"I can do everything but see!" – How People with Vision Impairments Negotiate their Abilities in Social Contexts

Anja Thieme[1], Cynthia L. Bennett[3], Cecily Morrison[1], Ed Cutrell[2] and Alex S. Taylor[4]

Microsoft Research
[1]Cambridge, UK
[2]Redmond, US
{anthie/cecilym/cutrell@microsoft.com}

[3]Computing Science & Engineering,
University of Washington,
Seattle, US
{bennec3@cs.washington.edu}

[4]Centre for HCI Design
City University London,
London, UK
{Alex.Talor@city.ac.uk}

ABSTRACT

This research takes an orientation to visual impairment (VI) that does not regard it as fixed or manifested alone through the body. Instead, we consider *(dis)ability* as produced through interactions with the environment and configured by the people and technology within it. Specifically, we explore how abilities become negotiated through video ethnography with six VI athletes and spectators during the Rio 2016 Paralympics. We use generated in-depth examples to identify how technology can be a meaningful part of ability negotiations, emphasizing how these embed into the social interactions and lives of people with VI. In contrast to treating technology as a solution to a 'sensory deficit', we pose for it to support the triangulation process of sense-making through provision of appropriate additional information. Further, we suggest that technology should not replace other people as helpers and information providers, and instead build social bridges to better support people with VI to identify and manage those others as a key resource.

Author Keywords

Ability; vision impairment; blindness; accessibility; assistive technology; social technology; collaboration; ethnography.

ACM Classification Keywords

H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION

Vision impairment (VI) is often defined as a functional limitation of the eyes or vision system, indicating the extent of vision that cannot be corrected to a 'normal' level [16]. Much existing HCI accessibility research has focused on assisting people with VI to circumvent visual problems, adapt to a world that assumes vision, and carry out daily activities more independently [i.e. 14, 25, 38]. Our research takes a different orientation to VI that builds on a definition by the World Health Organization [60], describing disability as "*a complex phenomenon, reflecting the interaction between features of a person's body and features of the society in which he or she lives"*. This recognizes disability as something that is not fixed or manifested alone through the body (e.g., an impaired sense), but created through interactions between a person and their environment. In line with the "social model" of disability [39, 45], this orientation places the responsibility of addressing disability on everyone collectively [cf. 9, 10], including technology designers.

To build an understanding of the interactions that create disability, we draw on work by Ingunn Moser [37], who describes how disability is configured through the social and material environment. It is through a person's continuous interactions within the social and material world that ability or disability is constructed [cf. 23]. As a result, ability or "*disability is not something a person is, but something a person becomes"* [37, p.668]. For example, whether a person is more or less able to climb a mountain may not only be determined by bodily fitness, but by how they interact with the physical world (using i.e. ladders, climbing tools or GPS devices) and other people, who may offer a hand to pull them up in critical moments. By understanding how such *situated negotiations* occur, we believe we can start to imagine how to support the extent of a person's ability – their capability.

Our research therefore seeks to provide insights into how people with VI build an understanding of, and construct their own abilities to interact within, different contexts. To this end, we present ethnographic video research capturing the experiences of two Paralympic athletes and four spectators with VI who attended the Rio 2016 Paralympic games. The Paralympics are an inspiring event for those living with an impairment that forefronts ability and capability, and expose VI spectators and athletes to new experiences whilst travelling to, and engaging in activities surrounding, the event. These can present challenges to how they construct their abilities in different situations, and thus, can make processes of ability negotiation more visible. The aim of our research then is to identify how technology can assist in negotiations of ability and serve to extent capability.

Our findings contribute examples that describe in rich detail how people with varying types of VI build an understanding of different contexts. We demonstrate how their negotiations of ability present a fluid, continuous process through their interactions with the world. The examples present a complex social picture that highlights the importance of information

CHI 2018, April 21–26, 2018, Montreal, QC, Canada

ACM 978-1-4503-5620-6/18/04…$15.00
https://doi.org/10.1145/3173574.3173777

access and triangulation for sense-making; how ability negotiations are often accomplished with, and through, other people; and bound up with a person's relationships and social experiences. We discuss these findings and present design sensitivities for extending the capabilities of people with VI.

We begin by describing how our research builds on other work and recent shifts in assistive technology (AT) towards a stronger focus on the social interactions and experiences of people with VI, beyond any individual or functional uses.

RELATED WORK: DESIGN TO ASSIST PEOPLE WITH VI

The majority of existing AT seeks to support people with VI to carry out everyday activities independently. Examples include systems to support spatial awareness and navigation [12, 13, 21, 22, 26, 62], to aid the identification of specific objects or their characteristics [5, 14, 15], to assist the detection and identification of text [17], barcodes [31], signs [18, 51], or currency [32], and help with handwriting [43]. For digital user interfaces, we further find many applications for the input and recognition of Braille on touchscreens [3, 27, 34, 52], and alternatives for text-entry or navigating digital menus [7, 38, 24, 25, 63]. These technologies have been oriented towards assisting practical, well-defined functional tasks that are often treated in isolation from the wider social contexts in which they occur. Only a few examples extend the relationship with a system beyond an *individual* user, to include i.e. social support through a crowd [5, 8, 15], or with a teacher [43], family and friends [34].

In recent years, we have started to witness a shift in focus from the design of tools to assist the independent, often mechanistic fulfillment of pragmatic needs towards research that gives greater consideration to how people with VI are inter-connected with others [i.e. 20, 53, 57, 1]. Next, we discuss three areas of early work in this particular space: *design for richer social experiences*, *social acceptability of AT*, and *socially co-constructed accessibility practices*.

Design for Richer Social Experiences

Progressively, AT design is targeted at enabling richer social experiences for people with VI by assisting them i.e. in the capture of good quality photos to make photography more appealing [56]; and to help them preserve memories, express creativity, and socialize [28]. Recent research by Wu et al. [61] further shows how a system that automatically integrates accessible alt-text information with Facebook photos allowed blind participants to feel more included and engaged with conversation around photos; and thereby supported their ability to interact with their social network more fully. Still, far more research in this space is needed.

Social Acceptability of Assistive Technology

Exploring reasons for a frequent abandoning of AT use [cf. 47], Shinohara and Wobbrock [49], for example explored perceptions of social acceptability and stigma associated with AT use. They found that many specialist devices drew unwanted attention to the person, thereby marking them out as 'different' or 'less able'; whereby stereotypes of disability overshadowed perceptions of who they were as individuals. This is especially salient for interactions in public spaces, and has been echoed in other research [1, 2, 30, 41, 44, 53]. Recent work [50] extends descriptions of how the form and uses of AT are observable and perceived by others, and thus affect whether people with sensory disabilities feel self-conscious or self-confident using AT. It proposes that AT design be understood not only as creating a functional aid, but also consider peoples' social needs and what is conveyed about their *ability* and *social identity* through their interactions in the world. Some users and designers of AT suggest how a strong aesthetic style of the device can become a creative expression of self, promoting self-pride as well as AT use [4, 45]. Much of this research suggests that to achieve a socially more acceptable design, we need to develop a better understanding of how people with VI negotiate their abilities in 'social contexts' and through unfolding relations.

Socially Co-Constructed Accessibility Practices

Taking on this 'relational' view, a small number of works explore how people with different visual abilities collaborate to co-create more accessible environments [i.e. 9, 10, 55, 58].

