or other substances administered to participants'; 'None of the above'.

M1) Will any of the following methods be involved in the project:
None of the above

M2) Does the project involve any deceptive research practices?
No

M3) Is there a possibility for over-research of participants?
No

M4) Please upload copies of any questionnaires, topic guides for interviews or focus groups, or equivalent research materials.
M5) Will participants be provided with the findings or outcomes of the project?
Yes

M5.1) Explain how this information will be provided.
The researcher w not prov de the f nd ngs or outcomes of the project to the part c pants d rect y, but she w nform them through the part c pant nformat on sheet that part c pants can request a copy of

the resu t to the researcher by ema . In th s case, a f nd ngs summary w be sent to the part c pant n an access b e format.

M6) If the research is intended to benefit the participants, third parties or the local community, please give details.

M7) Are you offering any incentives for participating?
Yes

M7.1) Please give details, justifying their type and amount.
As a compensat on for part c pants nvo vement, they w rece ve a Amazon voucher of £25 at the end of the nterv ew. We dec ded to cho ce vouchers because we do not know n advance where the nterv ew w be conducted and f part c pants w have some expenses dur ng the r journey(s). For these reasons we th nk that refreshment and trave refund are not appropr ate n such context, wh e vouchers are eas y carr ed on everywhere and can ensure an equa compensat on.

M8) Does the research involve clinical trial/intervention testing that does not require Health Research Authority or MHRA approval?
No

M9) Will the project involve the collection of human tissue or other biological samples that does not fall under the Human Tissue Act (2004) that does not require Health Research Authority Research Ethics Service approval?
No

M10) Will the project involve potentially sensitive topics, such as participants' sexual behaviour, their legal or political behaviour, their experience of violence?
No

M11) Will the project involve activities that may lead to 'labelling' either by the researcher (e.g. categorisation) or by the participant (e.g. 'I'm stupid', 'I'm not normal')?
Yes

Human participants: vulnerable

V1) Please provide details of enhanced ethical procedures to safeguard these participants.
We are recru t ng peop e who are ndependent and capab e n the r da y fe. Part c pants who are v sua mpa red:

- are a ready us ng ass st ve techno ogy, such as screen readers, app cat ons and too s to nav gate n the env ronment, for nstance wh te cane, gu de dog or a s ghted gu de.

- They have an act ve fe and th s research ntends a so to show that v sua mpa red peop e are ab e to nav gate successfu y.

As a ready argued the s ghted gu de techn que and the estab shed re at onsh p we are ook ng for ensure ndependence and ‘natura ’ behav our as safe y as poss b e to th s group of peop e. Moreover the researcher w h gh ght to the part c pants n any occas on and through part c pant nformat on

sheet to not take any unfam ar, unsafe path that can put you and your compan on n a dangerous s tuat on. Moreover she w prov de examp e of common journeys and w be ava ab e to d scuss potent a journeys that part c pants have thought.

F na y we a so safeguard these part c pants offer ng to go to the r home for the n t a and nterv ew meet ngs. We wou d ke to under ne that dur ng home v s ts both part c pants w a ways be present. Thanks to the s ghted gu de presence we m t gate the ow r sk of researchers tak ng advantage of the v sua y mpa red part c pants when n the r home.

V2) Please give details of the vulnerable participant protection procedures you propose to adopt should there be any evidence or suspicion of harm (physical, emotional or sexual) to a vulnerable person. Include a referral protocol identifying what to do and who should be contacted.

Dur ng the nterv ew we w co ect nformat on about the journey and the s ghted gu de exper ence. Thus there shou d be any ev dence or susp c on of harm to a vu nerab e person. However the ma n researcher dur ng the nterv ew w nform part c pants to contact the appropr ate resource or seek adv ce from RNIB. In such occas on I w prov de contact numbers and web s te addresses.

V3) Please give details of how you propose to ensure the well-being of the vulnerable participant, particularly with respect to ensuring that they do not feel pressured to take part in the research and that they are free to withdraw from the research without any prejudice to themselves at any time.

The ma n researcher w nform part c pants that part c pat on s vo untary and they can w thdraw from the study at any t me. She w wr te t on the part c pant nformat on sheet, she w repeat t verba y dur ng each meet ng and she w asked to part c pants to conf rm th s statement n the consent form. The target popu at on may nc ude vu nerab e peop e, but t s our ntent on to recru t on y peop e who are ab e to g ve consent.

V4) Will carers, parents, teachers or other parties be present during the research?

Yes

V4.1) Outline how the confidentiality of the participants will be upheld.

Part c pant conf dent a ty w be asked through a statement n the nformed consent (see statement 9 n " nformed consent" f e)

V5) Are participants able to give informed consent?

Yes

V6) Please give details of any City staff or students who will have contact with adults at risk and/or will have contact with young people (under the age of 18) and the details of current (within the last 3 years) Disclosure and Barring check.

Name

Beatr ce V ncenz

DBS reference number

001646045894

Date of DBS
31 Jan 2019

Type of Disclosure
D sc osure and Barr ng (DBS) enhanced d sc osure check

V7) Please give details of any non-City staff or students who will have contact with adults at risk and/or will have contact with young people (under the age of 18) and the details of current (within the last 3 years) Disclosure and Barring check.

Name

Institution

Address of organisation that requested disclosure

DBS reference number

Date of DBS

Type of disclosure

I w not be recru t ng any part c pants who fa under the Menta Capac ty Act 2005.

Data

D1) Indicate which of the following you will be using to collect your data.
Quest onna re
Interv ews
Aud o/d g ta record ng nterv ewees or events
V deo record ng

D2) How will the the privacy of the participants be protected?
De- dent f ed samp es or data

D3) Will the research involve use of direct quotes?
Yes

D5) Where/how do you intend to store your data?
Data to be kept n a ocked f ng cab net
Data and dent f ers to be kept n separate, ocked f ng cab nets
Password protected computer f es
Storage on encrypted dev ce (e.g. aptop, hard dr ve, USB
Storage at other s te

D5.1) If stored at another site, please provide details.
After the study v deo data w be transferred to F gshare repos tory

D6) Will personal data collected be shared with other organisations?
No

D7) Will the data be accessed by people other than the named researcher, supervisors or examiners?
Yes

D7.1) Explain by whom and for what purposes.
On y v deo data may be used n pub cat ons and presentat ons dur ng academ c events and conferences. In such case researchers w ensure that data w be de- dent f ed accord ng y w th the preference expressed by the part c pants and v deo data w be shown on y f part c pants have g ven consent. Researchers w nform part c pants who can v ew v deo data w thout b urr ng faces. Any frames conta n ng dent f ab e faces of peop e who have not g ven nformed consent w be b urred.

D8) Is the data intended or required (e.g. by funding body) to be published for reuse or to be shared as part of longitudinal research or a different/wider research project now or in the future?
No

D10) How long are you intending to keep the research data generated by the study?
Fo ow ng Un vers ty's gu de nes on retent on, data generated by the study w be reta ned for ten years.

D11) How long will personal data be stored or accessed after the study has ended?
AS above, we w stored persona data for ten years.

D12) How are you intending to destroy the personal data after this period?
A d g ta data w be permanent y de eted and paper data w be shredded and d sposed of.

Health & safety

HS1) Are there any health and safety risks to the researchers over and above that of their normal working life?
Yes

HS2) How have you addressed the health and safety concerns of the researchers and any other people impacted by this project?
The ma n researcher cou d meet part c pants n the r home. In such case an estab shed check- n check-out protoco w be used to ensure the researcher s safety. In part cu ar we w take nto account the Soc a Research Assoc at on codes of pract ce for researcher's safety at the fo ow ng nk: http://the-sra.org.uk/sra resources/safety-code/ (see P8 for deta s).

HS3) Are there hazards associated with undertaking this project where a formal risk assessment would be required?
No

Attached files

Part c pant Informat on sheet.pdf

Informed consent.pdf

advert sement.pdf

f yer.pdf

demograph c nformat on quest onna re.pdf

nc us on exc us on cr ter a.pdf

nformat ve card.pdf

Interv ew Gu de.pdf

A.2 ADVERTISEMENT

Department of Computer Science
City, University of London

What is our research study about?

Pairs of participants needed for research in exploring interpersonal interaction in the sighted guide experience.

We will record your guiding experiences on one or more journeys over 3 days and interview you about them.

Who are we looking for?

We are looking for an adult pair (over 18) living in London.

Your pair should be composed of a sighted guide and a sight impaired person with an established relationship through guiding of at least 3 months.

You should not have any mobility or cognitive impairment.

What would your participation involve?

An initial meeting of 1 hour for collecting demographic info and giving instructions on how to use cameras for recording your journeys.

After that, you will recording at least one journey of at least 20 minutes when you are using sighted guiding.

Finally, we will interview you both for about 30 minutes to collect some info about the journey and your relationship.

What do I receive?

In appreciation for your time, your pair will receive two Amazon vouchers of £25.

Who should I contact for further information or to volunteer?

Please contact: Beatrice Vincenzi.

Email: beatrice.vincenzi@city.ac.uk

Mobile: 07955 367 578,

Twitter: @Beatrice_vince

Supervisors.

PhD Simone Stumpf

simone.stumpf.1@city.ac.uk

PhD Alex Taylor

alex.taylor@city.ac.uk

This study has been reviewed by, and received ethics clearance through the Computer Science Department City, University of London.

If you would like to complain about any aspect of the study, please contact the Secretary to the Senate Research Ethics Committee on 020 7040 3040 or via email: Anna.Ramberg.1@city.ac.uk.

City, University of London is the data controller for the personal data collected for this research project. If you have any data protection concerns about this research project, please contact City's Information Compliance Team at dataprotection@city.ac.uk

A.3 RECRUITMENT FLYER

RESEARCH IN EXPLORING INTERPESONAL INTERACTION IN THE SIGHTED GUIDE EXPERIENCE

Are you part of an established relationship composed of a sighted guide and sight impaired person? We would love to hear from you!

We will record your guiding experiences on one or more journeys over 3 days and interview you about them

---

We are looking for an adult pair (over 18) living in London:

- composed of a sighted guide and a sight impaired person with an ESTABLISHED RELATIONSHIP through guiding of at least 3 months.
- You should not have any mobility or cognitive impairment

Your participation will involve:

- **Initial meeting**: attend 1 h session to collect demographic info and give instructions on how to use cameras for recording your journeys
- **Video-recorded journey**: record at least one journey of at least 20 mins using sighted guiding.
- **Pair interview:** attend for about 30 mins for talking about the journey and your relationship

Download accessible PDF version at:

In appreciation for your time, your pair will receive **2 Amazon vouchers** of **£25**

For further info or to volunteer:
Researcher: **Beatrice Vincenzi** beatrice.vincenzi@city.ac.uk mobile: 07955 367 578
Twitter: @Beatrice vince
Supervisors: Simone Stumpf simone.stumpf.1@city.ac.uk, Alex Taylor alex.taylor@city.ac.uk
Department of Computer Science City, University of London

A.4 INCLUSION EXCLUSION CRITERIA CHECKLIST

INCLUSION AND EXCLUSION CRITERIA CHECKLIST

(Internal document)

Thank you for your interest in this study!

- What is your age?
- Do you speak English fluently?
  Yes No
- Do you live in London?
  Yes No
- Have you contacted me as a pair of participants?
  Yes No

Depending on the person:

- Are you a person registered severely sight impaired or sight impaired?
  Yes No
- Are you a sighted guide?
  Yes No
- How long have you been a guide of … ?
  Yes No

Thinking about the relationship with your companion:

- Do you usually go around using a sighted guide technique?
  Yes No
- Do you feel comfortable going around with your companion using the sighted guide technique?
  Yes No

Mobility impairment check:

- Do you have a mobility impairment?
- How long can you travel using white cane, guide dog or sighted guide (at least 20 mins)?

Cognitive abilities check:

- DO you have any cognitive impairment?
  Yes No
- What is your preferred contact method:
  Mail Phone Text Social Media

  Contact details:

A.5 PARTICIPANT INFORMATION SHEET

REC reference number:

ETH1819-1113

Date:

24/04/2019

Title of study

Exploring interpersonal interaction in the sighted guide experience.

Research Team

Principal researcher: Beatrice Vincenzi.
Supervisors: PhD Simone Stumpf and PhD Alex Taylor.

Participant information sheet introduction

We would like to you to take part in a research study. Before you decide whether you would like to take part it is important that you understand why the research is being done and what it would involve for you. Please take the time to read the following information carefully and discuss it with others if you wish. Feel free to ask if there is anything that is not clear or if you would like more information.

What is the purpose of the study?

The purpose of the study is to understand the interpersonal interactions that constitute the experience between a sighted guide and a person with a visual impairment. This is an observational study and we are interested in studying the sighted guide experience and exploring the potential for technology to enhance the mutual interpersonal interactions between those who are visually impaired and their sighted guides.

Why have I been invited to take part?

You have been invited to participate in this study because you expressed interest in participating and because you are an adult living in London. Additionally, you are part of a pair of people composed of a sighted person and a person registered severely sight impaired or sight impaired. To participate in the study your pair needs to have an established relationship in the standard guide configuration. A maximum of 7 other pairs like you and your companion will be involved in the study.

Do I have to take part?

The participation in the study is voluntary and you can decide if you want to take part. Both your companion and you need to agree. It means that if either of you decides to not take part in the study, you will both be automatically excluded and your contact information will be permanently deleted. You have the right to withdraw at any time without giving a reason. You will not be penalized in any way for not taking part. If your pair choose to continue in the study, you will be asked to sign a consent form.

What will happen if I take part? What do I have to do?

If your pair chooses to take part in the study, you will be asked to meet with the researcher for one hour to gather your background details and show you how to use body cameras which you will wear during a sighted guiding journey. We will then leave the video equipment with you for 3 days.

Over the next 3 days, you will be asked to do a journey together. During this period your companion and you can record one or more journeys you usually do in your daily lives using the standard guide technique, for example "go grocery shopping, go to a museum, go to the GP appointment, go to a coffee for meeting friends etc". The journey should last at least 20 minutes.

After the 3 days, the researcher will meet you again to get the cameras back. The interview will be conducted with both you and your companion present and it will last 30 minutes. During the interview you will be asked some contextual information about the journey you have taken. In particular you will be asked to talk about your journey's choice, your experience as sighted guide or guidee and the journey experience itself.

What are the possible disadvantages and risks of taking part?

This study is completely confidential, and we have identified no reasonably foreseeable risks of harm, safety, or side effects to you as a result of taking part in this study. Additionally, we strongly recommend not taking any unfamiliar, unsafe path that can put you and your companion in a dangerous situation.

What are the possible benefits of taking part?

There are no direct benefits for taking part in the study. However, your participation in this research is greatly appreciated. For your involvement, you will receive an Amazon voucher of £25 at the end of the interview session.

What should I do if I want to take part?

If you would like to continue in the study, you should contact the main researcher Beatrice Vincenzi, contact details are reported at the end of the document. She will arrange with your pair the first meeting. During this meeting you will have the opportunity to ask any question about the study, revise the consent form and sign it up. After that she will collect some demographic information and explain to you how to use our cameras and what is the setting to use during your journeys. The cameras will be left for the next three days.

Data privacy statement

City, University of London is the sponsor and the data controller of this study based in the United Kingdom. This means that we are responsible for looking after your information and using it properly. The legal basis under which your data will be processed is City's public task. Your right to access, change or move your information are limited, as we need to manage your information in a specific way in order for the research to be reliable and accurate. To safeguard your rights, we will use the minimum personal-identifiable information possible (for further information please see guide to data protection).

City will use your name and contact details to contact you about the research study as necessary. If you wish to receive the results of the study, your contact details will also be kept for this purpose. The only people at City who will have access to your identifiable information will be *Beatrice Vincenzi*. City will keep identifiable information about you from this study for 10 years after the study has finished.

You can find out more about how City handles data by visiting City legal information. If you are concerned about how we have processed your personal data, you can contact the Information Commissioner's Office (IOC) IOC website.

Will my taking part in the study be kept confidential?

Your participation will be kept confidential and we will take some precautions to guarantee your anonymity:

- At the first meeting you receive a pseudonym which will be used throughout the study, rather than your personal name.
- Body cameras are encrypted. Unauthorized people do not have access to video records.
- Audio records will be transcribed in full and completely anonymized.
- Extracts of video records may be shown in academic conferences and in publications. We will always use your pseudonym rather than your personal name. Video records may contain your face and you have the option to have your face blurred in any of the extracts that we publish or show at conferences.
- Since video records may contain faces, they will be stored using a private and secure online repository called Figshare (managed by City University of London). Video will be stored here after the study.
- All other digital data and the mapping sheet between pseudonyms and real names will be stored on an encrypted folder protected by a password. Only the principal investigator Beatrice Vincenzi will know that password.
- All signed consent forms will be kept in a sealed envelope and stored in a locked cabinet.

What will happen to the results?

After the study the results will be reported in a written documentation as part of the PhD Thesis of Beatrice Vincenzi. Results could also be published in some academic journals or conferences. In both case we will not include your personal details. Videos might be viewed in academic events or conferences if you have agreed in the informed consent. If you desire

to have a copy of the result, please send a request by email to the researcher Beatrice Vincenzi.

What will happen when the research study stops?

All data will be kept in using secure storage for up to ten years. After the study digital data (except select video data) will be transferred to an external hard disk protected by a password and hard data will be kept in a locked cabinet.
Thanks to your participation in this research, we believe that some of the video data generated from this research will be of great value to the scientific research community. For this reason, some selected video clips will be stored securely and privately on the Figshare repository at City University of London. This video will be retained it until is no longer of any research value.

Who has reviewed the study?

This study has been approved by City, University of London's Computer Science Research Ethics Committee.

What if there is a problem?

If you have any problems, concerns or questions about this study, you should ask to speak to a member of the research team. If you remain unhappy and wish to complain formally, you can do this through City's complaints procedure. To complain about the study, you need to phone 020 7040 3040. You can then ask to speak to the Secretary to Senate Research Ethics Committee and inform them that the name of the project is: *Exploring the social interaction in the sighted guide experience*, conducted by Beatrice Vincenzi.

You can also write to the Secretary at:
Anna Ramberg
Research Integrity Manager
City, University of London, Northampton Square
London, EC1V 0HB
Email: Anna.Ramberg.1@city.ac.uk

Insurance

City holds insurance policies which apply to this study. If you feel you have been harmed or injured by taking part in this study you may be eligible to claim compensation. This does not affect your legal rights to seek compensation. If you are harmed due to someone's negligence, then you may have grounds for legal action.

Further information and contact details

Researcher: Beatrice Vincenzi, PhD student, beatrice.vincenzi@city.ac.uk.
Mobile: 07955 367 578.
Supervisors: PhD Simone Stumpf, simone.stumpf.1@city.ac.uk.
PhD Alex Taylor, alex.taylor@city.ac.uk.

Thank you for taking the time to read this information sheet.

A.6 INFORMED CONSENT

REC reference number
ETH1819-1113

Title of study
Exploring interpersonal interaction in the sighted guide experience.

Researcher
Beatrice Vincenzi

Informed consent instructions
For participating in the study I ask you to read and tick the following 13 statements, then sign this consent form at the end of the document. Statements from 7 to 10 have a choice between two options.

Statement number 1
I confirm that I have read and understood the participant information sheet dated 24/04/2019 for the above study. I have had the opportunity to consider the information and ask questions which have been answered satisfactorily.

Statement number 2
I understand that my participation is voluntary and that I am free to withdraw without giving a reason without being penalised or disadvantaged.

Statement number 3
I agree to the journey session being video recorded and the interview being audio recorded.

Statement number 4
I understand that a pseudonym will be assigned to me and audio data will be de identified.

Specifically, during the study conduction:

Statement number 5

I agree that videos containing my face can be viewed by the main researcher and supervisors. All other identifiable video data will be blurred.

Statement number 6

I understand that hard data will be kept in a locked cabinet and digital data in an encrypted folder protected by a password.

Additionally, after the study conduction:

Statement number 7

I agree for my video clips to be presented at research events, conferences and in published academic articles.

Yes, I agree statement number 7.

No, I do not agree statement number 7.

Statement number 8

I agree to use direct quotes from audio data in any publications.

Yes, I agree statement number 8.

No, I do not agree statement number 8.

Statement number 9

I understand that my video clips may be shown at conferences and publications. In such cases do I consent the video records to include full or partial views of my face and other information that could be used to identify me?

Yes, I give consent to use video records in which my face is visible.

Yes, I agree to be in these video clips to be shown at conferences and in publications but I would like my face to be blurred.

Statement number 10

I understand that only video records will be transferred to a safe and private online repository called Figshare, managed by the researcher at City University of London.

Yes, I agree statement number 10.

No, I do not agree statement number 10.

Overall:

Statement number 11

I agree to maintain confidentiality of the paired study. The gathered information will be held by Beatrice Vincenzi and processed for her PhD project as well as future research publication.

Statement number 12

I agree to City recording and processing this information about me. I understand that this information will be used only for the purpose(s) explained in the participant information and my consent is conditional on City complying with its duties and obligations under the General Data Protection Regulation (GDPR).

Statement number 13

I agree to take part in the above study, titled: Exploring interpersonal interaction in the sighted guide experience.

Date, Name and signature form

Date

Participant Name:

Signature space

Researcher Name:

Signature space

A.7 DEMOGRAPHIC INFORMATION QUESTIONNAIRE

Questions for demographic information

Date:

Questions addressed to pair of participants

#	Question	Pseudonym:	Pseudonym:
1	What is your age?		
2	I identify my gender as ….		
3	How long have you known each other?		
4	How long has your companion been your guide/guidee?		
5	Are you registered severely sight impaired or sight impaired?	[ ] Yes [ ] No	[ ] Yes [ ] No

Questions addressed to visually impaired person

6. How long have you been visual impaired?

7. How is your actual vision?
   - [ ] central vision only
   - [ ] peripheral vision only
   - [ ] completely blurry
   - [ ] no colors
   - [ ] only brightness
   - [ ] no vision at all
   - [ ] other (specify):

8. Do you use any assistive technology? [ ] Yes [ ] No

9. Do you use AT for navigating? [ ] Yes [ ] No

   Which one?
   - [ ] Long cane
   - [ ] short cane
   - [ ] guide dog
   - [ ] sighted guide
   - [ ] other (specify)

10. Do you use AT technology for reading? [ ] Yes [ ] No
    Which one? [ ] magnifier for reading
    [ ] screen reader
    [ ] app
    [ ] braille display
    [ ] other (specify):

11. Do you use AT technology for writing? [ ] Yes [ ] No
    Which one? [ ] voice synthesizer/voice over
    [ ] braille slate
    [ ] Braille computer
    [ ] other (specify):

12. Do you use any other AT?
13. What do you usually do with that?

A.8 INTERACTION ANALYSIS: SYMBOLS LEGEND

= Latching, no interval between the end of a prior and start of the next piece of talk.

- A single dash indicates a cut off either because of an interruption or self-repair.

// Overlapping, the double oblique indicates the point at which a current speaker's talk is overlapped by the talk of another.

∗text∗ Text between asterisks indicates what has been said by another speaker during overlapping.

: Colon(s) indicate that the prior syllable is prolonged. Multiple colons (e.g., :::) indicate a more prolonged syllable.

↑ An upward arrow indicates a marked rise in pitch.

↓ A downward arrow indicates a marked lowering of pitch.

[] Squared brackets are used to describe what is happening visually, such as movements, speed, gesture and so on.

( ) Single pairs of parentheses indicate that words are unclear or inaudible in the clip.

(( )) For vocalisations which are not easy to spell out such as ((cough)), ((snort)), and ((sniff)).

<u>text</u> Underlined text indicates a different voice tone.

→ Points to the location of the phenomenon being discussed.

0.5 Indicates time in seconds between two 2 turns talking.

B APPROACHING A DESIGN SPACE AT THE INTERSECTION OF AI AND INTERDEPENDENCE (STUDY 2)

B.1 ETHICS APPLICATION

Ethics ETH1920-0858: Beatrice Vincenzi (Medium risk)

Date	22 Jan 2020
Researcher	Beatrice Vincenzi
Project	Exploring interpersonal interaction in the sighted guide experience
School	School of Mathematics Computer Science & Engineering
Department	Computer Science

Ethics application

Risks

R1) Does the project have funding?
No

R2) Does the project involve human participants?
Yes

R3) Will the researcher be located outside of the UK during the conduct of the research?
No

R4) Will any part of the project be carried out under the auspices of an external organisation, involve collaboration between institutions, or involve data collection at an external organisation?
No

R5) Does your project involve access to, or use of, material that could be classified as security sensitive?
No

R6) Does the project involve the use of live animals?
No

R7) Does the project involve the use of animal tissue?
No

R8) Does the project involve accessing obscene materials?
No

R9) Does the project involve access to confidential business data (e.g. commercially sensitive data, trade secrets, minutes of internal meetings)?
No

R10) Does the project involve access to personal data (e.g. personnel or student records) not in the public domain?
No

R11) Does the project involve deviation from standard or routine clinical practice, outside of current guidelines?
No

R12) Will the project involve the potential for adverse impact on employment, social or financial standing?
No

R13) Will the project involve the potential for psychological distress, anxiety, humiliation or pain greater than that of normal life for the participant?
No

R15) Will the project involve research into illegal or criminal activity where there is a risk that the researcher will be placed in physical danger or in legal jeopardy?
No

R16) Will the project specifically recruit individuals who may be involved in illegal or criminal activity?
No

R17) Will the project involve engaging individuals who may be involved in terrorism, radicalisation, extremism or violent activity and other activity that falls within the Counter-Terrorism and Security Act (2015)?
No

Applicant & research team

T1) Principal Applicant

Name
Beatr ce V ncenz

Provide a summary of the researcher's training and experience that is relevant to this research project.
Beatr ce s a second-year PhD student and th s study s re ated to her project. She has a ready p anned and conducted a study dur ng the f rst year t t ed "Exp or ng nterpersona nteract ons n the s ghted gu de exper ence" where she worked c ose y w th v sua y mpa red peop e. She s a so vo unteer ng to B ndA d char ty for he p ng and ass st ng peop e w th v sua mpa rment. She s act ve y nvo ved n

events to offer company and conversat on to v sua y mpa red peop e and she s tra ned to be a gu de us ng the s ghted gu de techn que.

T2) Co-Applicant(s) at City

T3) External Co-Applicant(s)

T4) Supervisor(s)
Dr S mone Stumpf

Dr A ex Tay or

T5) Do any of the investigators have direct personal involvement in the organisations sponsoring or funding the research that may give rise to a possible conflict of interest?
No

T6) Will any of the investigators receive any personal benefits or incentives, including payment above normal salary, from undertaking the research or from the results of the research above those normally associated with scholarly activity?
No

T7) List anyone else involved in the project.

Project details

P1) Project title
Exp or ng AI techno ogy to support soc a nteract ons n the s ghted gu de nav gat on

P1.1) Short project title
Env s on ng AI techno ogy n the s ghted gu de exper ence.

P2) Provide a lay summary of the background and aims of the research, including the research questions (max 400 words).
Many d fferent ass st ve techno og es have been bu t to ass st v sua y mpa red and b nd peop e n the r everyday ves. More recent y, computer v s on, art f c a nte gence and mach ne earn ng have been everaged n Ass st ve Techno ogy research. W th n ass st ve techno ogy research, ndependent nav gat on for peop e w th v sua mpa rment s cons dered a major cha enge, draw ng s gn f cant attent on from the HCI research commun ty and, ncreas ng y, AI app cat ons. Nowadays, one of the AI-based ass st ve techno ogy a ms s enab ng peop e w th v sua mpa rment to a greater nav gat on ndependence. Research has focused extens ve y on ass st ng nav gat on n the phys ca env ronment, by prov d ng nformat on about surround ngs, through, for examp e, object recogn t on, obstac es avo dance, phys ca d stance, prox m ty of wa s and so on.

As recent work n HCI research argues, what r sks be ng neg ected here s that ndependence does not mean on y do ng tasks autonomous y. Indeed, C. Bennett et a . [1] have ntroduced the nterdependence perspect ve, show ng that peop e w th v sua mpa rment re y on and work together w th others to accomp sh the r da y act v t es, h gh ght ng that ndependence s a so ach eved n re at on w th others. Draw ng on th s new perspect ve we have conducted a deta ed qua tat ve ana ys s on the s ghted gu de exper ence to ga n a deep understand ng of how peop e w th v sua mpa rments and the r gu des are work ng together wh e they are nav gat ng. F nd ngs h gh ght the use of mu t moda resources to negot ate nav gat ona c ues and other act v t es (e.g. ongo ng conversat on). Both part c pants are act ve y engaged and nterdependent to one another. Further, ana ys s revea s how these resources are used to estab sh and c ose a common nteract ona space.

For nstance, the gesture of ett ng go s a c ear s gn of a change from an nteract ona space to a persona space, where peop e need to re y on others ab t es. S nce the s ghted gu de exper ence s an nterdependence re at onsh p, we are now nterested n nvest gat ng how AI techno ogy can support th s nterdependence n the nav gat on context.

Th s ser es of co-des gn workshops have been des gned to answer the fo ow ng research quest ons:

RQ1: How m ght AI be used to support the re at onsh p between a b nd/v sua y mpa red person and gu de?

RQ2: G ven the s ghted gu de re at onsh p as an examp e of nterdependence, what mp cat ons does t prov de for AI ass st ve techno ogy?

RQ3: How do pa rs adjust the r s ghted gu de re at onsh p n response to pre m nary ntervent ons, wh ch capture the bas c deas of what AI cou d ach eve?

[1] Bennett, C., Brady, E., & Branham, S. M. (2018). Interdependence as a Frame for Ass st ve Techno ogy Research and Des gn. In ASSETS.

P4) Provide a summary and brief explanation of the research design, method, and data analysis.

Th s research study s a m ng to nvest gate the ro e of AI techn ques to extend the s ghted gu de exper ence. The or g na p an was to exp ore our research quest ons through a ser es of 3 co-des gn workshops a ongs de three stages of mp ementat on over 6 months. Due to COVID-19 and UK Government restr ct ons on trave and meet ngs we dec ded to rev se our methods and procedure n the fo ow ng way.

The study w be conducted n 2 remote workshops over 4 months. Idea y the f rst workshop w be run n May/June and the second one n August/September. T me between the two workshops w be used by researchers to ana yse co ected data, wh ch w nform the des gn of the fo ow ng pre-task act v ty and nterv ew. Each workshop w be composed of a pre-task act v ty that part c pants w do n the r own homes, fo owed by an on ne nterv ew. The pre-task act v ty w be used to he p part c pants dent fy and ref ect on part cu ar aspects of the s ghted gu de exper ence, and promote d scuss on n the subsequent nterv ews. Th s was the a m of the work ng- n-pa r act v ty n the or g na workshops, but has been amended to respond to the need for a remote study. The nterv ews, themse ves, w be used to d scuss and promote further ref ect on on the exper ences n the pre-task act v ty, and more genera y the way b nd peop e and the r gu des commun cate us ng gesture, body movements and or entat on.

Workshop 1 - a m: Exp orat on of body movements and or entat on n the s ghted gu de conf gurat on to bu d a deep understand ng of " ett ng go" scenar o

Pre-task:

Record ng act v ty 1:

A m - Observe and d scuss the use of gestures, body movements and or entat on n the s ghted gu de exper ence.

Act v ty: tak ng two wa ks n part c pants' homes ho d ng gu de's arm/e bow (s ghted gu de conf gurat on) and ho d ng gu de's shou der. As part c pants wa k, they have to pay attent on and ref ect on the gestures, movements and body or entat on of the gu de that he p them to move through space and the gu de shou d observe and ref ect on what gestures, movements and body or entat on

he/she makes that are he pfu , as they go from one room to another. At the end of each wa k they w take a few m nutes to ref ect on what they have not ced and w make an aud o record ng us ng the r mob e phone to descr be gestures, movements and body or entat on (see "WS1 pre-taskAct v tyIntruct ons" f e for further deta s).

Record ng act v ty 2:

A m: Ref ect on the trans t on between be ng gu ded and not be ng n phys ca contact (" ett ng go" from one another) and how gestures, body movements and or entat on can be an obstac e.

Act v ty: tak ng a wa k n home us ng the s ghted gu de conf gurat on and act ng a scr pt. The scr pt s a m ng to exper ence the " ett ng go" scenar o we are nterested n. Th s can be found n the f e attached. After act ng the scr pt, as before, part c pants w take a moment to ref ect on what they have not ced. Thoughts w be recorded us ng the r phones.

Interv ew:

The a m of the nterv ew s to d scuss what part c pants have not ced dur ng the pre-task act v t es. Th s w he p us to understand body movements, or entat ons and gestures wh ch p ay an mportant ro e n the s ghted gu de re at onsh p. Moreover, we w focus on the " ett ng go" scenar o to understand what and how body movements, or entat on and gestures are used dur ng th s trans t on and how part c pants bu d a sense of one another ho d ng and unho d ng a person. (see "WS1 gu deInterv ew" f e for further deta s).

Workshop 2 - a m: Exp orat on of sound through the use of body movements, or entat on and gestures examp es we have ga ned from the prev ous stage

Pre-task:

A m: exper ence sound feedback n re at on to body movements, or entat on or gestures

Act v ty: As n phase 1, researchers w des gn a sma act v ty to do at home. S nce th s act v ty w be strong y based on the resu ts of phase 1, we cannot prov de as much deta s as n the prev ous workshop. However, part c pants w be nvo ved n a task where they w work together to exp ore sounds us ng the r phones and/or s mp e phys ca objects they can f nd home and they are fam ar w th. For nstance, p ayback a sound when the gu de s mov ng away.

Interv ew:

The a m of the nterv ew s to d scuss the exper ence they had. We are nterested n understand ng f sound feedback can be used to tr gger some body movements and or entat on, both when mov ng together and when stand ng/mov ng ndependent y and therefore how sound can be used to extend the sense pa rs make of each other.

Workshop 2 procedure may change f COVID-19 ockdown and soc a d stanc ng restr ct ons w be over at that t me. In th s case researchers w make new amendments to the Eth cs app cat on.

Dur ng the Pre-task act v ty, part c pants w record an aud o f e us ng the r phone. They w have the opt on to choose an app cat on they are fam ar w th and that s access b e for them. We w a so g ve them the opt on to contact the ma n researcher f they wou d ke any suggest ons or further nstruct ons on how to aud o record and share an aud o f e (see procedure deta s n "WS1 pre-taskAct v tyIntruct ons" f e). Aud o records w be sent by part c pants to the researcher at the end of the pre-task act v ty. A aud o records w be transcr bed by the researcher and anonym zed. After transcr pt on a d g ta data w be kept n an externa hard dr ve and stored n a fo der protected by a password. Aud o data wou d be rev ewed by the researcher before conduct ng nterv ews and used

as a start ng po nt and gu de n the conversat on. On ne nterv ews w be run on Webex and the researcher w ca part c pants a pa r at a t me. Th s w he p to ma nta n the access b ty of each sess on as much as poss b e. The nterv ew w ast approx mate y 30 m nutes. On ne meet ngs w be recorded. Recorded nterv ews w be transcr bed and anonym zed. Conversat ons w be ntegrated n the data ana ys s of the aud o records and we w conduct themat c ana ys s.

We w recru t three part c pant pa rs of adu ts v ng together, w th each pa r composed of a s ghted gu de and a person reg stered severe y s ght mpa red (b nd) or s ght mpa red (part a y s ghted). Interested pa rs need to have an estab shed re at onsh p through gu d ng, mean ng that they are used to nav gate together us ng the gu de techn que n the r da y ves for at east 3 months. Indeed, th s pre-estab shed re at onsh p a ows us to have the r 'natura ' behav our as safe y as poss b e (further nformat on about the s ghted gu de techn que: https://www.rn b.org.uk/adv ce/gu d ng-b nd-or-part a y-s ghted-person).

P4.1) If relevant, please upload your research protocol.

P5) What do you consider are the ethical issues associated with conducting this research and how do you propose to address them?

1. Vu nerab e peop e

V sua y mpa red peop e cou d be cons dered vu nerab e. However, we are recru t ng peop e who are ndependent and capab e n the r da y fe. Part c pants who are v sua y mpa red are a ready us ng ass st ve techno ogy, such as screen readers, app cat ons and too s to nav gate n the env ronment, for nstance wh te cane, gu de dog or a s ghted gu de. They have an act ve fe and our prev ous study has shown that peop e are ab e to nav gate successfu y. For th s study we are exc uded part c pants w th mob ty prob ems to reduce r sk, and a so exc ude part c pants w th any cogn t ve mpa rment who are not ab e to g ve nformed consent.

2. Conf dent a ty of data

- A data w be kept conf dent a and secure.

- We w not use the r rea names n any pub cat ons, and use a pseudonym nstead. Add t ona y, the key to the r dent ty w be kept n a password-protected and encrypted f e.

- On ne nterv ews w be conducted us ng WebEx. We chose th s on ne too because t s secure and conf dent a and part c pants do not need to create an account to access the meet ng. Further, to protect the r pr vacy we w ask them to keep the r v deo off, therefore meet ng record ng w not capture the r faces.

- A aud o data (both aud o-records and on ne nterv ew) w be transcr bed n fu by the ma n researcher and anonym sed.

P6) Project start date

The start date w be the date of approva .

P7) Anticipated project end date

30 Sept 2021

P8) Where will the research take place?

Research w take p ace n part c pants' homes and on ne, us ng Webex software for nterv ews. S nce research w take p ace n part c pants' homes and s ghted gu des w ass st peop e w th v sua mpa rment throughout a act v t es, nav gat on tasks can be cons dered safe.

P10) Is this application or any part of this research project being submitted to another ethics committee, or has it previously been submitted to an ethics committee?
No

Human participants: information and participation

The options for the following question are one or more of:
'Under 18'; 'Adults at risk'; 'Individuals aged 16 and over potentially without the capacity to consent'; 'None of the above'.

H1) Will persons from any of the following groups be participating in the project?
Adu ts at r sk

H2) How many participants will be recruited?
6

H3) Explain how the sample size has been determined.
S nce the approach s ma n y qua tat ve, we do not need a arge samp e. Moreover, engag ng w th a ow number of part c pants pa rs w a ow the ma n researcher to g ve enough and equa attent on to a .

H4) What is the age group of the participants?
Lower Upper
18
H5) Please specify inclusion and exclusion criteria.
Part c pants w s gn up to the study on y as a pa r. Both peop e w need to:

- ve together n UK,
- speak Eng sh,
- adu ts over 18 years o d,
- must be ab e to g ve consent.

Interested pa rs need to meet these nc us on cr ter a:

- The pa r must be composed by a s ghted person and a person reg stered severe y s ght mpa red (prev ous y "b nd") or s ght mpa red (prev ous y "part a y s ghted").
- Have an estab shed gu d ng re at onsh p for at east 3 months.

We exc ude part c pants who have:

- any cogn t ve mpa rments wh ch w mean that they cannot g ve nformed consent.
- Mob ty mpa rment, because the k nd of gu de exper ence can great y change cons der ng th s cond t on and for th s reason t s not appropr ate for our scenar o.