Branham and Kane [9] for instance interviewed people with VI and their sighted partners to understand how they jointly constructed accessibility in their homes. They describe this as a dynamic process that involves configuring objects or activities in a predictable way; spatially organizing and adding tactiles to items; or rehearsing routines. For primarily sighted office contexts, the authors [10] further describe how VI employees experience difficulty collaborating with others in a meeting whilst also having to listen to a screen reader. This start to foreground the relevance of social and material aspects of the context for accessibility. Further, they describe how involving others as assistants was carefully negotiated, describing concerns that other people in the workplace may perceive a blind person as needy rather than competent [10]; and how creating shared, accessible experiences between partners at home [9] serves not only practical means, but is entangled with inter-personal intimacies.

In the context of navigation, Williams et al. [58] studied how sighted people provided verbal guidance to people with VI. They found that sighted people are often unaware of the type of information that is helpful, which created complications. For example, sighted people often warned VI people of what they believe to be obstacles to avoid, such as a curb or parked vehicle. Instead these served as helpful physical cues for orientation when tapped with a cane. The work further shows how navigation if often a social activity, yet its focus remains on accurate, safe orientation rather than any wider social experiences bound up with seemingly more functional tasks.

Extending prior research that considers aspects of the social and material context for accessibility, technology use and experience, we explore (i) how people with VI negotiate their abilities with, and through, others; (ii) how this is entangled with their relationships; and (iii) how technology can be part of such negotiations and serve to extend capabilities.

Name	Age	Gender	Paralympics	Level of vision		Mobility aid	AT use
Tim	26	M	Professional athlete	Low vision	Little central vision, no color vision, difficulty to see in dark; sight deterioration since birth (macular dystrophy).	/	/
Sally	26	F	Professional athlete	Low vision	No central vision, very limited peripheral vision in left eye; sight deterioration since birth (macular dystrophy).	Guide dog (at home)	/
Jerry	26	M	Spectator	Blind	Little light perception, some short-distance vision in his right eye; severe vision loss at age 19.	Cane	Voice over + screen reader software
Amy	26	F	Spectator	Blind	Light perception in right eye, low peripheral vision in left eye; sight deterioration since birth (retina dysfunction).	Cane + guide dog (at home)	Voice over + screen reader software
Aaron	26	M	Spectator	Low vision	Can read text if held close to his eyes or magnified.	/	Pocket magnifier
Pia	26	F	Spectator	Blind	Little central but no peripheral vision; sight deterioration since birth (retina dysfunction).	Cane	Voice over + screen reader software

Table 1. Participant information including their age, gender, level of vison, mobility aids, and AT use (all names are pseudonyms).

OBSERVATIONAL FIELDWORK

To gain a better understanding of how technology can assist in extending the capabilities of people with VI, we conducted a video ethnography to explore how they manage and negotiate their abilities within different situations. As a team of four researchers with mixed backgrounds in HCI, Design and Disability Studies, we travelled for one week to the Rio 2016 Paralympics. One of the researchers, Cynthia, is blind and thus has overlapping experiences. Accompanied by an ethnographic filmmaker, we joined the activities of two Paralympic athletes and four spectators with VI as they travel, attend events, visit restaurants, or go sight-seeing.

Participants

Of our six participants, Tim and Sally are a couple. Both have low vision and are Paralympic athletes who are active in their sports. They competed in the London 2012 games, and Sally also qualified for Rio. We connected with Tim through a university program with a Paralympic theme[i]. Tim put us in touch with Sally, who joined our activities in Rio after she had finished competing. In Rio, we further spend time with four VI spectators and friends. First, we met Jerry through his involvement in a local charity for the blind. He had long planned travelling to the Paralympics with partner Amy, and their friends Pia and partner Aaron. All of them are active players and fans of Goalball – a team sport specific to VI. Jerry, Amy and Pia are registered blind, whereas friend Aaron has low vision and can read text if held close to his eyes or magnified. Table 1 provides additional detail on their age, gender, level of vision, use of mobility aids and AT.

Captured Research Material

Our research was captured in video by an ethnographic film maker, and in photos and field notes taken by the researchers. Across seven days, we filmed in total 35 hours of activities. Most of this time involved Tim (26 hours, across six days). On three of these days Sally joined us; and we spent one full day (9 hours) with the four friends as they went sight-seeing, visited restaurants and attended the Goalball finals. Video was chosen as the predominant tool to collect and preserve relevant features in a naturalistic way, and to produce short films to help communicate key scenarios and the nuance of experiences, from which to build new technologies.

Despite such advantages, we were mindful of our own involvement as participant-observers and that the shooting of video were potential sources of bias; and that the camera and the perspectives chosen for the video became an integral part of the social activity of interest and our analysis [35]. Having awareness of the camera meant that our participants at times displayed behaviors to it, which was most apparent in them giving running commentaries. This complemented our approach which involved a shadowing and interacting with participants [33], and occasional asks for clarifications of their motivations or actions that provided rich snapshots into their sense-making processes. Lastly, we must acknowledge that not all of the phenomena that we captured occurred naturally. For example, the researchers organised the sight-seeing events and orchestrated some situations that may not have taken place in the same way, if we had been absent. For instance, on occasion, we explicitly asked participants to choose a restaurant for lunch, or to self-organise travels with public transport rather than arranging a private driver.

Analysis of the Research Material

Captured video footage was edited to include key scenarios and conversations of interest that represented both breadth and depth across the different activities and participants. This was achieved through a joint, on-going review of the footage by the ethnographer and members of the research team; a process that provided a rich and detailed means to re-engage with the material and social interactions that were observed in the different contexts [6, 42]. To further assist in the identification of patterns in the research material, we followed a Thematic Analysis approach [11]. To this end, one of the researchers systematically reviewed the edited video, attaching descriptive labels to individual scenes at first, which were then developed into codes and overarching themes. As the analysis progressed, these were reviewed and adapted in discussions with three additional researchers. This included Cynthia, who also contributed her personal experiences as a blind HCI researcher; and two members of the project team with backgrounds in HCI and Sociology.

Our joint analysis revealed a nuanced and socially complex picture of how participants manage different situations. To illustrate this, our findings present in-depth examples that demonstrate identified approaches of how sense-making and effective participation are enabled or hindered in various contexts. These provide rich insights into how ability is negotiated through a person's interactions with the material world and, especially, with and through other people.

FINDINGS: HOW PEOPLE WITH VI NEGOTIATE ABILITY

Our findings are organized into three sections summarizing key observations of how participants negotiate their ability. Jointly, they reveal a socially complex picture that shows how ability negotiations present a fluid, continuous process that often involves other people. They show how participants (i) employ *mechanisms of triangulation* that include social cues to build an understanding of their surroundings, (ii) how they *convey ability* to, and *negotiate it through others*, and how this relates to self and social experiences; and (iii) how they negotiate *assistance by other people,* which reveals misperceptions of their abilities by others, and how providing assistance can be entangled with their social relationships. Whilst presented in three individual sections, the approaches described in each section are often found to be intertwined or shifting between one another.

Triangulation: Material & Social Interactions as Resource

As a research methodology, the term triangulation is broadly defined as *"the combination of methodologies in the study of the same phenomenon"* [19, p.291]. In integrating data collected through different methods, judgements made on the phenomenon can be more accurate and enhance credibility that the results are valid [29], or deepen and widen one's understanding about a phenomenon through use of multiple methods [36, 40]. In cross-checking different information sources that lead to the same result, the idea is that one can be more confident with an interpretation. As such, we take up this sense-making method to show how our participants gather and enact information from multiple sources.

We demonstrate how triangulation is particularly salient, but not always full-proof for our VI participants as resources are inaccessible or insufficient. Describing two examples in detail, we show how participants build on multiple senses, and material and social interactions to formulate assumptions about the world; and how these are tested, confirmed, or revisited through a triangulation with additional information. The first example depicts the seeking and integration of material cues, and related challenges for triangulation. The second shows how social dialogue assists in sense-making.

Multiple Senses & Information Resources

Tim has little central vision and no color vision. In this example, we describe how Tim navigates a UK airport; how he gains information and deepens his understanding of the space; and also how misjudgments – due to insufficient triangulation – lead to disorientation and frustration:

Following security clearance, Tim has 30 minutes to locate his departure gate for boarding. Using the vision he has, Tim identifies one of the large, bright and high-contrasting airport signs that hang just above the level of his head. Having difficulty reading it, he stops to activate the camera on his iPhone, points it towards the sign and uses the zoom to magnify its text and symbols. An arrow next to 'Gate A18' directs Tim to keep moving forward. Here, the phone serves to augment his vision, and thereby allows him to gather directional information. Despite this information, Tim opts to approach a person with a bright yellow safety-vest that is indicative of his potential role as an airport staff. Tim asks the man: "Excuse me, what gate is this one?". Being standing next to an open seating space that is enclosed by retail stores, and in absence of any symbol that may indicate Tim's visual impairment, the staff responds confused: "This isn't a gate.". Rephrasing his question Tim asks: "Alright, where's A18?" and receives instructions to "Hang on straight and it should just be there". This confirms Tim is going in the right direction. Thus, asking the staff for help, and building on that person's visual abilities and potential expertise of the airport, aids his understanding of the space.

As Tim keeps walking through the airport, he explains how the patterned floor makes it difficult for him to distinguish people: "People might just think I'm rude and that I'm walking at them, but I'm not just walking at them, I'm just a bit confused trying to work out what's floor and what's person, at the moment." At each step Tim carefully attends to the movements of other people to identify and avoid to accidentally walk into them. In the absence of a signifier of his visual impairment, like a cane, all the work that Tim puts into this process remains invisible to others, putting him at risk of being perceived as 'rude' if walking to close to them.

Soon, Tim stops and again uses his phone to read signs. One sign points to gates A13 and A14; another shows an information icon. Neither offers Tim the information he was looking for. As a high-table shapes up in the background, Tim takes a left turn and walks towards what he assumes to be a help desk. Moving closer, silhouettes of people working on laptops shape up instead, and Tim finds himself in a cul-de-sac. Having misjudged the situation, he turns around and expresses slight frustration: "This turns out to be a bit of a nightmare". Returned to the main path, the next sign points to gate A18 as straight ahead. Finally arrived, Tim admits: "It took 20 minutes longer than it should have, but there you go". Thus, while Tim is able to reach his destination, it shows how having to constantly collect and check for information, outside of (much) vision, is effortful and time-consuming.

This suggests that, despite frustrating, continuous access to relevant information resources can assist in the formation and validation of assumptions about the surroundings, and thus, a person's ability to act upon these more confidently.

Collective Triangulation: Social Cues & Dialogue

In the above example, Tim's consultation with the (sighted) staff is seen to inform his understanding of the terminal. Our second example shows how Jerry and Amy, who are both blind, locate a seat to have coffee together. It foregrounds how different methods of dialogue – social and material interactions – become integrated into sense-making processes and aid an understanding of the physical space:

With a cup of coffee and a cane in either hand, Jerry and Amy step outside a coffee shop. Jointly they walk towards what they assume is an area with tables and chairs. Side by side, they tentatively move forward. Using her cane as a

pointer, Amy asks: "Is there chairs in front of us?". Jerry confirms visually: "Yeah there is, but I don't know if there's people or not.". Continuing her path, Amy's cane now hits a chair. Tapping against its metal legs, she affirms: "That's a chair!". Still trying to make out whether there are people, Jerry takes slow steps, adding playful commentary to his every move: "Oh wait, wait. I'm edging ever so closer, bit by bit". Amy giggles. Now sat down she counters proudly: "I've got a chair, don't know about you guys.". Sensing the edge of the table, Jerry confesses: "I still can't make out people.". Putting his coffee down, he turns his head around once more to scan the surroundings. He concludes: "I think this seems like a reasonable place", and takes a seat.

This example of collective triangulation brings awareness to different methods of communication that are part of Jerry and Amy's sense-making processes. It describes a rich interplay of materials cues, such as Amy's tapping against the chair, with joint movements and conversation. By verbally sharing individual assumptions gained during their step-by-step discovery of the space, the couple build up a fuller picture of the surroundings for, and through, each other. This shows how social interactions, which are often disregarded in assistive technology design for people with VI, can support information gathering and triangulation, and extend their understanding of a space, and others in it.

Ability as Socially Performed & Collectively Negotiated

All our participants present and describe themselves as very able people. To negotiate their abilities and maintain a sense of independence however can be an effortful process. This is shown in the airport example with Tim, where he is, amongst others, carefully attending to people's movements to identify them against the patterned floor. In doing this, he displays his competence and ability to navigate the space. In this section, we illustrate how such demonstrations of ability do not only offer a functional process for achieving a particular task, such as locating a gate or empty seat, but are bound up with concerns of how a person's behavior is perceived by others or intervenes in a social context. We describe three examples of different participants performing their abilities in the presence of others, and how this is moderated by their perceptions of 'social norms'. At first, we present two examples of different meal times with Tim; then, we detail a sight-seeing activity Jerry participated in with his friends.

Wanting to 'fit in' to a World Made for Sighted People

For Tim, coming to terms with his continuing sight loss presents perhaps his biggest struggle. He describes himself as very able, wanting to do things by himself, and having '*sort of always tried to fit in'*. To realize that one may not be able to do certain activities anymore is a common issue for many people with VI and often means a perceived loss of independence. Describing his struggles, Tim says: "*I think I'm sort of starting to lose independence, but I'm really not, I'm clinging onto it as tightly as I can. I think one day I will have to sort of just like suppress all these stereotypes myself and start thinking about having to use either a cane or dog, even if it is just for the symbol. (...) There is a lot of people out there, a lot less disabled than me, who are a lot less able than me. And I just like being able, I like trying my best getting around."* For Tim, to be able and be perceived as able by others presents a constant issue of concern. His personal perceptions of 'social norms' and desires to conform to those, mean that, throughout our time together, he often tries to keep his disability hidden. The next example shows how this influences how he negotiates his abilities, and justifies the choices he makes in the presence of others.

--- Example 1: Tim Accounting for his Choices to Others

On our first morning in Rio, we have breakfast in the hotel. The breakfast room is not very well lit, making it appear as 'obscenely dark' to Tim, who's pupils do not dilate easily. Making his way tentatively towards the buffet, Tim picks up a plate and notices the warmth radiating from a stand with hot food containers. Opening the lid of a container to his right, he describes: "This is literally a massive issue now, 'cause this could be anything to me. It smells like bacon. I don't feel like eating any red meat today." He picks up a text label to one side of the next container. Unaware he is holding it upside down, he remarks: "I know this is sort of quite big [the letters], personally, I cannot make that out. I can't even see which way this is meant to go to be honest. Could be in any language; it's a bit hard work at times."