H6) What are the potential risks and burdens for research participants and how will you minimise them?

Adu ts at r sk

Even though v sua mpa red peop e are cons dered adu ts at r sk, th s research study does not ant c pate cons derab e r sks and burdens. However, we understand that ong nterv ews can be t r ng and ra se the r sk of stress, for th s reason we w nform part c pants that they can have any breaks they need.

Techno ogy access b ty

Dur ng Pre-task act v t es, peop e w need to send aud o record ngs to the researcher by ema us ng the r phones. Peop e may have access b ty ssues dur ng th s task comp ement, ead ng to stress and rr tat on fee ngs. To m n m ze th s r sk we w eave them the cho ce to use any app cat on they are fam ar w th and we w prov de a deta ed examp e of how to use an app to record and share an aud o f e by ema . Further, we w nform part c pants they can contact the ma n researcher at any t me f they have any prob em or to d scuss the best procedure for send ng record ngs (see "WS1 pre-taskAct v tyIntruct ons" f e). On ne meet ng too s can a so ra se access b ty prob ems. In th s case, we have m t gated th s r sk, fo ow ng some precaut ons. Interv ews w be conducted a pa r at a t me, nstead of schedu ng a common sess on among a part c pants. Th s w he p them to reduce the r work oad. Further, on ne sess ons w be on y n conversat on format. Other too s, such as screen shar ng or any nteract ve too (e.g. wh teboard, work ng on a shared document, etc.) w be avo ded. Indeed, usua y such too s cause most access b ty prob ems.

H7) Will you specifically recruit pregnant women, women in labour, or women who have had a recent stillbirth or miscarriage (within the last 12 months)?

No

H8) Will you directly recruit any staff and/or students at City?

None of the above

H8.1) If you intend to contact staff/students directly for recruitment purpose, please upload a letter of approval from the respective School(s)/Department(s).

H9) How are participants to be identified, approached and recruited, and by whom?

Researchers w ask part c pat on of three pa rs out of 4 from the prev ous study t t ed "Exp or ng nterpersona nteract ons n the s ghted gu de exper ence". We w present th s study as a new study, say ng that there s no ob gat on to take part n th s study. Indeed, we w a so recru t other pa rs of part c pants through adverts v a Tw tter, Facebook, and send ng ema s to ex st ng contacts of the student and superv sors. We w adopt the nc us on/exc us on cr ter a attached (see " nc-exc - cr ter a updated" pdf f e).

The pr nc pa researcher Beatr ce w create a recru tment advert sementTh s w be access b e through screen readers (see "advert sement updated" f e). Ema s w be sent n p a n text and content w be cop ed and pasted from the access b e advert sement. Interested pa rs w rece ve n advance by ema the part c pant nformat on sheet n access b e format, we w g ve them t me (5 days) to read and ask any quest ons and/or concerns. Pa rs of part c pants who are st nterested

and wou d ke to take part n the study w rece ve the nk to the nformed consent, wh ch w be s gned through Qua tr cs serv ce, offered by C ty.

H10) Please upload your participant information sheets and consent form, or if they are online (e.g. on Qualtrics) paste the link below.
H11) If appropriate, please upload a copy of the advertisement, including recruitment emails, flyers or letter.
H12) Describe the procedure that will be used when seeking and obtaining consent, including when consent will be obtained.
After part c pants have shown nterest n tak ng part n the study, the ma n researcher w send by ema a nk to the on ne survey to ga n consent before any act v ty. Consent w be obta ned by d g ta y s gn ng an on ne form. We w use Qua tr cs serv ce offered by C ty to create the on ne nformed consent and we w make sure t w be comp ant w th re evant W3C access b ty gu de nes. Spec f ca y, access b ty w be ver f ed through the "Check Survey Access b ty" too bu t- n the p atform.

H13) Are there any pressures that may make it difficult for participants to refuse to take part in the project?
No

H14) Is any part of the research being conducted with participants outside the UK?
No

Human participants: method

The options for the following question are one or more of:
'Invasive procedures (for example medical or surgical)'; 'Intrusive procedures (for example psychological or social)'; 'Potentially harmful procedures of any kind'; 'Drugs, placebos, or other substances administered to participants'; 'None of the above'.

M1) Will any of the following methods be involved in the project:
None of the above

M2) Does the project involve any deceptive research practices?
No

M3) Is there a possibility for over-research of participants?
No

M4) Please upload copies of any questionnaires, topic guides for interviews or focus groups, or equivalent research materials.

M5) Will participants be provided with the findings or outcomes of the project?
Yes

M5.1) Explain how this information will be provided.

The researcher w not prov de the f nd ngs or outcomes of the project to the part c pants d rect y, but she w nform them through the part c pant nformat on sheet that part c pants can request a copy of the resu t to the researcher by ema . In th s case, a f nd ngs summary w be sent to the part c pant n an access b e format.

M6) If the research is intended to benefit the participants, third parties or the local community, please give details.

M7) Are you offering any incentives for participating?
Yes

M7.1) Please give details, justifying their type and amount.
As a thank you for part c pants' pa rs nvo vement, we w offer £20 n Amazon vouchers per person.

M8) Does the research involve clinical trial or clinical intervention testing that does not require Health Research Authority or MHRA approval?
No

M9) Will the project involve the collection of human tissue or other biological samples that does not fall under the Human Tissue Act (2004) that does not require Health Research Authority Research Ethics Service approval?
No

M10) Will the project involve potentially sensitive topics, such as participants' sexual behaviour, their legal or political behaviour, their experience of violence?
No

M11) Will the project involve activities that may lead to 'labelling' either by the researcher (e.g. categorisation) or by the participant (e.g. 'I'm stupid', 'I'm not normal')?
No

Human participants: vulnerable

V1) Please provide details of enhanced ethical procedures to safeguard these participants.
We are recru t ng peop e who are ndependent and capab e n the r da y fe. Part c pants who are v sua y mpa red:

- are a ready us ng ass st ve techno ogy, such as screen readers, app cat ons and too s to nav gate n the env ronment, for nstance wh te cane, gu de dog or a s ghted gu de.

- They have an act ve fe and our prev ous research study has shown that v sua y mpa red peop e are ab e to nav gate successfu y.

Add t ona y, dur ng our sess ons we w adopt act v t es and methods such as bodystorm ng,, ro e p ay ng, tang b e objects (such as phones) to express op n ons, and fee ngs. In contrast to v sua mater a s, these methods w he p peop e w th v sua mpa rments to be act ve y engaged n act v t es where they have to work w th s ghted peop e. These methods a ow us to set up an access b e env ronment where peop e w th v sua mpa rments w fee comfortab e to share fee ngs.

V2) Please give details of the vulnerable participant protection procedures you propose to adopt should there be any evidence or suspicion of harm (physical, emotional or sexual) to a vulnerable person. Include a referral protocol identifying what to do and who should be contacted.

S nce the study w be run remote y, hav ng ev dence or susp c on of harm to a vu nerab e person s an un ke y event. However, f the researcher w have any susp c on about that, she w contact superv sors to seek adv ce. After that she w transfer the case to re evant author t es for further nvest gat on.

V3) Please give details of how you propose to ensure the well-being of the vulnerable participant, particularly with respect to ensuring that they do not feel pressured to take part in the research and that they are free to withdraw from the research without any prejudice to themselves at any time.

The ma n researcher w nform part c pants that part c pat on s vo untary and they can w thdraw from the study at any t me. She w wr te t on the part c pant nformat on sheet, she w repeat t verba y dur ng each workshop and she w ask part c pants to conf rm th s statement n the consent form. The target popu at on may nc ude vu nerab e peop e, but t s our ntent on to recru t on y peop e who are ab e to g ve consent.

V4) Will carers, parents, teachers or other parties be present during the research?

Yes

V4.1) Outline how the confidentiality of the participants will be upheld.

Deta s about conf dent a ty w be asked through a statement n the nformed consent.

V5) Are participants able to give informed consent?

Yes

V6) Please give details of any City staff or students who will have contact with adults at risk and/or will have contact with young people (under the age of 18) and the details of current (within the last 3 years) Disclosure and Barring check.

Name

Beatr ce V ncenz

DBS reference number

001646045894

Date of DBS

31 Jan 2019

Type of Disclosure

D sc osure and Barr ng (DBS) enhanced d sc osure check

V7) Please give details of any non-City staff or students who will have contact with adults at risk and/or will have contact with young people (under the age of 18) and the details of current (within the last 3 years) Disclosure and Barring check.

Name

Institution

Address of organisation that requested disclosure

DBS reference number

Date of DBS

Type of disclosure

I w not be recru t ng any part c pants who fa under the Menta Capac ty Act 2005.

Data

D1) Indicate which of the following you will be using to collect your data.

Interv ews
Aud o/d g ta record ng nterv ewees or events
Other

D1.1) Provide details if you have selected other.

phone apps for aud o record ng

D2) How will the the privacy of the participants be protected?

De- dent f ed samp es or data

D3) Will the research involve use of direct quotes?

Yes

D5) Where/how do you intend to store your data?

Data to be kept n a ocked f ng cab net
Data and dent f ers to be kept n separate, ocked f ng cab nets
Password protected computer f es
Storage on encrypted dev ce (e.g. aptop, hard dr ve, USB

D6) Will personal data collected be shared with other organisations?

No

D7) Will the data be accessed by people other than the named researcher, supervisors or examiners?

Yes

D7.1) Explain by whom and for what purposes.
P ctures may be used n pub cat ons and presentat ons dur ng academ c events and conferences to descr be sess on procedure and/or show act v t es. In such a case researchers w ask part c pants perm ss on through nformed consent and w ensure that dent f ab e data (such as faces) w be b urred.

D8) Is the data intended or required (e.g. by funding body) to be published for reuse or to be shared as part of longitudinal research or a different/wider research project now or in the future?
No

D10) How long are you intending to keep the research data generated by the study?
Fo ow ng Un vers ty's gu de nes on retent on, data generated by the study w be reta ned for ten years.

D11) How long will personal data be stored or accessed after the study has ended?
As above, we w store persona data for ten years.

D12) How are you intending to destroy the personal data after this period?
A d g ta data w be permanent y de eted and paper data w be shredded and d sposed of.

Health & safety

HS1) Are there any health and safety risks to the researchers over and above that of their normal working life?
No

HS3) Are there hazards associated with undertaking this project where a formal risk assessment would be required?
No

Attached files

WS1 pre-taskAct v tyInstruct ons.pdf

WS1-gu deInterv ew.pdf

consentForm samp e updated.pdf

Part c pantInformat onSheet updated.pdf

advert sement updated.pdf

nc-exc -cr ter a updated.pdf

Ethics ETH2021-1000: Miss Beatrice Vincenzi (Medium risk)

Date Created	14 Jan 2021
Date Subm tted	15 Jan 2021
Date of ast resubm ss on	17 Feb 2021
Date forwarded to comm ttee	15 Jan 2021
Academ c Staff	M ss Beatr ce V ncenz
Student ID	180045423
Category	Doctora Researcher
Superv sor	Dr S mone Stumpf
Project	Exp or ng AI techno ogy to support soc a nteract ons n the s ghted gu de nav gat on
Schoo	Schoo of Mathemat cs, Computer Sc ence & Eng neer ng
Department	Computer Sc ence
Current status	Approved after amendments made

Ethics application

Amendments

SA1) Types of modification/s

Change the procedures undertaken by part c pants, nc ud ng any change re at ng to the safety or phys ca or menta ntegr ty of research part c pants, or to the r sk/benef t assessment of the project or co ect ng add t ona types of data from research part c pants

Change the des gn and/or methodo ogy of the project, nc ud ng chang ng or add ng a new research method and/or research nstrument

SA2) Details of modification

We seek to make amendments to Stage 2. It was env saged that th s wou d nc ude a pre-task act v ty to do at home and an on ne nterv ew. The purpose was to exp ore sounds through the use of body movements examp es we have ga ned from the prev ous stage.

We have rev sed th s stage to cons st of an on ne co-des gn sess on on y dur ng wh ch we w present scenar os of use (see up oaded document) and prototype deas based on our f nd ngs from Workshop 1 and rece ve feedback and ns ghts from Stage 1 part c pants. The workshop w ast approx mate y one hour. A mater a w be ava ab e n v sua format (storyboard) and text format (story). We w ask part c pants to step through the scenar o and we may ask part c pants to use everyday mater a s wh ch they have ava ab e at home such as phone, bands or s m ar to s mu ate our prototype and prov de feedback.

Stepp ng through the nteract ons and the use of raw mater a s w he p part c pants to ref ect on the exper ence, generat ng deas and ref ect on strengths and weaknesses of the proposed prototype, env s on ng how the AI ass st ve techno ogy nterp ays n s ghted gu d ng and spec f ca y n moments where the gu de needs to sudden y eave the v sua mpa red prox m ty.

As the part c pants step through the scenar o, the researcher w prompt for feedback on:

- Benef ts and m tat ons of scenar o of use
- M ss ng or redundant steps n the scenar o
- Pos t ve and negat ve aspects of the proposed techn ca so ut on, e.g., start ng/stopp ng the system, aud tory feedback, camera p acement, etc.
- Potent a mpact of everyday use, such as secur ty, secur ty, user exper ence

SA3) Justify why the amendment is needed

We were asked to further spec fy stage 2, once we had more nformat on, after our n t a app cat on was approved.

SA4) Other information

SA5) Please upload all relevant documentation with highlighted changes

Project amendments

P1) Project title

Exp or ng AI techno ogy to support soc a nteract ons n the s ghted gu de nav gat on

P2) Principal Applicant

Name

M ss Beatr ce V ncenz

Provide a summary of the researcher's training and experience that is relevant to this research project.

Beatr ce s a second-year PhD student and th s study s re ated to her project. She has a ready p anned and conducted a study dur ng the f rst year t t ed "Exp or ng nterpersona nteract ons n the s ghted gu de exper ence" where she worked c ose y w th v sua y mpa red peop e. She s a so vo unteer ng to B ndA d char ty for he p ng and ass st ng peop e w th v sua mpa rment. She s act ve y nvo ved n

events to offer company and conversat on to v sua y mpa red peop e and she s tra ned to be a gu de us ng the s ghted gu de techn que.

P3) Co-Applicant(s) at City

P4) External Co-Applicant(s)

P5) Supervisor(s)

Dr S mone Stumpf

Dr A ex Tay or

B.2 ADVERTISEMENT

Department of Computer Science
City, University of London

Volunteers needed for research in envisioning AI technology in the sighted guide experience.

Who are we looking for?

We are looking for an adult pair (over 18) living together in UK.
Your pair should be composed of a sighted guide and a sight impaired person with an established relationship through guiding of at least 3 months.
You should not have any mobility or cognitive impairment.

What would your participation involve?

We will ask to participate in 2 remote workshops between May to September, each composed of a pre-task activity to do at home followed by an online interview. You will have 3 days to complete the pre-task activity of about 30 minutes and the subsequent interview will last about 30 minutes. You will be asked to identify and reflect on particular aspects of the sighted guide experience and promoting thoughts and discussion in the online interview.

What do I receive?

In appreciation for your time, your pair will receive 2 Amazon vouchers of £20.

Who should I contact for further information or to volunteer?

Please contact: Beatrice Vincenzi.
Email: beatrice.vincenzi@city.ac.uk. Mobile: 07955 367 578, Twitter: @Beatrice_vince
Supervisors. PhD Simone Stumpf simone.stumpf.1@city.ac.uk. PhD Alex Taylor
alex.taylor@city.ac.uk

This study has been reviewed by, and received ethics clearance
through the Computer Science Department City, University of London.

If you would like to complain about any aspect of the study, please contact the Secretary to the Senate Research Ethics Committee on 020 7040 3040 or via email: Anna.Ramberg.1@city.ac.uk.

City, University of London is the data controller for the personal data collected for this research project. If you have any data protection concerns about this research project, please contact City's Information Compliance Team at dataprotection@city.ac.uk

INCLUSION AND EXCLUSION CRITERIA CHECKLIST

(Internal document)

Thank you for your interest in this study!

What is your age?

Do you speak English fluently?

Yes No

Do you live together in UK?

Yes No

Have you contacted me as a pair of participants?

Yes No

Depending on the person:

Are you a person registered severely sight impaired or sight impaired?

Yes No

Are you a sighted guide?

Yes No

How long have you been a guide of ... ?

Yes No

Thinking about the relationship with your companion:

Do you usually go around using a sighted guide technique?

Yes No

Do you feel comfortable going around with your companion using the sighted guide technique?

Yes No

Mobility impairment check:

- Do you have a mobility impairment?
- How long can you travel using white cane, guide dog or sighted guide (at least 20 mins)?

Cognitive abilities check:

- DO you have any cognitive impairment?

  Yes No
- What is your preferred contact method:

  Mail Phone Text Social Media

Contact details:

B.4 PARTICIPANT INFORMATION SHEET

CITY
UNIVERSITY OF LONDON
EST 1894

REC reference number and date:
ETH1920 0858, 24th April 2020

Title of study
Envisioning AI technology in the sighted guide experience

Research Team
Principal researcher: Beatrice Vincenzi.
Supervisors: PhD Simone Stumpf and PhD Alex Taylor.

Participant information sheet introduction
We would like you to take part in this research study. Before you decide whether you would like to take part it is important that you understand why the research is being done and what it would involve for you. Please take the time to read the following information carefully. Feel free to ask if you would like more information.

What is the purpose of the study?
The purpose of this study is to investigate the role of AI techniques to extend the sighted guide experience, through exploration of body movements, orientation and gestures used in this experience and how sound can augment the sense pairs make of each other. This study will help researchers to design an AI technology you may envision as part of your future everyday life technology.

Why have I been invited to take part?
You have been invited to participate in this study because you expressed interest in participating. Additionally, you are an adult pair living together in UK, composed of a sighted person and a person registered severely sight impaired or sight impaired. To participate in the study your pair needs to have an established relationship in the standard guide configuration. A maximum of 2 other pairs like you and your companion will be involved in the project.

Do I have to take part?
The participation in the study is voluntary and you can decide if you want to take part. Both your companion and you need to agree. It means that if either of you decides to not take part in the study, you will both be automatically excluded and your contact information will be permanently deleted. You have the right to withdraw at any time without giving a reason. You will not be penalized in any way for not taking part. If your pair choose to continue in the project, you will be asked to sign an online consent form.

What will happen if I take part? What do I have to do?
We will be asked to your pair to take part in 2 workshops over a period of 4 months from May 2020 to September 2020, with 6 weeks in between workshops. Workshops will be run remotely and each session will be composed of a pre-task activity to do home, followed by an online interview. The pre-task activity will help you to identify and reflect on particular aspects of the sighted guide experience,

navigating in your home space and audio recording your thoughts using your phones. Pre-task activities will last about 30 minutes and you can choose to do them anytime over 3 days. Interviews will be conducted to promote further discussion on what you have experienced during the pre-task activities and on the sighted guide experience overall. We will use Webex meeting tool, interviews will last approximately 30 minutes and will be recorded. All audio data will be transcribed by the researcher and anonymized.

What are the possible disadvantages and risks of taking part?

This study is completely confidential, and we have identified no reasonably foreseeable risks of harm, safety, or side effects to you as a result of taking part in this study.

What are the possible benefits of taking part?

There are no direct benefits for taking part in the workshops. However, your participation in this research is greatly appreciated. As a thank for your involvement your pair will receive £20 in Amazon voucher per person.

What should I do if I want to take part?