In principle, Tim could use his phone to enlarge the text to Work out the various foods on offer. Yet, gathering such information comes at a cost. Pragmatically, in this context, it would take time and effort to 'zoom in' on all items. Socially, Tim may also not want to be perceived by others as peculiar as he inspects the buffet with his phone. Lifting the lid of the next hot food container, Tim notices: "Ah, tomatoes [He takes two]. So at this point, I literally just, every time I open these [the containers] I just smell what's in there mainly. I could be completely wrong. Gonna try and be quite healthy today." As he reaches the last container, Tim is surprised: "That smells sweet, is that a waffle? Alright, ok. I'm not going to be healthy today, I changed my mind." He reaches with the food pincer for a waffle: "Depth-perception don't fail me now." In this last comment, we begin to see how perceptions of ability are always present as a concern, and as something that is at stake for Tim. In this moment, he shows awareness of the limitations of the vision he has and is keen to not embarrass himself picking up the waffle.

Back at the table, Tim reflects on how his food choice appears to the research team: "I know it's just a really strange combination of tomatoes and waffle". While his food choice could be regarded as a consequence of the sequential order of the buffet that may have suggested these items, Tim feels obligated to justify his actions by expressing their liking. On this morning, and likely emphasized in front of the camera, Tim is maintaining an impression of being able that aligns his behavior more closely with his perception of the norm. Later in the week, as Tim continued to discover the richness of the buffet, he admits that struggles to see in this

space and his initial unfamiliarity with the buffet meant he did not want to spend too much time looking around, which led to his seemingly odd choice of tomato and waffle.

The example shows how, despite the availability of his phone and thereby functionality to extend his understanding of the space, Tim does not employ this technology. Here, uses of the phone in negotiations of ability are at odds with desires to be perceived as competent, independently able, and what he construes as 'normal'. Our second example extends these observations to show not only how a person's negotiations of ability may be perceived by themselves and others, but also, how these actions, in turn, shape the social context in which they are situated. We show how certain mechanisms might be avoided so as not to disrupt the rhythm of a group.

--- Example 2: Not Wanting to Disrupt the Group Rhythm
Leaving Copacabana beach, Tim leads the way in locating a place for lunch. He stops at the first beach bar and jokes to Sally: "Here we are, that will do. I can smell chips. That smells quite nice." Moving towards a large food menu board (Figure 1 left), he briefly takes a look at the menu, then turns back to Sally and the research team: "That's like tiny writing.", and suggests going in. Sat down, everyone starts browsing the food menus on the table. While Tim did not take his phone out to read the large food board earlier, both he and Sally are now using the camera zoom on their phones to magnify the various pages of the menu (Figure 1 right).

Ostensibly, Tim has the same technology available for the 'task of reading a food menu', yet he chooses to use it in one instance and not the other. We believe that differences in the social dynamics in each context moderate his choice. In social contexts, *timing* and the *flow of social activities* matter. For Tim, to read all the small print on the food board would take a long time to accomplish, risking inconvenience to others, who would have to wait. Thus, although in possession of technology that could assist, Tim may choose not to acquire that information to avoid potentially disrupting the rhythm of the group. Further, to be using his phone to enlarge the food board could again be perceived as unusual behavior and risk marking him out as 'less able'. Yet, when the group is at the table, the social situation shifts. With everyone engaged in reading the menu, Tim's effort to read it is now in keeping with the group. While 'using a phone to read' may still be perceived as unusual, here, this may be *socially more acceptable* than not reading the menu at all, whilst everybody else does.

Figure 1. Left: Tim approaching large food bard; Right: Tim using his phone to enlarge the text for reading the table menu.

This example shows how fluid shifts in configurations of the context can alter perceptions of what is considered socially acceptable behavior; and how concerns for maintaining the flow of a social group shape how sense-making strategies, including technology use, are applied.

Being More Accepting of one's Condition & 'Rolling with it'
Desires of wanting to be perceived as able are also present in the interactions we observe of Jerry and his friends, even though they seem less concerned with how their regular use of touch is perceived by others.

Since suddenly losing his sight at age 19, Jerry has come to terms with his changed experience of the world – he often speaks of '*just rolling with it'*. He has a very active social life as a player and coach of Goalball, and is involved with the blind community, which has enabled him to meet with other VI people and form close friendships. Partner Amy and friend Pia describe how, growing up with support from the blind community, has encouraged acceptance of their own sight loss, and has meant that they now feel more at ease with it. The next example describes how the friends engage in a sight-seeing activity. It shows how their greater comfort with VI, even in the presence of other people, opens up the capacity to apply alternative mechanisms for experiencing and interacting with the world. Specifically, we show how *touch* and *social exchanges* feature strongly in their negotiations of ability, and how their collective engagement in sense-making processes is *greatly enjoyed*.

--- Example 3: Experiencing the World Differently "Together"
Arriving at the iconic Christ de Redeemer (Figure 2 left) on a cloudy morning, Jerry points towards the statue: "Is that a christo? I can vaguely make out the shape, it's like a 'blob'." He remembers seeing it on TV when he was younger. For Amy, the light is too bright to make out any shape. Jerry suggests: "I can show you what he's like if you want [Taking the statue's pose], he's like this, I think." Using her hands to feel his body shape along the stretched out arms (Figure 2 right), Amy jokes: "Yeah, so it does look like he's been crucified"; Jerry clarifies: "But it doesn't look like he is in pain or anything. He looks like he's just chilling". While a touching of Jerry's body to depict the pose may be considered unusual behavior, it does not appear awkward but rather a natural way for them to interact with each other.

Touch also featured in their explorations of the physical space. Discovering two bronze figure heads with their hands (Figure 3, left), Amy and Pia speculate about the looks of the

Figure 2. Christ statue & Jerry posing for Amy as Christ.

Figure 3. Touching of bronze heads & small statue replica.

people who commissioned and created the statue. Despite the many other tourists around, both appear very comfortable and enjoy exploring these figures through touch. Standing to either side of them, they ask us to take a photo, and hand us their canes so these do not feature in it. In this moment, they show concern about the capture of their canes, not wanting to unnecessarily draw attention to these mobility aids, and associated perceptions; and instead seek to foreground their sight-seeing discoveries and experiences.

Leaving the attraction, the friends discover a souvenir shop and closely gather around a stall with tote bags. Pulling the top bag towards him, Aaron, who has most sight, starts reading out its repeated writing: "I heart Rio. I heart Rio. I heart Rio". Jerry jokes: "Who is Rio?"; and Amy teases: "Read that one more time." The bags spark interest from the girls. Each picks one up. Pia wonders about the color of the bag in her hand. Turning to Aaron she asks: "What kind of blue is this?" to which he clarifies how the bag is not blue, but red: "Coca cola read, with coca cola white on". Excitedly, Amy adds: "Oh! You like read!". Pia is thrilled about her find, and purchases it later. This shows how the friends build an understanding of the bags through their joint attending to material and social exchanges. Benefiting from Aaron's sight, or Jerry's memory of the statue, they complement and add to each other's sense-making abilities, and thereby achieve a richer picture of their surroundings. This suggests 'vision' as something that is enacted together.

The friends linger in the store for a while. They are particularly excited about small replica statues of the Christ made from its original stone, and take turns and their time in carefully feeling them (Figure 3, right). Continuing their discoveries, they weight, tap and explore the different textures of bottle openers and candle holders. Jerry makes out a box with what he assumes are magnets. From the sound created by finger taps against the flat object wrapped in foil, he confirms to Amy: "See this one here, this is a magnet" and places it in her hands. Touching its even, cold surface, Amy notes how she can't feel what it says. Jerry hands her another, this time a 'feel-y' magnet – as he describes it. Through the foil she explores its tactile surface and makes out a heart shape at first, and then the letter 'I'. Excitedly she shares: "Uh! This one is 'I heart Rio' and the 'I' is the Christ I think. That's cool. I like that!". Meanwhile, Jerry had found another magnet. As he starts describing it to Amy, she quickly interrupts: "Wait, wait, no, no, let me guess!", eagerly wanting to figure it out herself. In the abstract, one could construe the lengthy process involved in identifying different store items as a 'burdensome tasks'. Yet, it becomes clear from these observations how the joint discovery and passing of objects between the friends, to sense their shape and guess their purpose, does not only assist their sense-making; it presents a pleasurable activity, something that they enjoy and want to make time for, and that is a crucial part of their sight-seeing experience.

This instance of the four friends engaging in sight-seeing surfaces how a lesser concern for hiding their VI allows them to be more comfortable with engaging in tactile explorations. While such behavior can mark them out as 'being different', touch offers a rich sense for experiences of the world, and thus, a powerful mechanism in their negotiations of ability. Further, amongst this group of friends who all have VI, this behavior is generally perceived as common, and thus considered as socially accepted. This echoes research by [20] and foregrounds how differences in audience – a community of predominantly VI members rather than sighted people – can moderate what behavior is considered as appropriate. Finally, our example shows how the friends build up and extended their understanding of the surroundings through each other; and how this assisting of each other extends beyond the functional, so that it tightly interweaves with their social relations and experiences of the activity.

Negotiating Assistance From Others

As already alluded to in previous sections, we often observed how participants sought assistance by other people, and how receiving help from others can be valuable and assist in negotiations of ability. In this final section, we draw further attention to how common *(mis)perceptions of the abilities of people with VI*, mostly by strangers, can affect whether provided assistance feels 'helpful' or 'disempowering'. Further, we extend descriptions of how giving and receiving assistance does not need to be an explicit act or intervention, but can be *quite implicit and gentle,* and *closely entangled with a person's social relationships and experiences.*

(Mis)Perceptions of Abilities: What is Helpful Assistance?

In the following, we depict three short instances that our participants told us about and that nicely capture common misperceptions by others, mostly strangers, of what kind of assistance to provide to people with VI; and how these instances of negotiations of assistance have been perceived.

We begin with an example of Jerry and his friends, who describe to us how it takes them 2 hours and four changes in transportation to travel between their hotel in Rio and the Paralympic Park. They are raving about the friendliness and relaxed attitude of the people they met travelling, Pia: *"We met such nice people everywhere. Like, when we come off the metro or we are just walking down the street, we would have to wait 10 seconds, not even that, and someone would be at the side, 'oh do you need help? where do you want to go?'"*. Once, when they looked for a bus, Pia shares: *"And I think they thought they needed to take us all the way to the hotel.*

The bus is there, just show us."; Aaron: *"Yeah, we nearly missed one bus, because they were being too nice."*. While the friends are very appreciative of the pro-active, frequent and friendly offers of help by others, they are generally able to undertake this journey, and, in this instance only need guidance to locate the right bus. Yet, in this situation, and outside of a better understanding of the abilities of people with VI, the friendly helpers assume their inability to find the hotel and are 'overly helpful' in their offers to escort them all the way. This suggests a 'take over' of the activity, rather than the providence of the kind of assistance that would enable the friends to accomplish the journey themselves; and thus, to extend their capabilities.

Misconceptions of what people with VI may or may not be capable of, are even more pronounced in other stories. Pia and Amy for instance describe how other people respond, upon recognising their VI, by slowing down and increasing the volume of their speech, or often treating them as if they could not walk for long, needing transportation. This reflects conceptions of VI that regard it as a 'uniform category of disability' that appears indistinct from impaired cognition, hearing or mobility. That this can feel humiliating is particularly apparent in this example of Sally receiving airport assistance: "*They told me they'd gonna put me in a wheel chair, it was a bit degrading, I'm not going to lie, but you know, I could just not be bothered arguing with them in the end and just got into the chair and was like, 'Ok, that's what I gonna do', because they said they wouldn't give me assistance otherwise, they just did not understand*." This shows how approaches to assisting 'people with a disability' in a 'uniform way', risks a disregard of existing skills – Sally (especially as a professional athlete) is physically able to walk herself – and can enforce feelings of stigma. Jerry underlines the need to break-off misconceptions of VI (dis)ability by summarizing: "*I can do everything but see!"*.

In our last example, Pia critiques an instance of help, but also points to ways in which assistance could be improved: "*Or this thing when people hold doors open thinking they are helping you, but they don't say anything. You know there's a door there, you gonna try to open it and it's already open. 'Say something!'."* Here, we begin to see how this situation could be configured to assist sense-making through a verbalization of one's actions. Participants further often mentioned their dislike of other peoples' inability to articulate and explain a situation, and who, instead, often tended to 'grab' and 'pull' the person in efforts to assist them. This inability to verbally contextualize a situation is partly routed in challenges to provide meaningful explanations outside of sight being a shared sense; and also the temporal flow of many situations that can demand a response ad hoc.

Jointly, these examples point to a need for more education and empathy about what it means to have a sensory impairment; as well as design opportunities to support the provision of social assistance through developing better communications.

Assistance as Belonging to & Being with Others

Finally, we highlight how providing assistance can be more implicit and gentle, and be entangled with a person's social relationships and experiences. To illustrate this, we draw and extend on two previous examples of Jerry and Amy.

First, we revisit how the couple located free seats for coffee. Their assisting of each other in making sense of the surroundings has little resemblance with a 'functional operation of giving help'. Instead, their joint discovery of the space is more attuned in the way they move together step-by-step and respond to any difficulties or potential awkwardness in navigating the space with humor. In this instance, their mutual assistance appears as gentle and as something they are both comfortable and familiar with, and that has become an unremarkable part of their ways of *being together*. Their support of each other does not interrupt what they are doing, but is part of the activity, and their experience of it.

Similarly, when Jerry emulated for Amy the pose of the Christ statue with his body, this did not only assist her understanding of this attraction, it presented an act of care, expressed through his efforts in assisting her sense-making of the shape. Here, this assistance was again a reflection of their relationship; intertwined with a sense of connection to, and care for each other. It suggests that these kinds of social configurations of support present a desirable *inter-dependency* that can positively foster social experiences.

DISCUSSION: DESIGN TO EXTEND CAPABILITIES

Our findings reveal a nuanced, socially complex picture of how people with various types of VI fluidly and continuously negotiate their abilities to build up an understanding of, and partake in, different contexts. They show how, through social and material interactions with the world, participants extend their abilities. Next, we identify and discuss opportunities for technology to take a meaningful part in ability negotiations, with particular emphasis on how these can be embedded into the social interactions and lives of people with VI.