You should contact the main researcher Beatrice Vincenzi, contact details are reported at the end of the document. She will send you a link to fill in the informed consent online and will schedule the first workshop, providing also further information about pre-task activities.

Data privacy statement

City, University of London is the sponsor and the data controller of this study based in the United Kingdom. This means that we are responsible for looking after your information and using it properly. The legal basis under which your data will be processed is City's public task.
Your right to access, change or move your information are limited, as we need to manage your information in a specific way in order for the research to be reliable and accurate. To safeguard your rights, we will use the minimum personal-identifiable information possible (for further information please see guide to data protection).

City will use your name and contact details to contact you about the research study as necessary. If you wish to receive the results of the study, your contact details will also be kept for this purpose. The only people at City who will have access to your identifiable information will be *Beatrice Vincenzi*. City will keep identifiable information about you from this study for 10 years after the study has finished.

You can find out more about how City handles data by visiting City legal information. If you are concerned about how we have processed your personal data, you can contact the Information Commissioner's Office (IOC) IOC website.

Will my taking part in the study be kept confidential?

Your participation will be kept confidential and we will take some precautions to guarantee your anonymity. Your pair will receive two pseudonyms which will be used throughout the project, rather than your personal names. Online interviews will be recorded, but we will ask you to keep your webcam off. All audio data will be fully transcribed and anonymized. All digital data and the mapping sheet between pseudonyms and real names will be stored on an encrypted folder protected by a password. Only the principal investigator Beatrice Vincenzi will know that password.

What will happen to the results?

After the study the results will be reported in a written documentation as part of the PhD Thesis of Beatrice Vincenzi. Results could also be published in some academic journals or conferences. In both case we will not include your personal details. If you desire to have a copy of the result, please send a request by email to the researcher Beatrice Vincenzi.

What will happen when the research study stops?

All data will be kept in using secure storage for up to ten years. After the study digital data (except select video data) will be transferred to an external hard disk protected by a password and hard data will be kept in a locked cabinet.

Who has reviewed the study?

This study has been approved by City, University of London's Computer Science Research Ethics Committee.

What if there is a problem?

If you have any problems, concerns or questions about this study, you should ask to speak to a member of the research team. If you remain unhappy and wish to complain formally, you can do this through City's complaints procedure. To complain about the study, you need to phone 020 7040 3040. You can then ask to speak to the Secretary to Senate Research Ethics Committee and inform them that the name of the project is: *Envisioning AI technology in the sighted guide experience*, conducted by Beatrice Vincenzi.

You can also write to the Secretary at:
Anna Ramberg
Research Integrity Manager
City, University of London, Northampton Square
London, EC1V 0HB
Email: Anna.Ramberg.1@city.ac.uk

Insurance

City holds insurance policies which apply to this study. If you feel you have been harmed or injured by taking part in this study you may be eligible to claim compensation. This does not affect your legal rights to seek compensation. If you are harmed due to someone's negligence, then you may have grounds for legal action.

Further information and contact details

Researcher: **Beatrice Vincenzi**, PhD student, beatrice.vincenzi@city.ac.uk.
Mobile: **07955 367 578**.
Supervisors: PhD Simone Stumpf, simone.stumpf.1@city.ac.uk.
PhD Alex Taylor, alex.taylor@city.ac.uk.

Thank you for taking the time to read this information sheet.

B.5 INFORMED CONSENT

CITY
UNIVERSITY OF LONDON
EST 1894

REC reference number:
ETH1920 0858

Title of study

Envisioning AI technology in the sighted guide experience.

Informed consent instructions

For participating in the study, I ask you to fill in this online form, composed of 10 statements.

1	I have read and understood the participant information sheet dated 24/04/2019 for the above study. I have had the opportunity to consider the information and ask questions which have been answered satisfactorily.	
2	I understand that my participation is voluntary and that I am free to withdraw without giving a reason without being penalised or disadvantaged.	
3	I understand that this project involves participation in two remote workshops from May/June 2020 to August/September 2020.	
4	I consent pre-task activities to be audio recorded and interviews to be recorded. I understand that webcam during online interviews will be off.	
5	I agree the use of de-identified data in any publications and conferences.	
6	I agree the use of anonymised direct quotes from audio data in any publications and conferences.	
7	I understand that a pseudonym will be assigned to me and all digital data will be kept in an encrypted folder protected by a password.	
8	I agree to maintain confidentiality of the workshops. The gathered information will be held by Beatrice Vincenzi and processed for her PhD project as well as future research publication.	
9	I agree to City recording and processing this information about me. I understand that this information will be used only for the purpose(s) explained in the participant information and my consent is conditional on City complying with its duties and obligations under the General Data Protection Regulation (GDPR).	
10	I agree to take part in the above study, titled: *Envisioning AI technology in the sighted guide experience.*	

B.6 PART A: ACTIVITIES GUIDE

Workshop 1- Pre-task activity instructions

Please, read carefully the entire document before doing the following activities and contact the researcher if you have any question or concern. In the workshop 1 of the study you will have to take 3 short activities. At the end of each activity you will have to audio record your thoughts using your phone and send the record by email to Beatrice.

Activity 1

Aim: Observe and discuss the use of gestures, body movements and orientation in the sighted guide experience.

Step 1:

Plan a walk at home which starts and ends in the same location. With a member of your household navigate from one room to another (e.g. bedroom to kitchen) using the sighted guide configuration (holding arm or elbow). On this occasion you should use the configuration you usually have in everyday life and that you are more comfortable with.

Step 2:

As you walk, pay attention and reflect on the gestures, movements and body orientation of your guide that help you to move through space or if you are the guide observe and reflect on what gestures, movements and body orientation you make that are helpful, as you go from one room to another. For example, if you are holding the elbow, as you move through a narrow space like a corridor you might feel your guide raise their elbow and rotate their body. This gives you a clue that you need to move behind.

Step 3:

After the walk take a few minutes to reflect on what you have noticed.

- To Noah: what gestures, movements and body orientation of your guide have you noticed that helped you to move through space?
- What was your sense about the guide posture and position?
- How have those movements helped you?
- To Grace: what gestures, movements and body orientation have you made that were helpful while walking?
- Why did you do those movements?
- What did you want to say doing those movements?

Step 4:

Make an audio recording using your mobile phone where you both Noah and Grace describe gestures, movements and body orientation, answering the questions in step 3. Start the recording saying: “walk number 1”.

Step 5:

Send the 2 audio records to the researcher by email at beatrice.vincenzi@city.ac.uk

Activity 2

Aim: Observe and discuss differences in the use of gestures, body movements and orientation in a different configuration.

Step 1:

Repeat the walk you have done in Activity 1. This time walk holding a different part of the guide's body that you usually don't hold (for example the shoulder or the elbow).

Step 2:

As before, as you walk, pay attention and reflect on the gestures, movements and body orientation of your guide that help you to move through space or if you are the guide observe and reflect on what gestures, movements and body orientation you make that are helpful, as you go from one room to another.

Step 3:

After the walk take a minute to reflect on what you have noticed.

- To Noah: what **gestures**, **movements** and body **orientation** of your guide have you noticed that helped you to move through space?
- To Grace: what **gestures**, **movements** and body **orientation** have you made that were helpful while walking?
- To Both: How did gestures, movements and body orientation help you this time?
- Can you both describe any difference you have noticed compared to the previous walk?

Step 4:

Audio record your thoughts and answers in step 3 using your phone. Start the recording saying: "Walk number 2".

Step 5:

Send the audio recording to the researcher by email at beatrice.vincenzi@city.ac.uk

Activity 3

Aim: Reflect on the transition between being guided and not being in physical contact ("letting go" from one another) and how gestures, body movements and orientation can be an obstacle.

Step 1:

Plan a walk at home which starts and ends in the same location. With Grace navigate from one room to another (e.g. bedroom to kitchen) using your standard sighted guide configuration (the same you have used in Activity 1).

Step 2:

As you walk, act the following script.
Script:

- Start your trip sitting on the couch/bed/chairs and set up a timer on your phone for 15 seconds, start it, put the phone in your pocket and start walking together. Note: when the phone rings because the timer ends, stop it before continuing the walk.
- Continue to the path you have planned.
- When you are in the kitchen, Grace offers a glass of water: "would you like a glass of water?", Noah answers positively. Grace takes a glass of water and passes it to Noah. Noah drinks it and puts it back on the table.
- Resume your walk and when you pass close to a window, stop the walk to open the window and then resume your walk.
- After that continue your walk till you come back to the couch/bed/chairs and sit down as at your starting point.

Can you act this script at home? If for some reason, this script does not make sense in the environment where you live, please take some time to think of two tasks you can do at home and that require you to stop and reposition yourselves temporarily in the space while you are walking together.

During the walk observe and reflect if you experience some moments where you have to interrupt being in physical contact: how does the transition between the sighted guide configuration and not being in physical contact and vice versa happen? pay special attention to what body movements, orientation and gestures are perceived in this transition and what they help to tell you. For example, you stop, and you feel your guide twisting the held arm, this gives you a clue that he is turning to face you and it is time to let go of the arm you are holding.

Step 3:

After acting the script, take a moment to reflect on what you have noticed.

- Have you noticed moments where you had to let go from one another?
- How did this transition happen?
- To Noah: What body movements, orientation and gestures helped you in this transition? How?
- To Grace: What body movements, orientation and gestures did you do in this transition to help Noah? How?
- Once standing or moving independently were body movements, orientation and gestures still important to have a better sense of one another? How? Can you both bring an example?
- How did you regain physical contact?

Step 4:

Audio record your answers in step 3 using your phone. Start the recording saying: "Walk number 3".

Step 5:

Send the audio recording to the researcher by email at beatrice.vincenzi@city.ac.uk

How to record and share the audio recording.

IPhone users, using Voice Memo app

How to record a voice memo

1. Open the Voice Memos app or ask Siri to open it.
2. To record, tap or click the big red circle record button on the bottom of your screen. If you are running Voice Over you use two fingers and double tap to start the recording
3. To stop, tap the stop button on the bottom of your screen or using Voice Over use two fingers and double tap. When you stop the recording, your memo is saved automatically with your current location as the title. The application opens up the single recording interface
4. From here you can review and share your recording.

How to review the voice memo just saved

1. The audio file will appear on the top of your screen.
2. In order to go back and preview that audio file, tap the play button. Using VoiceOver, swipe right your finger till you find the "Play" option, double tap the screen to play it.
3. To stop it, tap the stop button or double tap the screen with VoiceOver.

How to share the voice memo just saved

1. The audio file will appear on the top of your screen.
2. In order to share the audio file, tap the "more actions" button. This button has three points, then tap on share. Using Voice Over, swipe right your finger till you find the "more functions" option and double tap the screen. Swipe right again to find "Share" option, double-tap the screen to select it.
3. You have now the possibility to select "email" option.
4. Insert my email address: beatrice vincenzi@city ac uk and send it.

Android users, using Sound Recorder

To record your voice, you can use an application of your choice, which you are familiar with and it is accessible for you. The application should allow you to share the audio record by email with the researcher.

For example, if you have an Android phone you may use the “Sound Recorder” application.

Once you have opened the app, you can press the red “start” button at the bottom-left corner. To stop recording, press the “Stop” button, it is the second button from the left at the bottom. The app will ask you to choose the file name and save it.

Pressing “Recordings” button, which is the second one from the left at the bottom of the screen, you can access to all audio records. The first one in the list is the last recording you have made. Select it and press the share button at the bottom of the screen (it is the first one from the left). You will have access to the email application, which allows you to send the audio recording.

If you have any further question or issue, please get in touch at beatrice vincenzi@city ac uk.

Thank you for taking part in these activities!

After sending all audio recordings, Beatrice will get in touch to schedule the interview.

B.7 PART A: INTERVIEW GUIDE

Interview Guide for the researcher:

Thanks for taking part in the study!

Turn off your webcam!
Begin recording

Introduction

The aim of this study is to explore body movements and orientation in the sighted guide configuration and some moments where you had to "let go" from one another.
For doing so, during this interview we will review together what you have recorded home and ask more questions about situations where you have lost physical contact.

Feel free to ask me questions at any time and if you need a break.
You do not have to talk about anything that makes you uncomfortable.

The session is recording and all information you provide is confidential.
Let's start!

Related to recording activity 1:

Recap/presentation of what they have recorded. Which body movements, orientation and gestures they have noticed and how they help them to make sense of one another.

[Think of a way to present them, for example by category.]
[Think a way to present differences that they have noticed from walk 1 and walk 2]

- Have I misunderstood something?
- Do you have anything to add?
- Doing the exercise, have you realised the importance of some movements that you usually take for granted while walking in the sighted guide configuration?

Extension:

- [To both] Thinking about your entire experience, have you noticed any other body movements, orientation and gestures that the walk did not capture?
    - If so, can you describe in more details what these gestures are and how they help you

Related to recording activity 2:

Recap/presentation of what they have recorded in the second part.

[Think about how to present them]

- What "letting go" scenario they have experienced.
- What moments/gesture they have associated with that moments
- Have I misunderstood something?
- Do you have anything to add?

Further exploration of "Letting go" from one another:

Thinking about your entire experience:

- To [name of blind person]: Can you recall a situation where you lost physical contact unexpectedly?
- Can you describe the situation? When did it happen? How? Who was the guide? [journey description]
- How did you feel? Did you become disoriented? [describe] Why did you feel like that?

- To [guide or household/family name]: Can you recall a situation where you became unsure of [blind person's name] safety or felt you were being unhelpful because of how you moved or orientated your body? [describe]
- When did it happen? How? Who was your guidee? [journey description]
- On that occasion have you moved away from the guidee? How did you feel? Did you become disoriented? [describe] Why did you feel like that?

- Can you remember any other positive or negative moment when you had to let go from each other? Can you describe in detail these situations?

It can be the same situation or two different ones. In that situation:

- Who was your guide/guidee?
- If it is relevant, when it happened, journey description?

Losing/regain physical contact:

In these situations, you have just described:

- (What was happening before you lost contact?)
- How did you lose contact with them?
- What did you do to regain contact? (or did something else happen?)

Related to body movements, orientations and gestures:

- During the transition from being in physical contact to moving/standing independently, did body movements, orientations and gestures help you to make sense of one another? [How?]
- Thinking about situations you have described previously, have body movements, orientations and gestures been an obstacle?
- Which movements in particular, why and how?
- Which gestures, body movements and orientations helped you to re-establish physical contact? How?
- Have you noticed and can you describe any difference perception of body movements, orientation and gestures that helps you to build sense of the other person when you are in the guide configuration and when you are not in physical contact?
- Is there anything that you would like to know about the guide when you are moving independently?
- Is this something you usually make sense through body movements, orientations and gestures when you are in physical contact?

- Is there anything you would like to add that we have not covered?

Thanks for taking part in the study.
End audio recording

B.8 PART A: PRELIMINARY CODES FOR THEMATIC ANALYSIS OF BODY LANGUAGE

Initial code	
Body Movements	**Meaning**
Moving the elbow behind	Letting go
Pausing the walk	Locate the guide
Slowing down	Orientation to each other
Twisting the upper body	Setting up the guide configuration
Developed codes	
Body Movements	**Meaning**
G gripping the VI's hand	End Journey
G Guiding with hands	Letting go
to a body part	Locate the guide
to an object/space	Location in space
G Lifting up/down	Next direction
the linking arm	What is happening
the linking shoulder	New Journey
G moving in front of VI	Orientation to each other
G moving the held arm/elbow/hand	Setting-up
Behind their back	Bodies re-configuration
In front of VI's body	Changing in direction
Pushing-pulling	Changing in height level
G moving upper body upwards	Contextual information
G pausing the walk	Guarantee safety
G slowing down	Something coming up-changing
G stopping the walk	
G Tapping VI's body part	
G twisting their upper body	
VI (un)linking the hand to the G	
VI putting the hand out	
VI standing-up/sitting down	
Vi standing still	

B.9 PART A: MATRIX IN NVIVO TO UNCOVER MOST FREQUENT BODY MOVEMENT–MEANING ASSOCIATIONS

	A End journey	B Letting go	C Locate the guide	D Location in space	E Next Direction	F What is happening	G New journey	H Orientation to each other	Setting-up	J Bodies reconfiguration	K Change in direction	L Change in height	M Contextual nformation	N Guarantee safety	O Something coming up-is changing
1 G Gripping the hand	0	1	0	0	0	0	0	0	0	0	2	0	0	0	0
2 G guiding to a body part	0	0	0	0	0	0	0	0	3	5	0	1	0	0	0
3 G guiding to an object-space	1	14	0	17	0	0	0	0	0	0	0	2	0	0	0
4 G lifting the linking arm	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
5 G lifting the linking shoulder	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
6 G moving in front of V	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
7 G moving arm behind their back	1	3	0	0	0	0	0	0	0	1	11	2	0	0	1
8 G moving arm n front of V 's body	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
9 G Pushing-pulling	0	2	0	0	0	0	0	0	0	0	1	0	0	0	2
10 G moving upper body upwards	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0
11 G Pausing the walk	0	0	0	0	0	0	0	0	0	0	2	17	19	0	4
12 G slowing down	2	3	0	0	0	0	0	0	0	0	0	0	0	0	2
13 G stopping the walk	2	4	0	0	0	0	0	0	0	0	0	0	0	0	0
14 G Tapping V 's body part	0	6	0	2	0	0	0	7	9	7	2	0	0	0	0
15 G twisting their upper body	0	0	0	0	0	0	0	0	0	0	7	8	0	0	0
16 V (un)linking the hand to the G	0	3	0	0	0	0	0	2	5	15	2	0	0	0	0
17 V putting the hand out	0	0	0	0	0	0	0	0	4	4	0	0	0	0	0
18 V standing still	0	4	2	7	0	4	0	0	1	1	0	0	0	0	0
19 V standing up-sitting down	1	10	0	9	0	0	0	3	4	3	1	1	0	0	0

C MAKING DESIGN SPACE FOR AI AND INTERDEPENDENCE (STUDY 3)

C.1 ETHICS APPLICATION

Ethics ETH2021-2166: Miss Beatrice Vincenzi (Medium risk)

Date Created	22 Jun 2021
Date Submitted	19 Jul 2021
Date forwarded to committee	19 Jul 2021
Academic Staff	Miss Beatrice Vincenzi
Student ID	180045423
Category	Doctoral Researcher
Supervisor	Dr Simone Stumpf
Project	AI for People with Visual Impairments Exploring Design Methods for Interdependence
School	School of Mathematics, Computer Science & Engineering
Department	Computer Science
Current status	Approved

Ethics application

Risks

R1) Does the project have funding?
No

R2) Does the project involve human participants?
Yes

R3) Will the researcher be located outside of the UK during the conduct of the research?
No

R4) Will any part of the project be carried out under the auspices of an external organisation, involve collaboration between institutions, or involve data collection at an external organisation?
No

R5) Does your project involve access to, or use of, terrorist or extremist material that could be classified as security sensitive?
No

R6) Does the project involve the use of live animals?
No

R7) Does the project involve the use of animal tissue?
No

R8) Does the project involve accessing obscene materials?