Triangulation: Afford Relevant Information Resources

Our examples demonstrate how participants skillfully gather information in the world to enable this sense-making process outside of normal vision. Further to Williams et al. [58], who describe some of the skills that blind people involve in detecting environmental cues through their cane use, we detail a host of sensory strategies – feeling, smelling, listening to sounds created by, or magnifying material things. We demonstrate how these sense-making strategies and their interplay are central to negotiations of ability. Moreover, the examples show uses of many additional information sources: past experiences, social interactions, and technology uses.

Our findings illustrate how our participants triangulate these information sources, creating elaborate juxtapositions to formulate and test assumptions about their environment. Yet, we also described moments where sense-making processes broke down. This includes Tim wandering into the wrong direction at the airport and his semi-intentional breakfast

choice of tomatoes and waffle, or the four friends searching for the right bus to their hotel. These suggest that providing additional information could assist their awareness of the surroundings, and thereby extend their ability to travel more effectively, or to make more desirable food choices.

Unfolding how ability is negotiated in these contexts challenges existing approaches in the AT design space that continue to seek to either replicate a sense like vision [i.e. 61], or assist the individual to circumvent visual problems [i.e. 14, 25, 32, 38]. In line with Shinohara and Wobbrock [49], we argue that the focus of AT design should not be on technology becoming the 'primary source' of information, nor should it be the 'primary solution' to a 'sensory problem'. Instead, we pose that technology can be re-imagined as supporting the triangulation process through the provision of relevant information about the environment:

Refocus Technology to Assist Sense-making (not Vision) – Our examples illustrate a myriad of sense-making strategies that are employed by VI people to construct their abilities; and through this extend their capabilities. As highlighted by Williams et al. [58], any additional information provided must complement on-going sense-making processes, not disrupt them. Whilst a shift in orientation from replicating vision to sense-making presents a starting point in this direction, our findings have also pointed to considerations of the *personal* and *social context* as a key driver in how ability becomes negotiated. We unpack those in more detail next.

Adapt Information to the Person – In principle, technology use can ease many practical accessibility challenges involved in gathering contextual information to aid triangulation and sense-making. For example, computer vision can support the recognition of signs, objects, peoples' faces, or the layout of a space [14, 28, 46]. Yet, the challenge remains how to identify from all potentially available information about an environment those that is relevant to the person's in-situ ability negotiations; and present it without interrupting the skills of a particular person with VI [cf. 58]. While previous research on ability-based design [59] highlights the need for systems to adapt to their user, the examples describe singular notions of a person's needs and mechanisms for systems to adapt to a user's behavior and to be customizable to their abilities. Yet, to develop adaptive systems for more complex, real-world situations suggests a widening of focus from 'modeling a user' or 'specific task' towards a much closer consideration of, and more nuanced system response to, the context-dependency of a person's (information) needs.

Adapt Information to the Social Context – Our findings illustrate how the strategies that become employed in negotiations of ability can vary depending on the social context in which interactions are situated. Context-dependency is most apparent in the examples of Tim, who used his phone to 'read a menu' in one situation and not the other. Here, we describe how desires to convey an image of ability to others, to display socially appropriate behaviors, and to fit into the context of a restaurant are key drivers in his ability negotiations. This resonates with previous works [2, 20, 44, 49, 50] that emphasize how AT use is shaped by how device interactions become perceived by others. While this existing work has led to a notion of social accessibility for a given technology, our findings show how notions of social acceptability of AT are *continuously shifting* in different situations and for different people. This suggests for AT design to be more considerate of how system use finds integration within other, on-going (social) interactions, and to not unnecessarily disrupt those. This could be achieved through a stronger focus on subtle, embedded ways to notify about information, and to assist information access in-situ.

Social Bridges: Support Assistance by People

Our findings illustrate a myriad of ways in which participants sought and received assistance by others, both explicitly and more implicitly. Tim, for example, explicitly approaches an airport staff to help direct him to his gate. More implicit provisions of assistance in ability negotiations are apparent in the interactions we observed of the four friends. Their attuned processes of physical and verbal exchanges allow them to build on each other's senses and assumptions about the world. Taking the souvenir shopping as an example, we show how such collective negotiations of ability enable them to gain a fuller sense of the shop items with, and through, each other; and how this extends their ability e.g., to make more desired purchases. The giving and receiving of help in these implicit processes of assistance present a gentle process that does not interrupt, but rather foster pleasure in, their sight-seeing experiences. Our examples show how both these processes of seeking and receiving support by others, explicitly and more implicitly in on-going interactions, can assist in information gathering and triangulation; and as such present an important resource for ability negotiations.

This is somewhat echoed in assistive crowdsourcing systems such as VizWiz[ii] [5, 15], a service that allows people with VI to pose questions about a visual problem (captured through a photo) either to Mechanical Turk[iii] or peoples' wider social network on Facebook [8]; as well as in ethnographic work of co-constructed accessibility in the home [9] and at work [10]. However, outside routine environments in which access to information can be pre-configured or better planned for, the reaching out to other people for help becomes a different challenge for technology to assist. We illustrate this in particular in the examples of Tim at the airport or the friends at the bus stop, where the identification of helpers in less constraint, public spaces is often more opportune. Thus, considering the importance of other people as an intelligent information resource, we suggest that technology should not try and replace people, and instead assist people with VI to better identify and manage those other people in-situ.

Aid Awareness of People in the Vicinity – Enabling people with VI to be more aware of other people in their vicinity can enable opportunities to engage with others and choice about who to approach for assistance, and thus, include in ability negotiations. The literature suggests that people have strong

preferences about who they might ask for assistance, with many carefully considering the social costs that is implied in asking for favors i.e. of friends or colleagues [10, 61]. Our examples too suggest that asking for assistance from those whose job it is to offer assistance, e.g. transportation staff, is often preferred. However, we also show differences in the kinds of support that is given by other people. This is most apparent in interactions by the friends, whose more intimate knowledge of each other, such as preferences for the color red or tactile-y things, means that their help is of a different kind and quality. Thus, the aim should not only be for AT design to create mere awareness of others in the vicinity, but to also be mindful of, and consider creating opportunities for, a VI person's personal preferences in identifying who might be most suited to offer them the kind of assistance they want.

Support Formation of Common Ground with Helpers – Our findings also describe some of difficulties that participants experienced in receiving the kind of information or help they desired from other people. This was apparent in their sharing of stories of others 'grabbing' or 'pulling' them in efforts to assist, or where helpful conversations were difficult to establish. For VI people, establishing a conversation (i.e. what question to ask) can be more complicated since much of the information in their surroundings that could assist in formulating certain questions and grounding a conversation may be outside their immediate awareness. Difficulties to establish common ground are also reported in AT research for navigation [e.g. 20, 48, 58, 54] that reference how sighted helpers' struggle to verbally articulate information about the surroundings in a non-visual, unambiguous, and yet helpful manner. Our findings suggest that creating a greater shared understanding of other peoples' actions can act as a starting point to address such challenge. For example, identifying someone as 'approaching' can give opportunity for a person with VI to verbally manage an interaction before the assistor takes action (i.e. walks past). To assist in creating common ground when vision is not a shared sense is still underexplored in the AT space, and warrants more research.