No

R9) Does the project involve access to confidential business data (e.g. commercially sensitive data, trade secrets, minutes of internal meetings)?
No

R10) Does the project involve access to personal data (e.g. personnel or student records) not in the public domain?
No

R11) Does the project involve deviation from standard or routine clinical practice, outside of current guidelines?
No

R12) Will the project involve the potential for adverse impact on employment, social or financial standing?
No

R13) Will the project involve the potential for psychological distress, anxiety, humiliation or pain greater than that of normal life for the participant?
No

R15) Will the project involve research into illegal or criminal activity where there is a risk that the researcher will be placed in physical danger or in legal jeopardy?
No

R16) Will the project specifically recruit individuals who may be involved in illegal or criminal activity?
No

R17) Will the project involve engaging individuals who may be involved in terrorism, radicalisation, extremism or violent activity and other activity that falls within the Counter-Terrorism and Security Act (2015)?
No

Applicant & research team

T1) Principal Applicant

Name
M ss Beatr ce V ncenz

Provide a summary of the researcher's training and experience that is relevant to this research project.
Beatr ce s a th rd-year PhD student and th s study s re ated to her project. She has a ready p anned and conducted two other re ated stud es nvo v ng peop e w th v sua mpa rments. She s a so vo unteer ng to B ndA d char ty for he p ng and ass st ng peop e w th v sua mpa rment. She s

act ve y nvo ved n events to offer company and conversat on to v sua y mpa red peop e and she s tra ned to be a gu de us ng the s ghted gu de techn que.

T2) Co-Applicant(s) at City

T3) External Co-Applicant(s)

T4) Supervisor(s)
Dr S mone Stumpf

Dr A ex Tay or

T5) Do any of the investigators have direct personal involvement in the organisations sponsoring or funding the research that may give rise to a possible conflict of interest?
No

T6) Will any of the investigators receive any personal benefits or incentives, including payment above normal salary, from undertaking the research or from the results of the research above those normally associated with scholarly activity?
No

T7) List anyone else involved in the project.

Project details

P1) Project title
Invest gat ng des gn methods for augment ng s ghted gu d ng partnersh ps w th AI.

P1.1) Short project title

P2) Provide a lay summary of the background and aims of the research, including the research questions (max 400 words).
Des gn ng human-AI systems ntended to support v sua y mpa red peop e nterdependenc es and co aborat on -- such as S ghted Gu d ng (SG) partnersh p [1] – s d ff cu t. When work ng w th AI, trad t ona HCI methods tend to reduce AI comp ex ty to terat ve y bu d rap d prototypes, ref n ng and eva uat ng them w th users. Th s process promotes techno og ca so ut ons that a m to pr or t se ndependence, rather than the co aborat ve work that takes p ace n s ghted gu d ng. For nstance, one of our prev ous stud es wh ch used th s trad t ona approach ed to a prototype wh ch users d d not f nd usefu . Thus, to move beyond the dea of AI as a so ut on and b ndness as d sab ty, we need new des gn methods wh ch he p to nvo ve peop e n the des gn process and pay spec a attent on to the r co aborat ve ach evement and competenc es.

Th s study a ms to deve op a new access b e and nteract ve des gn method to better engage w th SG compan ons, and creat ve y th nk ng about nterdependence and AI, based on des gn workbooks and cu tura probes [2]. Des gn workbooks and cu tura probes are exp oratory methods deve oped to co ect nsp rat ona data for the purposes of def n ng a des gn space and sett ng a des gn trajectory

(e.g., 'How do peop e descr be the r rea -wor d exper ences?', 'How do peop e make sense of d verse scenar os?', and 'What are peop e's responses to a range of techno og ca proposa s/provocat ons?') but they so far have on y been used w th s ghted users, and not app ed to co aborat ve work n s ghted gu d ng nvo v ng AI. Workbooks prov de co ect on of provocat ve des gn proposa s wh ch a m ng to create a space where part c pants can engage w th and expand upon n t a deas, and ref ect ons. Current y workbooks are ma n y v sua , made of sketches, and text, so they are naccess b e for v sua y mpa red peop e. Cu tura probes are tang b e objects, phys ca packets conta n ng open-ended, and tasks to support ear y part c pant engagement w th the des gn process. Cu tura probes have the potent a to be more access b e to a w der popu at on, therefore a comb nat on of these exp oratory methods may he p SG compan ons to th nk about what AI m ght offer n the r partnersh p.

RQ1: How do peop e engage w th a des gn space wh ch attends to the SG partnersh p and modes of commun cat on?

RQ2: How can we get SG compan ons to creat ve y th nk ng about AI as a further resource n commun cat on?

RQ3: How can we make workbooks an access b e nteract ve des gn too for peop e w th d fferent ab t es?

[1] S ghted Gu d ng: https://www.rn b.org.uk/adv ce/gu d ng-b nd-or-part a y-s ghted-person

[2] Gaver, W. (2011). Mak ng Spaces: How Des gn Workbooks Work. https://0-d -acm-org.wam.c ty.ac.uk/do /10.1145/1978942.1979169

P4) Provide a summary and brief explanation of the research design, method, and data analysis.

To address our research quest ons, we are p ann ng to de ver an access b e workbook to part c pant pa rs (.e the s ghted gu d ng compan ons). We ntend to create a m xed co ect on of act v t es and proposa s, compr sed of both d g ta and tang b e mater a s. We carefu y make d g ta mater a s access b e through screen reader and other methods (e.g., pre-recorded aud o). Instead, the rema n ng mater a s w be compr sed of tang b e objects wh ch can be perce ved through touch and hands-on act v t es. We w ask part c pants to nteract w th a mater a and comp ete tasks. Workbook outputs w be our co ected data. Outputs may be n d g ta format, such as screen/aud o record ngs, or phys ca mater a s part c pants have created (e.g., Lego, c ay art facts etc.).

In ne w th COVID-19 government restr ct ons n p ace at the start of the project, the study w be conducted e ther ent re y n-person, remote y, or n a hybr d format. We w ask the part c pant pa rs the r preference on whether they want to take part n an n-person or remote workshop (see Consent Form f e). We choose d fferent formats for severa reasons:

1. Current y, we are not sure whether n-person meet ngs w be a owed at the start of the study, and th s format w he p the ma n researcher to be f ex b e to COVID-19 restr ct ons changes.

2. Even though n-person meet ngs w be a owed, part c pants may not fee comfortab e to trave and/or meet other peop e.

3. We be eve that n-person workshops prov de a more comfortab e space and a more act ve engagement, so f the r sk assessment s ow and peop e are w ng to meet, we w g ve pr or ty to n-person act v t es.

4. Further, data co ect on us ng d fferent approaches cou d be of nterest for further ana ys s, for nstance to compare research methods and understand how the format p ays a ro e n the research quest ons we want to address.

In case of n-person workshop:

Part c pants pa rs w take part n 2.5 hours workshop at C ty, Un vers ty of London w th the ma n researcher (see P5 for further deta s on r sk assessment and safety). We w sp t workbook act v t es nto 3 sess ons w th breaks n between:

- Induct on to COVID-19 measures, workshop a ms, and ntroduct on to each other (15 m nutes)

- Pa r act v ty 1: Workbook - Strengthen the connect on s ghted gu d ng partnersh p (30 m nutes)

- Break (5 m nutes)

- Pa r act v ty 2: Workbook – AI techno ogy proposa s n s ghted gu d ng partnersh p (30 m nutes)

- Break (5 m nutes)

- Pa r act v ty 3: Workbook – AI techno ogy proposa s n s ghted gu d ng partnersh p (30 m nutes)

- Feedback: shar ng of some outputs proposed by another pa r to have further ref ect on on access b ty and deas (15 m nutes)

- Thank you and compensat on (5 m nutes)

The ma n researcher w fac tate the d scuss on.

In case of remote act v t es:

Part c pants pa rs w engage w th the workbook act v t es from home on the r own. We w g ve them 4 days to comp ete a act v t es. Act v t es w be the same proposed n the n-person workshop a ong w th deta ed nstruct ons to how to comp ete them. To promote a d scuss on between part c pants pa rs, we may send some d g ta output (e.g., an anonym zed aud o excerpt or d g ta text summary) made by a pa r to another pa r and ask to aud o record further ref ect on. We w ask perm ss on through nformed consent (see pdf f e). Once workshop has been comp eted, a d g ta outputs w be sent by ema to the ma n researcher, tang b e art facts w be sent back by post through an SAE nstead.

Workbooks and cu tura probes are ntent ona y set aga nst quant tat ve methods and forms of ana ys s that seek one correct nterpretat on of peop e's behav ours, exper ences and needs [3, 4]. In th s project, co ected data from both remote and n-person workshops—both us ng a m xture of workbook entr es and cu tura probes—w be ana ysed us ng qua tat ve, and nterpret ve approach. Spec f ca y, we w terat ve y work through part c pants outputs to dent fy and ref ne sa ent ssues and themes. To address RQ1 we w dent fy themes that enr ch our understand ng of commun cat on n s ghted gu d ng. RQ2 w be addressed by dent fy ng sa ent themes about the use of AI as a resource.

Focus ng on workbooks and cu tura probes as des gn methods for peop e w th v s on mpa rments, we w a so be assess ng to what extent they enab e creat v ty. RQ1 and RQ2 w be further nvest gated by dent fy ng cases where part c pants: ( ) ref ect on the presented proposa s, ( ) adapt deas or des gn proposa s/techno og es, and ( ) deve op new deas wh ch have at east one e ement of nove ty compared to the n t a proposa . W th each of these ways of assess ng creat v ty, we w a so cons der d vers ty n the deas generated, ook ng for cases where part c pants avo d f xat ng on so ut ons and are ab e to ntroduce and work w th mu t p e deas. F na y, to address RQ3, the outputs of the workshop w be subject to an eva uat on n terms of access b ty and overa engagement. We

w ook at pos t ve and negat ve feedback n re at on to use of workbooks, use of screen readers, cha enges n nteract ng w th mater a s, and understand ng of tasks and act v t es.

[3] K rsten Boehner, Janet Vertes , Phoebe Sengers, and Pau Dour sh. 2007. How HCI nterprets the probes. Proceed ngs of the SIGCHI Conference on Human Factors n Comput ng Systems. Assoc at on for Comput ng Mach nery, New York, NY, USA, 1077–1086. DOI:https://do .org/10.1145/1240624.1240789

[4] Connor Graham, Mark Rouncef e d, Mart n G bbs, Frank Vetere, and Ke th Cheverst. 2007. How probes work. In Proceed ngs of the 19th Austra as an conference on Computer-Human Interact on: Enterta n ng User Interfaces, OZCHI 07. Assoc at on for Comput ng Mach nery, New York, NY, USA, 29–37. DOI:https://do .org/10.1145/1324892.1324899

P4.1) If relevant, please upload your research protocol.

P5) What do you consider are the ethical issues associated with conducting this research and how do you propose to address them?

1. Vu nerab e peop e

V sua mpa rment peop e cou d be cons dered vu nerab e. However, we are recru t ng peop e who are ndependent and capab e n the r da y fe. Part c pants who are v sua mpa red are a ready us ng ass st ve techno ogy, such as screen readers, app cat ons and too s to nav gate n the env ronment, for nstance wh te cane, gu de dog or a s ghted gu de. They have an act ve fe and prev ous research has shown that v sua mpa red peop e are ab e to nav gate successfu y. For th s study we are exc uded part c pants w th mob ty prob ems to reduce r sk, and a so exc ude part c pants w th any cogn t ve mpa rment who are not ab e to g ve nformed consent (see nformed consent pdf).

2. Conf dent a ty of data.

- A data w be kept conf dent a and secure. D g ta data w be encrypted and stored n a fo der protected by a password on an externa hard dr ve and w be managed by the ma n researcher. Tang b e mater a s w be kept n a ocked cab net at C ty Un vers ty of London.

- A record ngs rece ved by ema s w be transferred to an externa hard dr ve and erased from the ema nbox prov der.

- We w not use part c pants rea names n any pub cat on and use a pseudonym nstead. Add t ona y, the key to the r dent ty w be kept n a password-protected and encrypted f e.

- A conversat on n d g ta format w be transcr bed and anonym sed n fu by the ma n researcher. On y anonym sed aud o or transcr pt on excepts w be shared w th other part c pants, f and on y f part c pants g ve nformed consent.

- We w ask consent to use d rect quotes for pub cat ons and academ c conferences and workshops.

- Add t ona y, part c pants need to g ve exp c t consent for us ng anonym sed workshop outputs excepts n d g ta format (e.g., p ctures) n academ c pub cat ons, presentat ons and workshops.

See nformed consent f e n attachment.

P6) Project start date

The start date w be the date of approva .

P7) Anticipated project end date
30 Sept 2022

P8) Where will the research take place?
Accord ng to COVID-19 government restr ct ons at the start of the study, th s research may be taken p ace n-person, tota y remote y or n a hybr d format.

Remote study w take p ace at part c pants' home, n-person workshop w take p ace at the Interact on Lab, at C ty, Un vers ty of London, and we w put n p ace measures to guarantee safety, such as soc a d stanc ng, use of san t sers, etc. (see r sk assessment pdf f e, and H6 for further deta s).

P10) Is this application or any part of this research project being submitted to another ethics committee, or has it previously been submitted to an ethics committee?
No

Human participants: information and participation

The options for the following question are one or more of:
'Under 18'; 'Adults at risk'; 'Individuals aged 16 and over potentially without the capacity to consent'; 'None of the above'.

H1) Will persons from any of the following groups be participating in the project?
Adu ts at r sk

H2) How many participants will be recruited?
40

H3) Explain how the sample size has been determined.
Stat st ca samp ng s not re evant for th s research because we adopt a qua tat ve approach. In case of n-person workshops we th nk that engag ng w th a ow number of pa rs w a ow the ma n researcher to g ve enough and equa attent on to a . However, we a so recogn ze the potent a to reach a w der aud ence f the study w be ent re y remote, therefore the samp e s ze has been determ ned cons der ng both sett ngs.

H4) What is the age group of the participants?

Lower	Upper
18	

H5) Please specify inclusion and exclusion criteria.
Part c pants w s gn up to the study on y as a pa r. Both peop e w need to:

- ve together or fee safe and comfortab e to meet each other for do ng the act v t es.
- ve n the UK for remote study, ve n London for n-person workshops,

speak Eng sh,

- adu ts over 18 years o d,
- must be ab e to g ve consent.

Interested pa rs need to meet these nc us on cr ter a:

- The pa r must be composed by a s ghted person and a person reg stered severe y s ght mpa red (prev ous y "b nd") or s ght mpa red (prev ous y "part a y s ghted").

- Have an estab shed gu d ng re at onsh p for at east 3 months.

We exc ude part c pants who have:

- any cogn t ve mpa rments wh ch w mean that they cannot g ve nformed consent.

- Mob ty mpa rment, because the k nd of gu de exper ence can great y change cons der ng th s cond t on and for th s reason t s not appropr ate for our scenar o.

See nc us on and exc us on cr ter a f e n attachment for further deta s

H6) What are the potential risks and burdens for research participants and how will you minimise them?

1. Safety – R sk Assessment due to COVID-19, for both part c pants and the ma n researcher.

Throughout the study we w assess COVID-19 r sk for conduct ng n-person workshops and protect ng part c pants and researcher tak ng reasonab e steps (see r sk assessment f e for deta s). Once a pa r have agreed to meet n-person, we w proceed w th the r sk assessment. We w use the R sk Matr x prov ded by C ty, Un vers ty of London to ass gn a rat ng to a dent f ed hazards. If the f na r sk rat ng dent f ed w th ex st ng contro measures n p ace s above LOW, the study w be conduct ng remote y.

We have dent f ed 3 ma n and potent a hazards re ated to COVID-19: part c pants and researcher enter ng C ty and Interact on ab w th COVID-19, prevent ng transm ss on of COVID-19 dur ng the workshop, and nappropr ate behav ors ead ng to transm ss on of COVID-19. To m t gate these r sks, we w put n p ace severa contro measures:

- any part c pant v s t ng C ty w be nformed that they are not to enter f they are exper enc ng COVID-19 symptoms and w be adv sed to se f- so ate n ne w th government recommendat ons.

- Part c pants and researcher on s te are respons b e for ensur ng they ma nta n s te ru es and soc a d stanc ng wh st on s te.

- Soc a d stanc ng w be n p ace across bu d ng and n the workshop room n ne w th government adv ce.

- Any part c pant w be nformed to use face cover ng wh e on s te and throughout the workshop, un ess they are exempt.

- The researcher w encourage the use of hand san t zer before start ng the workshop. San t zers w a so be ava ab e n the room throughout the workshop.

- The researcher w san t ze a mater a s part c pants need to nteract w th before the workshop.

- The researcher w a so san t ze Interact on Lab furn ture (tab es, cha rs, and door hand es) before the workshop.

- Before the start of the sess on the researcher w g ve an nduct on to out ne appropr ate behav ors to adopt regard ng soc a d stanc ng, face cover ng, and use of san t zers.

In-person workshop

We a so understand that ong sess on can be t r ng and ra se the r sk of stress, for th s reason we w take regu ar breaks and nform part c pants that they can have any break they need.

Remote workshop

Part c pants w send d g ta record ngs to the researcher by ema us ng the r phones. Peop e may have access b ty ssues dur ng th s task comp ement, ead ng to stress and rr tat on fee ngs. To m n m ze th s r sk, we w eave them the cho ce to use any app cat on they are fam ar w th, and we w prov de a deta ed examp e of how to record and share f es by ema . Further, we w nform part c pants they can contact the ma n researcher at any t me f they have any prob em or to d scuss the best procedure for send ng record ngs.

H7) Will you specifically recruit pregnant women, women in labour, or women who have had a recent stillbirth or miscarriage (within the last 12 months)?
No

H8) Will you directly recruit any staff and/or students at City?
None of the above

H8.1) If you intend to contact staff/students directly for recruitment purpose, please upload a letter of approval from the respective School(s)/Department(s).

H9) How are participants to be identified, approached and recruited, and by whom?
We w recru t a max mum of 20 part c pant pa rs of adu ts v ng n UK, w th each pa r composed of a s ghted gu de and a person reg stered severe y s ght mpa red (b nd) or s ght mpa red (part a y s ghted). Interested pa rs need to have an estab shed re at onsh p through gu d ng, mean ng that they are used to nav gat ng together us ng the gu de techn que n the r da y ves for at east 3 months. Indeed, th s pre-estab shed re at onsh p a ows us to have ns ghts on the r 'natura ' pract ce and guarantee safety.

Pa rs of part c pants w be recru ted through an access b e advert sement n p a n text v a soc a med a (Tw tter and Facebook), ema s to ex st ng contacts of the student and superv sors, and by contact ng oca char t es n London and UK.

Peop e who are nterested n the study w be ab e to contact Beatr ce V ncenz v a ema , text, phone or soc a med a for ask ng nformat on and c ar f cat on. The researcher w exp a n them the deta s of the study and determ ne f the pa r f ts the nc us on cr ter a us ng a check st sheet.

H10) Please upload your participant information sheets and consent form, or if they are online (e.g. on Qualtrics) paste the link below.
H11) If appropriate, please upload a copy of the advertisement, including recruitment emails, flyers or letter.
H12) Describe the procedure that will be used when seeking and obtaining consent, including when consent will be obtained.
After part c pants have shown nterest n tak ng part n the study, the ma n researcher w send by ema the part c pant nformat on sheet f rst and we w g ve part c pants 4 days to carefu y read t and ask any c ar f cat on. After that 2 separate nks to the on ne nformed consent survey w be sent to the part c pants pa r for ga n ng consent before any act v ty. We w use Qua tr cs serv ce offered by C ty because t generates an on ne form access b e through screen readers. After the s gnature a pdf copy of the nformed consent w be down oaded and sent to the part c pant.

H13) Are there any pressures that may make it difficult for participants to refuse to take part in the project?
No

H14) Is any part of the research being conducted with participants outside the UK?
No

Human participants: method

The options for the following question are one or more of:
'Invasive procedures (for example medical or surgical)'; 'Intrusive procedures (for example psychological or social)'; 'Potentially harmful procedures of any kind'; 'Drugs, placebos, or other substances administered to participants'; 'None of the above'.

M1) Will any of the following methods be involved in the project:
None of the above

M2) Does the project involve any deceptive research practices?
No

M3) Is there a possibility for over-research of participants?
No

M4) Please upload copies of any questionnaires, topic guides for interviews or focus groups, or equivalent research materials.

M5) Will participants be provided with the findings or outcomes of the project?
Yes

M5.1) Explain how this information will be provided.
The researcher w not prov de the f nd ngs or outcomes of the project to the part c pants d rect y, but she w nform them through the part c pant nformat on sheet that part c pants can request a copy of the resu t to the researcher by ema . In th s case, a f nd ngs summary w be sent to the part c pant n an access b e format.

M6) If the research is intended to benefit the participants, third parties or the local community, please give details.

M7) Are you offering any incentives for participating?
Yes

M7.1) Please give details, justifying their type and amount.
As a thank you for part c pants' pa rs nvo vement, we w offer £20 n Amazon voucher per person.

M8) Does the research involve clinical trial or clinical intervention testing that does not require Health Research Authority or MHRA approval?

No

M9) Will the project involve the collection of human tissue or other biological samples that does not fall under the Human Tissue Act (2004) that does not require Health Research Authority Research Ethics Service approval?
No

M10) Will the project involve potentially sensitive topics, such as participants' sexual behaviour, their legal or political behaviour, their experience of violence?
No

M11) Will the project involve activities that may lead to 'labelling' either by the researcher (e.g. categorisation) or by the participant (e.g. 'I'm stupid', 'I'm not normal')?
No

Human participants: vulnerable

V1) Please provide details of enhanced ethical procedures to safeguard these participants.
We are recru t ng peop e who are ndependent and capab e n the r da y fe. Part c pants who are v sua y mpa red:

- are a ready us ng ass st ve techno ogy, such as screen readers, app cat ons and too s to nav gate n the env ronment, for nstance wh te cane, gu de dog or a s ghted gu de.

- They have an act ve fe, and our prev ous research study has shown that v sua y mpa red peop e are ab e to nav gate successfu y.

Add t ona y, dur ng our sess ons we w adopt act v t es and methods such as tang b e mater a s and objects (such as phones) to express op n ons, and fee ngs. In contrast to v sua mater a s, these methods w he p peop e w th v sua mpa rments to be act ve y engaged. These methods a ow us to set up an access b e env ronment where peop e w th v sua mpa rments w fee comfortab e to share fee ngs.

V2) Please give details of the vulnerable participant protection procedures you propose to adopt should there be any evidence or suspicion of harm (physical, emotional or sexual) to a vulnerable person. Include a referral protocol identifying what to do and who should be contacted.
If the ma n researcher has any ev dence or susp c on of harm (phys ca , emot ona or sexua) to a vu nerab e person, she w prompt y contact superv sors to seek adv ce. After that she w transfer the case to re evant author t es for further nvest gat on.

V3) Please give details of how you propose to ensure the well-being of the vulnerable participant, particularly with respect to ensuring that they do not feel pressured to take part in the research and that they are free to withdraw from the research without any prejudice to themselves at any time.
The ma n researcher w nform part c pants that part c pat on s vo untary, and they can w thdraw from the study at any t me. She w wr te t on the part c pant nformat on sheet, and she w ask

part c pants to conf rm th s statement n the consent form. The target popu at on may nc ude vu nerab e peop e, but t s our ntent on to recru t on y peop e who are ab e to g ve consent.

V4) Will carers, parents, teachers or other parties be present during the research?
No

V5) Are participants able to give informed consent?
Yes

V6) Please give details of any City staff or students who will have contact with adults at risk and/or will have contact with young people (under the age of 18) and the details of current (within the last 3 years) Disclosure and Barring check.

Name
M ss Beatr ce V ncenz

DBS reference number
001646045894

Date of DBS
31 Jan 2019

Type of Disclosure
D sc osure and Barr ng (DBS) enhanced d sc osure check

V7) Please give details of any non-City staff or students who will have contact with adults at risk and/or will have contact with young people (under the age of 18) and the details of current (within the last 3 years) Disclosure and Barring check.

Name

Institution

Address of organisation that requested disclosure

DBS reference number

Date of DBS

Type of disclosure

I w not be recru t ng any part c pants who fa under the Menta Capac ty Act 2005.

Data

D1) Indicate which of the following you will be using to collect your data.

Aud o/d g ta record ng nterv ewees or events
Computer-based tasks, screen record ng or software nstrumentat on
Other

D1.1) Provide details if you have selected other.
tang b e workbook outputs

D2) How will the the privacy of the participants be protected?
De- dent f ed samp es or data

D3) Will the research involve use of direct quotes?
Yes

D5) Where/how do you intend to store your data?
Data to be kept n a ocked f ng cab net
Data and dent f ers to be kept n separate, ocked f ng cab nets
Password protected computer f es
Storage on encrypted dev ce (e.g. aptop, hard dr ve, USB
Storage at C ty

D6) Will personal data collected be shared with other organisations?
No

D7) Will the data be accessed by people other than the named researcher, supervisors or examiners?
Yes

D7.1) Explain by whom and for what purposes.
P ctures and d rect quotes may be used n pub cat ons and presentat ons dur ng academ c events and conferences to descr be sess on procedure, show act v t es, and f nd ngs. In such a case researchers w ask part c pants perm ss on through nformed consent and w ensure that dent f ab e data w be b urred, or anonym sed.

D8) Is the data intended or required (e.g. by funding body) to be published for reuse or to be shared as part of longitudinal research or a different/wider research project now or in the future?
No

D10) How long are you intending to keep the research data generated by the study?
Fo ow ng Un vers ty's gu de nes on retent on, data generated by the study w be reta ned for ten years.

D11) How long will personal data be stored or accessed after the study has ended?
As above, we w store persona data for ten years.

D12) How are you intending to destroy the personal data after this period?
A d g ta data w be permanent y de eted, paper data w be shredded and d sposed of, and tang b e artefacts destroyed.

Health & safety

HS1) Are there any health and safety risks to the researchers over and above that of their normal working life?
Yes

HS2) How have you addressed the health and safety concerns of the researchers and any other people impacted by this project?
We put n p ace a COVID-19 r sk assessment to undertake n case of n-person workshop at C ty. See H6 quest on and f e n attached.

HS3) Are there hazards associated with undertaking this project where a formal risk assessment would be required?
Yes

HS3.1) Has a risk assessment been undertaken?
Yes

C.2 ADVERTISEMENT

Advertisement in plain text to send by e mail

Help shape the future of Assistive Technology

Are you blind or partially sighted, and do you work with a sighted guide? Would you like to help shape the future of Assistive Technologies? You are invited to join a short workshop, as part of a research project, where your experiences will help inform the design of future technologies to strengthen sighted guiding relationships.

Who can participate?
Pairs of adults (over 18) living in UK, composed of a blind or partially sighted person and a sighted guide. You might be family members, friends, work together in a professional capacity, or being part of the VIP World community the regular travel companions through. What's important is experience of moving and navigating as a pair and a trusting relationship. You should not have any physical mobility or cognitive impairment.

What is involved?
A 3 hour online workshop in which you will work together as a pair and complete a number of short activities, presented through an accessible website. You will need a smart phone to participate and some materials that you will receive at home.

Each participant will receive a £50 voucher of their choice. Places are limited.

Who is running the research?
I am a PhD student at City, University of London, where I work with people with sight impairments. I am passionate about exploring with people with visual impairments how assistive technology can be designed to strengthen sighted guiding partnerships.

For more information, and to sign up, please contact me via email: beatrice.vincenzi@city.ac.uk, Mobile: 07955 367 578, or Twitter: @Beatrice vince

Many thanks
Beatrice Vincenzi

Advertisement for social media

Are you blind or partially sighted and do you work with a sighted guide? Your experience can help shape the future of Assistive Technology in a 2 hour workshop looking at how tech can strengthen the guiding relationship. 2x£50 vouchers per pair. More info:
https://workshop.beatricevincenzi.com/

OR

Are you blind or partially sighted and do you work with a sighted guide? Contribute your experience in a research workshop aimed at better supporting sighted guide partnerships and shape future Assistive Technologies. Pairs of participants will receive 2 x £50 vouchers. more info:
https://workshop.beatricevincenzi.com/

Are you blind or partially sighted and do you work with a sighted guide? Contribute your experience in a workshop aimed at better supporting sighted guide partnerships and shape future Assistive Technologies. Pairs will receive 2 x £50 vouchers. more info:
https://workshop.beatricevincenzi.com/

C.3 INCLUSION EXCLUSION CRITERIA CHECKLIST

Screening Criteria for taking part in the study Shape the Future of Assistive Technology in sighted guiding.

Please, answer the following 14 questions separately:

Your personal details:
What is your name?
What is your age?
Do you speak English fluently?
Do you live in UK?
Have you contacted me as a pair of participants?

Thinking about your pair relationship:
Are you a pair composed of a person registered severely sight impaired or sight impaired, and a sighted companion?
Do you usually go around with your companion using a sighted guide technique (e.g., holding an elbow, arm, hand, or shoulder)?
Do you feel comfortable going around with your companion using the sighted guide technique?
How long have you been in a guiding relationship?
Would you feel comfortable to meet your companion for doing some activity together?

Mobility and cognitive impairments:
Do you have a mobility impairment?
Do you have any cognitive impairment?

Further information:
What is your preferred contact method (e.g., email, phone, text, social media?)?
Please, provide your preferred contact details.
Where would you like research materials to be sent to? Please, provide only an address per pair.

Participant Information Sheet

Shape the future of Assistive Technology to strengthen your sighted guiding partnership.

We would like you to take part in workbook activities. Before you decide whether you would like to take part it is important that you understand why the research is being done and what it would involve for you. Please take the time to read the following information carefully. Feel free to ask if you would like more information.

What is the purpose of this study?

The purpose of this research is to reflect on ways AI technology could be used to strengthen sighted guiding partnership. Unlike other technological solutions that aim to prioritise independence, we are much more curious about how technology can support what already works so well, that is, the way visually impaired people and their guides move together.

Why have I been invited to take part?

You have been invited to participate in this research because you expressed interest in participating. Additionally, you are an adult living in UK and are part of a pair composed of a sighted person and a person registered severely sight impaired or sight impaired. To participate in the study your pair needs to have an established relationship in the standard guide configuration. A maximum of 10 other pairs like you and your companion will be involved in the project.

Do I have to take part?

The participation in this research is voluntary and you can decide if you want to take part. Both your companion and you need to agree. It means that if either of you decides to not take part in the study, you will both be automatically excluded, and your contact information will be permanently deleted. You have the right to withdraw at any time without giving a reason. You will not be penalized in any way for not taking part. If your pair choose to continue in the project, you will be asked to sign an online consent form.

What will happen if I take part? What do I have to do?

I will invite your pair to complete workbook activities. These activities are presented through an accessible website. You will need a smartphone for doing tasks and send answers to the researcher. Tools are comprised of digital (e.g., pre-recorded audio) and tangible materials (e.g., bands, post-it, blue tack), and very simple technologies to help stimulate ideas for the role technology might play.

Due to the Pandemic, you can complete activities in a 2.5-hour online workshop. You will receive a link when a time and date have been scheduled. We may ask you to digital record some activities and thoughts, helping us to revise your reflections. Some direct quotes or audio excepts may be shared with other participants pairs. You can express your preference in the consent form. All data will be de-identified and anonymised.

What are the possible benefits of taking part?

There are no direct benefits for taking part in the workshops. However, your participation in this research is greatly appreciated. For your involvement, we will provide 2 x £50 voucher of your choice.

What should I do if I want to take part?

You should contact the main researcher Beatrice Vincenzi, contact details are reported at the end of the document. She will send a link to an online consent form to sign up before arranging any activity.

Data privacy statement

City, University of London is the sponsor and the data controller of this study based in the United Kingdom. This means that we are responsible for looking after your information and using it properly. The legal basis under which your data will be processed is City's public task.
Your right to access, change or move your information are limited, as we need to manage your information in a specific way in order for the research to be reliable and accurate. To safeguard your rights, we will use the minimum personal-identifiable information possible (for further information please see guide to data protection).

City will use your name and contact details to contact you about the research study as necessary. If you wish to receive the results of the study, your contact details will also be kept for this purpose. The only people at City who will have access to your identifiable information will be *Beatrice Vincenzi*. City will keep identifiable information about you from this study for 10 years after the study has finished.

You can find out more about how City handles data by visiting City legal information. If you are concerned about how we have processed your personal data, you can contact the Information Commissioner's Office (IOC) IOC website.

Will my taking part in the study be kept confidential?

Your participation will be kept confidential, and we will take some precautions to guarantee your anonymity. You will receive a pseudonym which will be used instead of your personal name. All digital data will be completely anonymized.

What will happen to the results?

After the study the results will be reported in a written documentation as part of the PhD Thesis of Beatrice Vincenzi. Results could also be published in some academic journals or conferences. In both case we will not include your personal details. If you desire to have a copy of the result, please send a request by email to the researcher Beatrice Vincenzi.

What will happen when the research study stops?

All data will be kept in using secure storage for up to ten years. After the study digital data will be transferred to an external hard disk protected by a password and hard data will be kept in a locked cabinet.

Who has reviewed the study?

This study has been approved by City, University of London's Computer Science Research Ethics Committee.

What if there is a problem?

If you have any problems, concerns or questions about this study, you should ask to speak to a member of the research team. If you remain unhappy and wish to complain formally, you can do this through City's complaints procedure. To complain about the study, you need to phone 020 7040 3040. You can then ask to speak to the Secretary to Senate Research Ethics Committee and inform them that the name of the project is: *Envisioning how AI might strengthen sighted guiding partnership*, conducted by Beatrice Vincenzi.

You can also write to the Secretary at:
Anna Ramberg, Research Integrity Manager
City, University of London, Northampton Square, London, EC1V 0HB
Email: Anna.Ramberg.1@city.ac.uk

Insurance

City holds insurance policies which apply to this study. If you feel you have been harmed or injured by taking part in this study, you may be eligible to claim compensation. This does not affect your legal rights to seek compensation. If you are harmed due to someone's negligence, then you may have grounds for legal action.

Further information and contact details

Beatrice Vincenzi, PhD student, **beatrice.vincenzi@city.ac.uk**.
Mobile: 07955 367 578.

Research Team

Beatrice Vincenzi, Alex Taylor, and Simone Stumpf

Thank you for taking the time to read this information sheet.

BIBLIOGRAPHY

[1] Subeida Ahmed, Harshadha Balasubramanian, Simone Stumpf, Cecily Morrison, Abigail Sellen, and Martin Grayson. "Investigating the intelligibility of a computer vision system for blind users." In: *International Conference on Intelligent User Interfaces, Proceedings IUI* (2020), pp. 419–429. DOI: 10.1145/3377325.3377508.

[2] Dragan Ahmetovic, Valeria Alampi, Cristian Bernareggi, Andrea Gerino, and Sergio Mascetti. "Math Melodiess: Supporting Visually Impaired Primary School Students in Learning Math." In: *Proceedings of the 14th Web for All Conference on The Future of Accessible Work - W4A '17*. 2017, pp. 1–2. ISBN: 9781450349000. DOI: 10.1145/3058555.3058583. URL: http://dx.doi.org/10.1145/3058555.3058583http://dl.acm.org/citation.cfm?doid=3058555.3058583.

[3] Dragan Ahmetovic, Masayuki Murata, Cole Gleason, Erin Brady, Hironobu Takagi, Kris Kitani, and Chieko Asakawa. "Achieving Practical and Accurate Indoor Navigation for People with Visual Impairments." In: *Proceedings of the 14th Web for All Conference on The Future of Accessible Work - W4A '17*. 2017, pp. 1–10. ISBN: 9781450349000. DOI: 10.1145/3058555.3058560. URL: http://dx.doi.org/10.1145/3058555.3058560http://dl.acm.org/citation.cfm?doid=3058555.3058560.

[4] Mara Balestrini, Paul Marshall, Raymundo Cornejo, Monica Tentori, Jon Bird, and Yvonne Rogers. "Joke box: Coordinating shared encounters in public spaces." In: *Proceedings of the ACM Conference on Computer Supported Cooperative Work, CSCW 27* (2016), pp. 38–49. DOI: 10.1145/2818048.2835203.

[5] Maryam Bandukda, Catherine Holloway, Aneesha Singh, and Nadia Berthouze. "PLACES: a framework for supporting blind and partially sighted people in outdoor leisure activities." In: *The 22nd international ACM SIGACCESS conference on computers and accessibility*. 2020, pp. 1–13.

[6] Giulia Barbareschi, Ben Oldfrey, Long Xin, Grace Nyachomba Magomere, Wycliffe Ambeyi Wetende, Carol Wanjira, Joyce Olenja, Victoria Austin, and Catherine Holloway. "Bridging the Divide: Exploring the use of digital and physical technology to aid mobility impaired

people living in an informal settlement." In: *The 22nd International ACM SIGACCESS Conference on Computers and Accessibility*. 2020, pp. 1–13.

[7] Andrew Begel, John Tang, Sean Andrist, Michael Barnett, Tony Carbary, Piali Choudhury, Edward Cutrell, Alberto Fung, Sasa Junuzovic, Daniel McDuff, et al. "Lessons Learned in Designing AI for Autistic Adults." In: *The 22nd International ACM SIGACCESS Conference on Computers and Accessibility*. 2020, pp. 1–6.

[8] Cynthia L. Bennett, Daniela K. Rosner, and Alex S. Taylor. "The Care Work of Access." In: *Conference on Human Factors in Computing Systems - Proceedings* (2020). DOI: 10.1145/3313831.3376568. URL: https://doi.org/10.1145/3313831.3376568.

[9] Cynthia Bennett, Erin Brady, and Stacy M Branham. "Interdependence as a Frame for Assistive Technology Research and Design." In: *ASSETS*. Vol. 18. 2018. ISBN: 9781450356503. DOI: 10.1145/3234695.3236348. URL: https://doi.org/10.1145/3234695.3236348.

[10] Jeffrey P Bigham, Chandrika Jayant, Hanjie Ji, Greg Little, Andrew Miller, Robert C Miller, Robin Miller, Aubrey Tatarowicz, Brandyn White, Samual White, et al. "Vizwiz: nearly real-time answers to visual questions." In: *Proceedings of the 23rd annual ACM symposium on User interface software and technology*. 2010, pp. 333–342.

[11] BlindSquare. *BlindSquare*. Retrieved 17-January-2022. 2016. URL: https://www.blindsquare.com.

[12] Stuart Blume, Vasilis Galis, and Andrés Valderrama Pineda. "Introduction: STS and Disability." In: *Science Technology and Human Values* 39.1 (2014), pp. 98–104. ISSN: 15528251. DOI: 10.1177/0162243913513643. URL: https://journals.sagepub.com/doi/pdf/10.1177/0162243913513643.

[13] Mark Blythe, Enrique Encinas, Jofish Kaye, Miriam Lueck Avery, Rob McCabe, and Kristina Andersen. "Imaginary design workbooks: Constructive criticism and practical provocation." In: *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*. 2018, pp. 1–12.

[14] Susanne Bødker, Pelle Ehn, Dan Sjögren, and Yngve Sundblad. "Co-operative Design—perspectives on 20 years with 'the Scandinavian IT Design Model'." In: *proceedings of NordiCHI*. Vol. 2000. 2000, pp. 22–24.

[15] Kirsten Boehner, Janet Vertesi, Phoebe Sengers, and Paul Dourish. "How HCI Interprets the Probes." In: *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. CHI '07. San Jose, California, USA: Association for Computing Machinery, 2007, pp. 1077–1086. ISBN: 9781595935939. DOI: 10.1145/1240624.1240789. URL: https://doi.org/10.1145/1240624.1240789.