Aid Collective Sense-Making – Lastly, we attend to how our examples of collective negotiations of ability show how this assisted participants understanding of their surroundings, and was also bound up with pleasurable experience for our participants. In the AT literature, the provision of assistance is frequently considered as an explicit and pragmatic act of help and as often a burden to the helper. Less often, we find considerations of how the provision of assistance can also be an opportunity to connect with another person through joint interactions and resulting shared experiences. In our findings this was perhaps most pronounced in the examples of Jerry and Amy, whose mutual guidance whilst exploring new spaces is very attuned and gentle, and has become a natural part of their way of being with each other. This presents a form of inter-dependency that not only helps extend their abilities, it is linked to a sense of belonging and enjoyable experiences. This binding of assistance with relationships is also described by Branham and Kane [9] in the co-creation of an accessible home, something that can be both a burden and an aid to relational intimacy. Contrary to a previously strong focus on *independence* in the contexts of AT design and disability, we suggest that designers think about how their technology can help enable collective sense-making experiences, and how it sits within these important social relationships to avoid risks of interfering with them.

Limitations

We chose to conduct our ethnographic research as part of the 2016 Paralympic games in Rio rather than peoples' ordinary lives. This meant that participants came to explore both everyday scenarios such as restaurant visits or shopping as well as new spaces and activities such as sight-seeing, which may appear less likely and less frequently in daily life. Yet, having to navigate a foreign country can add to challenges in sense-making, and thus, pronounce such processes and help foreground key insights into how abilities are negotiated. For example, while difficulties recognizing bank notes and monetary amounts occur in daily life, this was emphasized in Rio, where the currency was less unfamiliar and requested payments were often verbalized in Portuguese. Further, we have to acknowledge that during the Paralympics, official helpers were present at key transportation points or sporting venues, proactively approaching our participants to offer help upon seeing their canes. Generally, participants valued the more relaxed attitude other people showed towards their VI, which differed from their experiences at home and aided their readiness to seek help. Finally, our research focused on the experiences of few individuals with varying types of VI to provide examples in rich depth that would surface some of the complexity and nuance involved in different ability negotiations, rather than their full breadth or frequencies.

CONCLUSION

Our research took an orientation to disability that regards it as something that is not fixed or manifested alone through the body, but created through a person's social and material interactions with the world. We explored, through rich video ethnography, how athletes and spectators with VI negotiated their abilities in various contexts during the Rio Paralympics. Our findings presented in-depth examples that show how our participants triangulated information resources to understand their environments, posing this as a way to focus design in this space. We showed how providing additional information to on-going sense-making should not solely be considered as a mechanistic process, but as one that is deeply embedded in the social context in which interactions occur. We drew out how negotiating ability is shaped by perceived social norms, social opportunities for connection, and not least, assistance by other people, who can act as a vital information resource. Discussing these insights, we identified many opportunities for technology design to become a meaningful part in processes of ability negotiation, and, through this, to assist in extending the abilities of people with vision impairments.

ACKNOWLEDGEMENTS

We thank our participants, CamSight, and our colleagues and collaborators Helene Steiner & Jan Stöckel for their support.

REFERENCES

1. Ali Abdolrahmani, William Easley, Michele Williams, Stacy Branham, and Amy Hurst. 2017. Embracing Errors: Examining How Context of Use Impacts Blind Individuals' Acceptance of Navigation Aid Errors. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems* (CHI '17). ACM, 4158-4169. https://doi.org/10.1145/3025453.3025528
2. Shiri Azenkot, Catherine Feng, and Maya Cakmak. 2016. Enabling Building Service Robots to Guide Blind People: A Participatory Design Approach. In *The Eleventh ACM/IEEE International Conference on Human Robot Interaction* (HRI '16). IEEE Press, Piscataway, NJ, USA, 3-10.
3. Shiri Azenkot, Jacob O. Wobbrock, Sanjana Prasain, and Richard E. Ladner. 2012. Input finger detection for nonvisual touch screen text entry in *Perkinput*. In *Proceedings of Graphics Interface 2012* (GI '12). Canadian Information Processing Society, 121-129.
4. Cynthia L. Bennett, Keting Cen, Katherine M. Steele, and Daniela K. Rosner. 2016. An Intimate Laboratory?: Prostheses as a Tool for Experimenting with Identity and Normalcy. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems* (CHI '16). ACM, 1745-1756. https://doi.org/10.1145/2858036.2858564
5. Jeffrey P. Bigham, Chandrika Jayant, Hanjie Ji, Greg Little, Andrew Miller, Robert C. Miller, Robin Miller, Aubrey Tatarowicz, Brandyn White, Samual White, and Tom Yeh. 2010. VizWiz: nearly real-time answers to visual questions. In *Proceedings of the 23nd annual ACM symposium on User interface software and technology* (UIST '10). ACM, 333-342. https://doi.org/10.1145/1866029.1866080
6. Susanne Bødker. 1995. Applying activity theory to video analysis: how to make sense of video data in human-computer interaction. In Bonnie A. Nardi (Ed.). *Context and consciousness*. Massachusetts Institute of Technology, Cambridge, MA, USA, 147-174.
7. Matthew N. Bonner, Jeremy T. Brudvik, Gregory D. Abowd, and W. Keith Edwards. 2010. No-look notes: accessible eyes-free multi-touch text entry. In *Pervasive Computing*, Springer Berlin Heidelberg, pp. 409-426. http://rd.springer.com/chapter/10.1007/978-3-642-12654-3_24
8. Erin Brady, Meredith Ringel Morris, and Jeffrey P. Bigham. 2015. Gauging Receptiveness to Social Microvolunteering. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems* (CHI '15). ACM, 1055-1064. https://doi.org/10.1145/2702123.2702329
9. Stacy M. Branham and Shaun K. Kane. 2015. 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* (CHI '15), 2373-2382. http://dx.doi.org/10.1145/2702123.2702511
10. Stacy M. Branham and Shaun K. Kane. 2015. 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* (ASSETS '15), 163-171. http://dx.doi.org/10.1145/2700648.2809864
11. Virginia Braun and Victoria Clarke. 2006. Using thematic analysis in psychology. *Qualitative research in psychology* 3, no. 2 (2006): 77-101.
12. Michael Brock and Per Ola Kristensson. 2013. Supporting blind navigation using depth sensing and sonification. In *Proceedings of the 2013 ACM conference on Pervasive and ubiquitous computing adjunct publication* (UbiComp '13 Adjunct). ACM, 255-258. http://dx.doi.org/10.1145/2494091.2494173
13. Galit Buchs, Shachar Maidenbaum, and Amir Amedi. 2014. Obstacle Identification and Avoidance Using the 'EyeCane': a Tactile Sensory Substitution Device for Blind Individuals. In M. Auvray and C. Duriez (eds.), *Haptics: Neuroscience, Devices, Modeling, and Applications. Lecture Notes in Computer Science Volume 8619,* 96-103. http://dx.doi.org/10.1007/978-3-662-44196-1_13
14. J.M. Hans du Buf, João Barroso, João M.F. Rodrigues, Hugo Paredes, Miguel Farrajota, Hugo Fernandes, João José, Victor Teixeira, and Mário Saleiro. 2011. The SmartVision Navigation Prototype for Blind Users. *International Journal of Digital Content Technology and its Applications 5*(5), 351-361. http://hdl.handle.net/10400.1/893
15. Michele A. Burton, Erin Brady, Robin Brewer, Callie Neylan, Jeffrey P. Bigham, and Amy Hurst. 2012. Crowdsourcing subjective fashion advice using VizWiz: challenges and opportunities. In *Proceedings of the 14th international ACM SIGACCESS conference on Computers and accessibility* (ASSETS '12). ACM, 135-142. http://dx.doi.org/10.1145/2384916.2384941
16. Centers for Disease Control and Prevention (CDC). 2016. Facts about Vision Loss. *National Center of Birth Defects and Developmental Disabilities.* Last retrieved 7th December 2016 from http://www.cdc.gov/ncbddd/actearly/pdf/parents_pdfs/VisionLossFactSheet.pdf
17. Xiangrong Chen and Alan L. Yuille. 2004. Detecting and reading text in natural scenes. In *IEEE Computer Society Conference on Computer Vision and Pattern Recognition, 2004. CVPR 2004.* vol. 2. http://dx.doi.org/10.1109/CVPR.2004.1315187