[16] Stacy M Branham and Shaun K Kane. "Collaborative accessibility: How blind and sighted companions co-create accessible home spaces." In: *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*. 2015, pp. 2373–2382.

[17] Stacy M Branham and Shaun K Kane. "The invisible work of accessibility: how blind employees manage accessibility in mixed-ability workplaces." In: *Proceedings of the 17th international acm sigaccess conference on computers & accessibility*. 2015, pp. 163–171.

[18] Virginia Braun and Victoria Clarke. "Using thematic analysis in psychology." In: *Qualitative research in psychology* 3.2 (2006), pp. 77–101.

[19] Virginia Braun and Victoria Clarke. "Thematic analysis." In: (2012).

[20] Tim Brooke. "Workshop: Guidelines for haptic lo-fi prototyping." In: *Guidelines for Haptic Lo-Fi prototyping* (2008), p. 13.

[21] Barry Brown and Matthew Chalmers. "Tourism and mobile technology." In: *Ecscw 2003* September (2003), pp. 335–354. DOI: 10.1007/978-94-010-0068-0 18.

[22] Barry Brown, Moira McGregor, and Donald McMillan. "Searchable objects: Search in everyday conversation." In: *CSCW 2015 - Proceedings of the 2015 ACM International Conference on Computer-Supported Cooperative Work and Social Computing* (2015), pp. 508–517. DOI: 10.1145/2675133.2675206.

[23] Michele A. Burton, Erin Brady, Robin Brewer, Callie Neylan, Jeffrey P. Bigham, and Amy Hurst. "Crowdsourcing subjective fashion advice using vizwiz: Challenges and opportunities." In: *ASSETS'12 - Proceedings of the 14th International ACM SIGACCESS Conference on Computers and Accessibility* (2012), pp. 135–142. DOI: 10.1145/2384916.2384941.

[24] Carrie J Cai, Emily Reif, Narayan Hegde, Jason Hipp, Been Kim, Daniel Smilkov, Martin Wattenberg, Fernanda Viegas, Greg S Corrado, Martin C Stumpf, et al. "Human-centered tools for coping with imperfect algorithms during medical decision-making." In: *Proceed-*

ings of the 2019 chi conference on human factors in computing systems. 2019, pp. 1–14.

[25] Joseph N Cappella and Sally Planalp. "Talk and silence sequences in informal conversations III: Interspeaker influence." In: *Human Communication Research* 7.2 (1981), pp. 117–132.

[26] James I Charlton. *Nothing about us without us*. University of California Press, 1998.

[27] Design Council. *What is the framework for innovation? Design Council's evolved Double Diamond*. Retrieved 17-January-2022. 2015. URL: https://www.designcouncil.org.uk/news-opinion/what-framework-innovation-design-councils-evolved-double-diamond.

[28] Audrey Desjardins, Cayla Key, Heidi R. Biggs, and Kelsey Aschenbeck. "Bespoke booklets: A method for situated co-speculation." In: *DIS 2019 - Proceedings of the 2019 ACM Designing Interactive Systems Conference* (2019), pp. 697–709. DOI: 10.1145/3322276.3322311.

[29] Paul Dourish. "Re-Space-ing Place: "Place" and "Space" Ten Years On." In: *Proceedings of the 2006 20th anniversary conference on Computer supported cooperative work - CSCW '06* (2006), p. 299. DOI: 10.1145/1180875.1180921. URL: http://blogs.iad.zhdk.ch/embodied-interaction-advanced/files/2014/11/p299-dourish.pdfhttp://portal.acm.org/citation.cfm?doid=1180875.1180921.

[30] Brian L. Due and Simon Bierring Lange. "Troublesome Objects: Unpacking Ocular-Centrism in Urban Environments by Studying Blind Navigation Using Video Ethnography and Ethnomethodology." In: *Sociological Research Online* 24.4 (2018), pp. 475–495. ISSN: 13607804. DOI: 10.1177/1360780418811963.

[31] Brian Due and Simon Lange. "Semiotic resources for navigation: A video ethnographic study of blind people's uses of the white cane and a guide dog for navigating in urban areas." In: *Semiotica* 2018.222 (2018), pp. 287–312. ISSN: 16133692. DOI: 10.1515/sem-2016-0196.

[32] Rebecca Fiebrink. "Real-Time Interaction with Supervised Learning." In: *CHI '10 Extended Abstracts on Human Factors in Computing Systems*. CHI EA '10. Atlanta, Georgia, USA: Association for Computing Machinery, 2010, pp. 2935–2938. ISBN: 9781605589305. DOI: 10.1145/1753846.1753889. URL: https://doi.org/10.1145/1753846.1753889.

[33] Rebecca Fiebrink. "Machine learning as meta-instrument: Human-machine partnerships shaping expressive instrumental creation." In: *Musical instruments in the 21st century*. Springer, 2017, pp. 137–151.

[34] Rebecca Fiebrink and Marco Gillies. "Introduction to the Special Issue on Human-Centered Machine Learning." In: *ACM Trans. Interact. Intell. Syst.* 8.2 (2018). ISSN: 2160-6455. DOI: 10.1145/3205942. URL: https://doi.org/10.1145/3205942.

[35] Kelly Fritsch. "Intimate assemblages: Disability, intercorporeality, and the labour of attendant care." In: *Critical Disability Discourses/Discours critiques dans le champ du handicap* 2 (2010), pp. 1–14.

[36] Vasilis Galis. "Enacting disability: how can science and technology studies inform disability studies?" In: *Disability & Society* 26.7 (2011), pp. 825–838.

[37] Sergio Garrido-Jurado, Rafael Muñoz-Salinas, Francisco José Madrid-Cuevas, and Manuel Jesús Marín-Jiménez. "Automatic generation and detection of highly reliable fiducial markers under occlusion." In: *Pattern Recognition* 47.6 (2014), pp. 2280–2292.

[38] Bill Gaver, Tony Dunne, and Elena Pacenti. "Design: Cultural Probes." In: *Interactions* 6.1 (1999), pp. 21–29. ISSN: 1072-5520. DOI: 10.1145/291224.291235. URL: https://doi.org/10.1145/291224.291235.

[39] William W. Gaver, Andrew Boucher, Sarah Pennington, and Brendan Walker. "Cultural probes and the value of uncertainty." In: *Interactions* 11.5 (2004), pp. 53–56. ISSN: 1072-5520. DOI: 10.1145/1015530.1015555.

[40] William Gaver. *Making Spaces: How Design Workbooks Work*. 2011. ISBN: 9781450302678.

[41] Maliheh Ghajargar and Jefrey Bardzell. "Synthesis of Forms: Integrating Practical and Reflective Qualities in Design." In: (2021). DOI: 10.1145/3411764.3445232. URL: https://doi.org/10.1145/3411764.3445232.

[42] David Goode. *Playing with my dog Katie: an ethnomethodological study of dog-human interaction*. Purdue University Press, 2007.

[43] Charles Goodwin. "A Competent Speaker Who Can't Speak: The Social Life of Aphasia." In: *Journal of Linguistic Anthropology* 14.2 (2004), pp. 151–170. ISSN: 1055-1360. DOI: 10.1525/jlin.2004.14.2.151. URL: http://doi.wiley.com/10.1525/jlin.2004.14.2.151.

[44] UK Government. *Assistive Technology definition*. Retrieved 17-January-2022. 2021. URL: https://www.gov.uk/government/publications/assistive-technology-definition-and-safe-use/assistive-technology-definition-and-safe-use.

[45] Douglas Graham and Thomas T Bachmann. *Ideation: The birth and death of ideas*. John Wiley & Sons, 2004.

[46] Martin Grayson, Anja Thieme, Rita Marques, Daniela Massiceti, Ed Cutrell, and Cecily Morrison. "A dynamic AI system for extending the capabilities of blind people." In: *Conference on Human Factors in Computing Systems - Proceedings* (2020). DOI: 10.1145/3334480.3383142.

[47] João Guerreiro, Dragan Ahmetovic, Daisuke Sato, Kris Kitani, and Chieko Asakawa. "Airport accessibility and navigation assistance for people with visual impairments." In: *Conference on Human Factors in Computing Systems - Proceedings* (2019), pp. 1–14. DOI: 10.1145/3290605.3300246.

[48] João Guerreiro, Jefrey P. Bigham, Daisuke Sato, Chieko Asakawa, Hernisa Kacorri, Edward Cutrell, and Dragan Ahmetovic. "Hacking blind navigation." In: *Conference on Human Factors in Computing Systems - Proceedings* (2019), pp. 1–8. DOI: 10.1145/3290607.3299015.

[49] J. M. Hans du Buf, João Barroso, João M.F. Rodrigues, Hugo Paredes, Miguel Farrajota, Hugo Fernandes, João José, Victor Teixeira, and Mário Saleiro. "The SmartVision navigation prototype for blind users." In: *International Journal of Digital Content Technology and its Applications* 5.5 (2011), pp. 351–361. ISSN: 19759339. DOI: 10.4156/jdcta.vol5.issue5.39.

[50] Donna Haraway. *Situated knowledges: The science question in feminism and the privilege of partial perspective*. Routledge, 2020.

[51] Christina Harrington and Tawanna R Dillahunt. "Eliciting Tech Futures Among Black Young Adults: A Case Study of Remote Speculative Co-Design." In: *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*. 2021, pp. 1–15.

[52] Christian Heath. "Embodied action: Video and the analysis of social interaction." In: *Qualitative research* 3 (2011), pp. 250–270.

[53] Christian Heath and Jon Hindmarsh. *Analysing Interaction: Video, ethnography and situated conduct*. Tech. rep. London: King's college London, 2002.

[54] Christian Heath, Hubert Knoblauch, and Paul Luff. "Technology and social interaction: the emergence of 'workplace studies'." In: *The British Journal of Sociology* 51.2 (2000), pp. 299–320. ISSN: 0007-1315. DOI: 10.1111/j.1468-4446.2000.00299.x.

[55] Christian Heath, Marcus Sanchez Svensson, Jon Hindmarsh, Paul Luff, and Dirk Vom Lehn. "Configuring awareness." In: *Computer Supported Cooperative Work (CSCW)* 11.3-4 (2002), pp. 317–347.

[56] Megan Hofmann, Devva Kasnitz, Jennifer Mankoff, and Cynthia L Bennett. "Living Disability Theory: Reflections on Access, Research, and Design." In: *The 22nd International ACM SIGACCESS Conference on Computers and Accessibility*. ASSETS '20. Virtual Event, Greece: Association for Computing Machinery, 2020. ISBN: 9781450371032. DOI: 10.1145/3373625.3416996. URL: https://doi.org/10.1145/3373625.3416996.

[57] Megan Hofmann, Devva Kasnitz, Jennifer Mankoff, and Cynthia L Bennett. "Living disability theory: Reflections on access, research, and design." In: *Proceedings of the 22nd International ACM SIGACCESS Conference on Computers and Accessibility*. 2020, pp. 1–13.

[58] Kristina Hook. *Designing with the body: Somaesthetic interaction design*. MIT Press, 2018.

[59] CloudSight Inc. *TapTapSee application*. Retrieved 17-January-2022. 2014. URL: https://taptapseeapp.com.

[60] QSR International. *NVivo 12 software*. Retrieved 17-January-2022. 2018. URL: https://www.qsrinternational.com/nvivo-qualitative-data-analysis-software/home.

[61] Rabia Jafri and Marwa Mahmoud Khan. "User-centered design of a depth data based obstacle detection and avoidance system for the visually impaired." In: *Human-centric Computing and Information Sciences* 8.1 (2018), p. 14. ISSN: 21921962. DOI: 10.1186/s13673-018-0134-9. URL: https://hcis-journal.springeropen.com/articles/10.1186/s13673-018-0134-9.

[62] Nusrat Jahan, Giulia Barbareschi, Clara Aranda Jan, Charles Musungu Mutuku, Naemur Rahman, Victoria Austin, and Catherine Holloway. "Inclusion and Independence: The impact of Mobile Technology on the Lives of Persons with Disabilities in Kenya and Bangladesh." In: *2020 IEEE Global Humanitarian Technology Conference (GHTC)*. IEEE. 2020, pp. 1–8.

[63] Chandrika Jayant, Hanjie Ji, Samuel White, and Jeffrey P. Bigham. "Supporting Blind Photography." In: *The Proceedings of the 13th International ACM SIGACCESS Conference on Computers and Accessibility*. ASSETS '11. Dundee, Scotland, UK: Association for Computing Machinery, 2011, pp. 203–210. ISBN: 9781450309202. DOI: 10.1145/2049536.2049573. URL: https://doi.org/10.1145/2049536.2049573.

[64] Preece Jennifer, Rogers Yvonne, and Sharp Helen. "Interaction design: beyond human-computer interaction." In: *NY: Wiley* (2002).

[65] Brigitte Jordan and Austin Henderson. "Interaction Analysis: Foundations and Practice." In: *Journal of the Learning Sciences* 4.1 (1995), pp. 39–103. ISSN: 15327809. DOI: 10.1207/s15327809jls0401 2.

[66] Hernisa Kacorri, Kris M. Kitani, Jeffrey P. Bigham, and Chieko Asakawa. "People with Visual Impairment Training Personal Object Recognizers: Feasibility and Challenges." In: *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*. CHI '17. Denver, Colorado, USA: Association for Computing Machinery, 2017, pp. 5839–5849. ISBN: 9781450346559. DOI: 10.1145/3025453.3025899. URL: https://doi.org/10.1145/3025453.3025899.

[67] Seita Kayukawa, Keita Higuchi, João Guerreiro, Shigeo Morishima, Yoichi Sato, Kris Kitani, and Chieko Asakawa. "BBEEP: A sonic collision avoidance system for blind travellers and nearby pedestrians." In: *Conference on Human Factors in Computing Systems - Proceedings* (2019), pp. 1–12. DOI: 10.1145/3290605.3300282.

[68] Wally JW Keijzer-Broers and M de Reuver. "Applying agile design sprint methods in action design research: prototyping a health and wellbeing platform." In: *International Conference on Design Science Research in Information System and Technology*. Springer. 2016, pp. 68–80.

[69] Christine Kelly. "Building bridges with accessible care: Disability studies, feminist care scholarship, and beyond." In: *Hypatia* 28.4 (2013), pp. 784–800. ISSN: 08875367. DOI: 10.1111/j.1527-2001.2012.01310.x.

[70] Eric Laurier et al. "Driving and 'passengering': Notes on the ordinary organization of car travel." In: *Mobilities* 3.1 (2008), pp. 1–23. ISSN: 17450101. DOI: 10.1080/17450100701797273.

[71] Kyungjun Lee, Jonggi Hong, Simone Pimento, Ebrima Jarjue, and Hernisa Kacorri. "Revisiting Blind Photography in the Context of Teachable Object Recognizers." In: *The 21st*

International ACM SIGACCESS Conference on Computers and Accessibility. ASSETS '19. Pittsburgh, PA, USA: Association for Computing Machinery, 2019, pp. 83–95. ISBN: 9781450366762. DOI: 10.1145/3308561.3353799. URL: https://doi.org/10.1145/3308561.3353799.

[72] Kyungjun Lee, Daisuke Sato, Saki Asakawa, Chieko Asakawa, and Hernisa Kacorri. "Accessing Passersby Proxemic Signals through a Head-Worn Camera: Opportunities and Limitations for the Blind." In: *Proceedings of the 23rd International ACM SIGACCESS Conference on Computers and Accessibility*. ASSETS '21. Virtual Event, USA: Association for Computing Machinery, 2021. ISBN: 9781450383066. DOI: 10.1145/3441852.3471232. URL: https://doi.org/10.1145/3441852.3471232.

[73] Young Hoon Lee and Gérard Medioni. "RGB-D camera based wearable navigation system for the visually impaired." In: *Computer Vision and Image Understanding* 149 (2016), pp. 3–20. ISSN: 1090235X. DOI: 10.1016/j.cviu.2016.03.019. URL: https://doi.org/10.1016/j.cviu.2016.03.019.

[74] van der Linden, Clara Mancini, Janet van der Linden, Jon Bryan, and Andrew Stuart. "Exploring interspecies sensemaking: dog tracking semiotics and multispecies ethnography." In: (2012), pp. 143–152. DOI: 10.1145/2370216.2370239. URL: http://dx.doi.org/.

[75] Eric Livingston. *Making sense of ethnomethodology*. Taylor & Francis, 1987.

[76] Christina Low, Emma McCamey, Cole Gleason, Patrick Carrington, Jeffrey P. Bigham, and Amy Pavel. "Twitter A11y: A Browser Extension to Describe Images." In: *The 21st International ACM SIGACCESS Conference on Computers and Accessibility*. ASSETS '19. Pittsburgh, PA, USA: Association for Computing Machinery, 2019, pp. 551–553.

[77] Haley MacLeod, Cynthia L. Bennett, Meredith Ringel Morris, and Edward Cutrell. "Understanding Blind People's Experiences with Computer-Generated Captions of Social Media Images." In: *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*. CHI '17. Denver, Colorado, USA: Association for Computing Machinery, 2017, pp. 5988–5999. ISBN: 9781450346559. DOI: 10.1145/3025453.3025814. URL: https://doi.org/10.1145/3025453.3025814.

[78] Hannah Macpherson. "Walkers with visual-impairments in the British countryside: Picturesque legacies, collective enjoyments and well-being benefits." In: *Journal of Rural*

Studies 51 (2017), pp. 251–258. ISSN: 07430167. DOI: 10.1016/j.jrurstud.2016.10.001. URL: http://dx.doi.org/10.1016/j.jrurstud.2016.10.001.

[79] Parth Mehta, Pavas Kant, Poojan Shah, and Anil K Roy. "VI-Navi : A Novel Indoor Navigation System for Visually Impaired People." In: *International Conference on Computer Systems and Technologies – CompSysTech'11 VI-Navi:* 11 (2011), pp. 365–371. ISSN: 9781450309172. DOI: 10.1145/2023607.2023669.

[80] Helena M. Mentis and Alex S. Taylor. "Imaging the body: Embodied vision in minimally invasive surgery." In: *Conference on Human Factors in Computing Systems - Proceedings* (2013), pp. 1479–1488. DOI: 10.1145/2470654.2466197.

[81] Oussama Metatla, Nick Bryan-Kinns, Tony Stockman, and Fiore Martin. "Designing with and for people living with visual impairments: audio-tactile mock-ups, audio diaries and participatory prototyping." In: *CoDesign* 11.1 (2015), pp. 35–48. ISSN: 17453755. DOI: 10.1080/15710882.2015.1007877.

[82] Mei Miao, Wiebke Köhlmann, Maria Schiewe, and Gerhard Weber. "Tactile paper prototyping with blind subjects." In: *International Conference on Haptic and Audio Interaction Design*. Springer. 2009, pp. 81–90.

[83] Microsoft. *Microsoft Soundscape*. Retrieved 17-January-2022. 2019. URL: https://www.microsoft.com/en-us/research/product/soundscape/.

[84] Microsoft. *SeeingAI*. Retrieved 15-May-2020. 2019. URL: https://www.microsoft.com/en-us/ai/seeing-ai.

[85] Microsoft and Guide Dogs for the Blind. *The Cities Unlocked*. Retrieved 18-January-2022. 2014. URL: https://www.guidedogs.org.uk/cities-unlocked.

[86] Jennie Middleton and Hari Byles. "Interdependent temporalities and the everyday mobilities of visually impaired young people." In: *Geoforum* 102.April (2019), pp. 76–85. ISSN: 00167185. DOI: 10.1016/j.geoforum.2019.03.018. URL: https://doi.org/10.1016/j.geoforum.2019.03.018.

[87] Lorenza Mondada. "Emergent focused interactions in public places: A systematic analysis of the multimodal achievement of a common interactional space." In: *Journal of Pragmatics* 41 (2008). DOI: 10.1016/j.pragma.2008.09.019. URL: www.elsevier.com/locate/pragma.

[88] Cecily Morrison, Edward Cutrell, Anupama Dhareshwar, Kevin Doherty, Anja Thieme, and Alex Taylor. "Imagining Artificial Intelligence Applications with People with Visual Disabilities using Tactile Ideation." In: (2017). DOI: 10.1145/3132525.3132530. URL: https://doi.org/10.1145/3132525.3132530.

[89] Cecily Morrison, Edward Cutrell, Martin Grayson, Anja Thieme, Alex S Taylor, Geert Roumen, Camilla Longden, Sebastian Tschiatschek, Rita Faia Marques, and Abigail Sellen. "Social Sensemaking with AI: Designing an Open-ended AI Experience with a Blind Child; Social Sensemaking with AI: Designing an Open-ended AI Experience with a Blind Child." In: (). DOI: 10.1145/3411764.3445290. URL: https://doi.org/10.1145/3411764.3445290.

[90] Ingunn Moser. "Disability and the promises of technology: Technology, subjectivity and embodiment within an order of the normal." In: *Information Communication and Society* 9.3 (2006), pp. 373–395. ISSN: 1369118X. DOI: 10.1080/13691180600751348.

[91] Henrik Mucha, Dennis Mevißen, Sebastian Robert, Ricarda Jacobi, Kirsten Meyer, Winfried Heusler, and Daniel Arztmann. "Co-Design Futures for AI and Space: A Workbook Sprint." In: *Extended Abstracts of the 2020 CHI Conference on Human Factors in Computing Systems*. 2020, pp. 1–8.

[92] Michael J. Muller and Sarah Kuhn. "Participatory Design." In: *Commun. ACM* 36.6 (1993), pp. 24–28. ISSN: 0001-0782. DOI: 10.1145/153571.255960. URL: https://doi.org/10.1145/153571.255960.

[93] UK National Health Service. *BeSpecular - Help the Blind*. Retrieved 17-January-2022. 2016. URL: https://www.bespecular.com/.

[94] UK National Health Service. *Blindness and vision loss*. Retrieved 17-January-2022. 2022. URL: https://www.nhs.uk/conditions/vision-loss/.

[95] Timothy Neate, Aikaterini Bourazeri, Abi Roper, Simone Stumpf, and Stephanie Wilson. "Co-Created Personas: Engaging and Empowering Users with Diverse Needs Within the Design Process." In: *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*. CHI '19. Glasgow, Scotland Uk: Association for Computing Machinery, 2019, pp. 1–12. ISBN: 9781450359702. DOI: 10.1145/3290605.3300880. URL: https://doi.org/10.1145/3290605.3300880.

[96] Marianna Obrist, Sue Ann Seah, and Sriram Subramanian. "Talking about tactile experiences." In: *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. 2013, pp. 1659–1668.

[97] Makoto Okamoto. "Possibility of participatory design." In: *International Conference on Human Centered Design*. Springer. 2009, pp. 888–893.

[98] Michael Oliver. "The social model in context." In: *Understanding disability*. Springer, 1996, pp. 30–42.

[99] Optelec. *Ruby - Handheld Magnifier*. Retrieved 18-January-2022. 2014. URL: https://uk.optelec.com/products/880123-007-ruby-hd.html.

[100] World Health Organisation. *Blindness and vision impairment*. Retrieved 17-January-2022. 2022. URL: https://www.who.int/news-room/fact-sheets/detail/blindness-and-visual-impairment.

[101] Nicole Perterer, Petra Sundström, Alexander Meschtscherjakov, David Wilfinger, and Manfred Tscheligi. "Come drive with me: An ethnographic study of driver-passenger pairs to inform future in-car assistance." In: *Proceedings of the ACM Conference on Computer Supported Cooperative Work, CSCW* (2013), pp. 1539–1548. DOI: 10.1145/2441776.2441952.

[102] James Pierce. "In Tension with Progression: Grasping the Frictional Tendencies of Speculative, Critical, and other Alternative Designs." In: (). DOI: 10.1145/3411764.3445406. URL: https://doi.org/10.1145/3411764.3445406.

[103] Beryl Plimmer, Andrew Crossan, Stephen A Brewster, and Rachel Blagojevic. "Multimodal collaborative handwriting training for visually-impaired people." In: *Proceeding of the twenty-sixth annual CHI conference on Human factors in computing systems - CHI '08*. 2008, p. 393. ISBN: 9781605580111. DOI: 10.1145/1357054.1357119. URL: www.sensable.comhttp://portal.acm.org/citation.cfm?doid=1357054.1357119.

[104] Martin Porcheron, Joel E. Fischer, Stuart Reeves, and Sarah Sharples. "Voice interfaces in everyday life." In: *Conference on Human Factors in Computing Systems - Proceedings* 2018-April (2018), pp. 1–12. DOI: 10.1145/3173574.3174214.

[105] RNIB. *Sighted Guide Technique*. Retrieved 17-January-2022. 2020. URL: https://www.rnib.org.uk/advice/guiding-blind-or-partially-sighted-person.

[106] Daniel Richardson, Rick Dale, and Kevin Shockley. "Synchrony and swing in conversation: Coordination, temporal dynamics, and communication." In: *Embodied communication in humans and machines* (2008), pp. 75–94.

[107] Karen Ruhleder and Brigitte Jordan. "Co-constructing non-mutual realities: Delay-generated trouble in distributed interaction." In: *Computer Supported Cooperative Work (CSCW)* 10.1 (2001), pp. 113–138.

[108] Stuart J. (Stuart Jonathan) Russell, Peter Norvig, and Ming-Wei Chang. *Artificial intelligence: a modern approach*. English. Fourth, Global. Harlow, United Kingdom: Pearson, 2022. ISBN: 9781292401171;1292401176;

[109] Harvey Sacks, Emanuel A. Schegloff, and Gail Jefferson. "A Simplest Systematics for the Organization of Turn-Taking for Conversation." In: *Language* 50.4 (1974), p. 696. DOI: 10.2307/412243. URL: https://doi.org/10.2307%2F412243.

[110] Nuzhah Gooda Sahib, Tony Stockman, Anastasios Tombros, and Oussama Metatla. "Participatory design with blind users: a scenario-based approach." In: *IFIP Conference on Human-Computer Interaction*. Springer. 2013, pp. 685–701.

[111] Clinton R Sanders. "The impact of guide dogs on the identity of people with visual impairments." In: *Anthrozoös* 13.3 (2000), pp. 131–139.

[112] EB-N Sanders. "Generative tools for co-designing." In: *Collaborative design*. Springer, 2000, pp. 3–12.

[113] Elizabeth B-N Sanders and Pieter Jan Stappers. "Co-creation and the new landscapes of design." In: *Co-design* 4.1 (2008), pp. 5–18.

[114] Emanuel A Schegloff. "Overlapping talk and the organization of turn-taking for conversation." In: *Language in society* 29.1 (2000), pp. 1–63.

[115] Emanuel A. Schegloff, Gail Jefferson, and Harvey Sacks. "The Preference for Self-Correction in the Organization of Repair in Conversation." In: *Linguistic Society of America* 53.2 (1977), pp. 361–382.

[116] Emanuel A Schegloff and Harvey Sacks. *Opening up Closings*. Tech. rep. 1973.

[117] Douglas Schuler and Aki Namioka. *Participatory design: Principles and practices*. CRC Press, 1993.

[118] Phoebe Sengers, Rainer Liesendahi, Werner Magar, Christoph Seibert, Boris Müller, Thorston Joachims, Weidong Geng, Pia Mårtensson, and Kristina Höök. "The Enigmatics of Affect." In: *Proceedings of the 4th Conference on Designing Interactive Systems: Processes, Practices, Methods, and Techniques*. DIS '02. London, England: Association for Computing Machinery, 2002, pp. 87–98. ISBN: 1581135157. DOI: 10.1145/778712.778728.

[119] Kristen Shinohara, B Thomas Golisano, Jacob O Wobbrock, and Wanda Pratt. "Incorporating Social Factors in Accessible Design." In: *ASSETS* 18 (). DOI: 10.1145/3234695.3236346. URL: https://doi.org/10.1145/3234695.3236346.

[120] Kristen Shinohara, Nayeri Jacobo, Wanda Pratt, and Jacob O Wobbrock. "Design for Social Accessibility Method Cards: Engaging Users and Reflecting on Social Scenarios for Accessible Design." In: *ACM Transactions on Accessible Computing (TACCESS)* 12.4 (2020), pp. 1–33.

[121] Kristen Shinohara and Jacob O Wobbrock. "In the shadow of misperception: assistive technology use and social interactions." In: *Proceedings of the SIGCHI conference on human factors in computing systems*. 2011, pp. 705–714.

[122] Kristen Shinohara and Jacob O Wobbrock. "Self-conscious or self-confident? A diary study conceptualizing the social accessibility of assistive technology." In: *ACM Transactions on Accessible Computing (TACCESS)* 8.2 (2016), pp. 1–31.

[123] British Blind Sport. *Sport activities*. Retrieved 17-January-2022. 2020. URL: https://britishblindsport.org.uk/play-sport/links/.

[124] Lee Stearns and Anja Thieme. "Automated Person Detection in Dynamic Scenes to Assist People with Vision Impairments: An Initial Investigation." In: *Proceedings of the 20th International ACM SIGACCESS Conference on Computers and Accessibility*. ASSETS '18. Galway, Ireland: Association for Computing Machinery, 2018, pp. 391–394. ISBN: 9781450356503. DOI: 10.1145/3234695.3241017. URL: https://doi.org/10.1145/3234695.3241017.

[125] Kate Stephens, Matthew Butler, Leona M Holloway, Cagatay Goncu, and Kim Marriott. "Smooth Sailing? Autoethnography of Recreational Travel by a Blind Person." In: *The 22nd International ACM SIGACCESS Conference on Computers and Accessibility*. ASSETS '20. Virtual Event, Greece: Association for Computing Machinery, 2020. ISBN: 9781450371032. DOI: 10.1145/3373625.3417011. URL: https://doi.org/10.1145/3373625.3417011.

[126] Anna Ståhl, Kristina Höök, Martin Svensson, Alex S. Taylor, and Marco Combetto. "Experiencing the Affective Diary." In: *Personal Ubiquitous Comput.* 13.5 (2009), pp. 365–378. ISSN: 1617-4909. DOI: 10.1007/s00779-008-0202-7.

[127] Lucy Suchman. *Human–Machine Reconfigurations: Plans and Situated Actions*. Cambridge University Press, 2007. DOI: 10.1017/cbo9780511808418.017.

[128] Lucy Suchman. "Agencies in technology design: Feminist reconfigurations." In: *Machine Ethics and Robot Ethics*. Routledge, 2020, pp. 361–375.

[129] Cella M Sum, Rahaf Alharbi, Franchesca Spektor, Cynthia L Bennett, Christina N Harrington, Katta Spiel, and Rua Mae Williams. "Dreaming Disability Justice in HCI." In: *Extended Abstracts of the 2022 CHI Conference on Human Factors in Computing Systems*. CHI EA '22. New Orleans, LA, USA: Association for Computing Machinery, 2022. ISBN: 9781450391566. DOI: 10.1145/3491101.3503731. URL: https://doi.org/10.1145/3491101.3503731.

[130] M. Swobodzinski and Raubal M. "An Indoor Routing Algorithm for the Blind: Development and Comparison to a Routing Algorithm for the Sighted." In: *International Journal of Geographical Information Science* 23.10 (2009), pp. 1315–1343.

[131] Lida Theodorou, Daniela Massiceti, Luisa Zintgraf, Simone Stumpf, Cecily Morrison, Edward Cutrell, Matthew Tobias Harris, and Katja Hofmann. "Disability-first Dataset Creation: Lessons from Constructing a Dataset for Teachable Object Recognition with Blind and Low Vision Data Collectors." In: *The 23rd International ACM SIGACCESS Conference on Computers and Accessibility*. 2021, pp. 1–12.

[132] Anja Thieme, Cynthia L Bennett, Cecily Morrison, Edward Cutrell, and Alex S Taylor. ""I can do everything but see!"–How People with Vision Impairments Negotiate their Abilities in Social Contexts." In: *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*. 2018, pp. 1–14.

[133] Anja Thieme, Cecily Morrison, Nicolas Villar, Martin Grayson, and Siân Lindley. "Enabling Collaboration in Learning Computer Programing Inclusive of Children with Vision Impairments." In: *Proceedings of the 2017 Conference on Designing Interactive Systems - DIS '17*. 2017, pp. 739–752. ISBN: 9781450349222. DOI: 10.1145/3064663.3064689. URL: http://dx.doi.org/10.1145/3064663.3064689http://dl.acm.org/citation.cfm?doid=3064663.3064689.

[134] Yingli Tian, Xiaodong Yang, Chucai Yi, and Aries Arditi. "Toward a computer vision-based wayfinding aid for blind persons to access unfamiliar indoor environments." In: *Machine Vision and Applications* 24.3 (2013), pp. 521–535. ISSN: 09328092. DOI: 10.1007/s00138-012-0431-7.

[135] Laura & Tom. *Ramble tag website*. Retrieved 17-January-2022. 2018. URL: https://rambletag.co.uk.

[136] Frank Vetere, Martin R. Gibbs, Jesper Kjeldskov, Steve Howard, Florian 'Floyd' Mueller, Sonja Pedell, Karen Mecoles, and Marcus Bunyan. "Mediating Intimacy: Designing Technologies to Support Strong-Tie Relationships." In: CHI '05 (2005), pp. 471–480. DOI: 10.1145/1054972.1055038.

[137] Beatrice Vincenzi. "AI Assistive Technology for Extending Sighted Guiding." In: *ACM SIGACCESS Accessibility and Computing* 129 (2021). URL: http://www.sigaccess.org/newsletter/2021-01/vincenzi.html.

[138] Beatrice Vincenzi. "Exploring AI-enabled Assistive Technology in Sighted Guiding." In: *Proceedings of Artificially Intelligent Technology for the Margins (CHI'21 Workshop)*. ACM New York NY USA. 2021, p. 6.

[139] Beatrice Vincenzi, Alex S. Taylor, and Simone Stumpf. "Interdependence in Action: People with Visual Impairments and Their Guides Co-Constituting Common Spaces." In: *Proc. ACM Hum.-Comput. Interact.* 5.CSCW1 (2021). DOI: 10.1145/3449143. URL: https://doi.org/10.1145/3449143.

[140] Beatrice Vincenzi, Alex Taylor, and Simone Stumpf. "Hacking Sighted Guide Navigation." In: *Proceedings of Hacking Blind Navigation (CHI'19 Workshop)*. ACM New York NY USA. 2019, p. 6.

[141] Ryan Wedoff, Lindsay Ball, Amelia Wang, Yi Xuan Khoo, Lauren Lieberman, and Kyle Rector. "Virtual showdown: An accessible virtual reality game with scaffolds for youth with visual impairments." In: *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*. 2019, pp. 1–15.

[142] Peter Weeks. "Synchrony Lost , Synchrony Regained : The Achievement of Musical Co-Ordination Author(s): Peter Weeks Reviewed work (s): Published by : Springer Stable URL : http://www.jstor.org/stable/20011105 . Your use of the JSTOR archive indicates your acceptan." In: 19.2 (2013), pp. 199–228.

[143] Michele A. Williams, Caroline Galbraith, Shaun K. Kane, and Amy Hurst. ""just let the cane hit it": how the blind and sighted see navigation differently." In: *ACM SIGACCESS conference on Computers & accessibility*. Vol. 8. 9. 2014, pp. 217–224. ISBN: 9781450327206. DOI: 10.1145/2661334.2661380. URL: http://dl.acm.org/citation.cfm?doid=2661334.2661380.

[144] Stephanie Wilson, Abi Roper, Jane Marshall, Julia Galliers, Niamh Devane, Tracey Booth, and Celia Woolf. "Codesign for people with aphasia through tangible design languages." In: *CoDesign* 11.1 (2015), pp. 21–34.

[145] J O Wobbrock, S K Kane, K Z Gajos, S Harada, and J Froehlich. "Ability-based design: Concept, principles and examples." In: *ACM Trans. Access. Comput* 3.9 (2011), p. 27. DOI: 10.1145/1952383.1952384. URL: http://doi.acm.org/10.1145/1952383.1952384.

[146] Shaomei Wu, Jeffrey Wieland, Omid Farivar, and Julie Schiller. "Automatic alt-text: Computer-generated image descriptions for blind users on a social network service." In: *Proceedings of the 2017 ACM Conference on Computer Supported Cooperative Work and Social Computing*. 2017, pp. 1180–1192.

[147] Qian Yang, Justin Cranshaw, Saleema Amershi, Shamsi T Iqbal, and Jaime Teevan. "Sketching nlp: A case study of exploring the right things to design with language intelligence." In: *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*. 2019, pp. 1–12.

[148] Qian Yang, Aaron Steinfeld, Carolyn Rosé, and John Zimmerman. "Re-examining Whether, Why, and How Human-AI Interaction Is Uniquely Difficult to Design." In: (). DOI: 10.1145/3313831.3376301. URL: http://dx.doi.org/10.1145/3313831.3376301.

[149] Yuhang Zhao, Edward Cutrell, Christian Holz, Meredith Ringel Morris, Eyal Ofek, and Andrew D. Wilson. "SeeingVR: A Set of Tools to Make Virtual Reality More Accessible to People with Low Vision." In: *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems - CHI '19*. New York, New York, USA: ACM Press, 2019, pp. 1–14. ISBN: 9781450359702. DOI: 10.1145/3290605.3300341. URL: http://dl.acm.org/citation.cfm?doid=3290605.3300341.

[150] Yuhang Zhao, Shaomei Wu, Lindsay Reynolds, and Shiri Azenkot. "A Face Recognition Application for People with Visual Impairments: Understanding Use Beyond the Lab." In: *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*.

CHI '18. Montreal QC, Canada: Association for Computing Machinery, 2018, pp. 1–14. ISBN: 9781450356206. DOI: 10.1145/3173574.3173789. URL: https://doi.org/10.1145/3173574.3173789.

[151] Michael Zöllner, Stephan Huber, Hans Christian Jetter, and Harald Reiterer. "NAVI – A proof-of-concept of a mobile navigational aid for visually impaired based on the microsoft kinect." In: *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)* 6949 LNCS.PART 4 (2011), pp. 584–587. ISSN: 03029743. DOI: 10.1007/978-3-642-23768-3 88.

[152] BlindAid charity. *BlindAid for visually impaired Londoners since 1834 – website*. Retrieved 17-January-2022. 1834. URL: https://www.blindaid.org.uk.

[153] Be my eyes. *Be My Eyes - See the World Together*. Retrieved 17-January-2022. 2015. URL: https://www.bemyeyes.com/.

[154] openCV. *openCV Library and Documentation*. Retrieved 17-January-2022. 2011. URL: https://opencv.org/.

COLOPHON

This document was typeset using the typographical look-and-feel `classicthesis` developed by André Miede and Ivo Pletikosić. The style was inspired by Robert Bringhurst's seminal book on typography "*The Elements of Typographic Style*". `classicthesis` is available for both LaTeX and LyX:

https://bitbucket.org/amiede/classicthesis/

Final Version as of June 13, 2023 (classicthesis v4.6).