18. James Coughlan and Roberto Manduchi. 2007. Color targets: Fiducials to help visually impaired people find their way by camera phone. *EURASIP Journal on Image and Video Processing* 2007, no. 1 (2007), Article ID 096357, 13 pages. https://rd.springer.com/article/10.1155/2007/96357
19. Norman K. Denzin. 1978. *The Research Act, A Theoretical Introduction to Sociological Methods*, 2d ed. New York: McGraw-Hill.
20. William Easley, Michele A. Williams, Ali Abdolrahmani, Caroline Galbraith, Stacy M. Branham, Amy Hurst, and Shaun K. Kane. 2016. Let's Get Lost: Exploring Social Norms In Predominately Blind Environments. In *Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems* (CHI EA '16). ACM, 2034-2040. https://doi.org/10.1145/2851581.2892470
21. Hugo Fernandes, José Faria, Hugo Paredes, and João Barroso. 2011. An integrated system for blind day-today life autonomy. In The proceedings of the 13th international ACM SIGACCESS conference on Computers and accessibility (ASSETS '11). ACM, 225-226. http://dx.doi.org/10.1145/2049536.2049579
22. Giuseppe Ghiani, Barbara Leporini, and Fabio Paternò. 2008. Supporting orientation for blind people using museum guides. In *CHI '08 Extended Abstracts on Human Factors in Computing Systems* (CHI EA '08). ACM, 3417-3422. http://dx.doi.org/10.1145/1358628.1358867
23. Charles Goodwin, Marjorie H. Goodwin, and David Olsher. 2002. Producing sense with nonsense syllables. *The Language of Turn and Sequence, Oxford (CUP)*, (2002), 56-80.
24. Tiago Guerreiro, Paulo Lagoá, Hugo Nicolau, Daniel Gonçalves, and Joaquim A. Jorge. 2008. From tapping to touching: Making touch screens accessible to blind users. *IEEE MultiMedia* 15(4), 48-50. http://doi.ieeecomputersociety.org/10.1109/MMUL.2008.88
25. Anhong Guo, Jeeeun Kim, Xiang 'Anthony' Chen, Tom Yeh, Scott E. Hudson, Jennifer Mankoff, and Jeffrey P. Bigham. 2017. Facade: Auto-generating Tactile Interfaces to Appliances. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems* (CHI '17). ACM, 5826-5838. https://doi.org/10.1145/3025453.3025845
26. Richard Guy and Khai Truong. 2012. CrossingGuard: exploring information content in navigation aids for visually impaired pedestrians. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '12). ACM, 405-414. http://dx.doi.org/10.1145/2207676.2207733
27. Chandrika Jayant, Christine Acuario, William Johnson, Janet Hollier, and Richard Ladner. 2010. V-braille: haptic braille perception using a touch-screen and vibration on mobile phones. In *Proceedings of the 12th international ACM SIGACCESS conference on Computers and accessibility* (ASSETS '10). ACM, 295-296. http://dx.doi.org/10.1145/1878803.1878878
28. Chandrika Jayant, Hanjie Ji, Samuel White, and Jeffrey P. Bigham. 2011. Supporting blind photography. In *The proceedings of the 13th international ACM SIGACCESS conference on Computers and accessibility* (ASSETS '11). ACM, 203-210. http://dx.doi.org/10.1145/2049536.2049573
29. Todd D. Jick. 1979. Mixing qualitative and quantitative methods: Triangulation in action. *Administrative science quarterly* 24, no. 4 (1979), 602-611.
30. Shaun K. Kane, Chandrika Jayant, Jacob O. Wobbrock, and Richard E. Ladner. 2009. Freedom to roam: a study of mobile device adoption and accessibility for people with visual and motor disabilities. In *Proceedings of the 11th international ACM SIGACCESS conference on Computers and accessibility* (Assets '09). ACM, 115-122. http://dx.doi.org/10.1145/1639642.1639663
31. Vladimir Kulyukin and Aliasgar Kutiyanawala. 2010. From ShopTalk to ShopMobile: vision-based barcode scanning with mobile phones for independent blind grocery shopping. In *Proceedings of the 2010 Rehabilitation Engineering and Assistive Technology Society of North America Conference (RESNA 2010),* vol. 703, pp. 1-5.
32. Xu Liu. 2008. A camera phone based currency reader for the visually impaired. In *Proceedings of the 10th international ACM SIGACCESS conference on Computers and accessibility* (Assets '08). ACM, 305-306. http://dx.doi.org/10.1145/1414471.1414551
33. Seonaidh McDonald. 2005. Studying actions in context: a qualitative shadowing method for organizational research. *Qualitative research* 5(4), 455-473. http://dx.doi.org/10.1177/1468794105056923v
34. Lauren R. Milne, Cynthia L. Bennett, and Richard E. Ladner. 2013. VBGhost: a braille-based educational smartphone game for children. In *Proceedings of the 15th International ACM SIGACCESS Conference on Computers and Accessibility* (ASSETS '13). ACM, Article 75, 2 pages. http://dx.doi.org/10.1145/2513383.2513396
35. Loranza Mondada. 2006. Video recording as the reflexive preservation and configuration of phenomenal features for analysis. In Knoblauch, H., Raab, J., Soeffner, H.-G., Schnettler, B. (eds.). *Video Analysis*. Bern: Lang, 51-68. https://pdfs.semanticscholar.org/87f3/956fbb4d5c07e2738b0f8d8fc1a718493698.pdf
36. Jo Moran-Ellis, Victoria D. Alexander, Ann Cronin, Mary Dickinson, Jane Fielding, Judith Sleney, and

Hilary Thomas. 2006. Triangulation and integration: processes, claims and implications. *Qualitative research* 6, no. 1 (2006), 45-59.

37. Ingunn Moser. 2005. On becoming disabled and articulating alternatives: The multiple modes of ordering disability and their interferences. *Cultural Studies* 19, no. 6 (2005), 667-700. http://dx.doi.org/10.1080/09502380500365648
38. João Oliveira, Tiago Guerreiro, Hugo Nicolau, Joaquim Jorge, and Daniel Gonçalves. 2011. Blind people and mobile touch-based text-entry: acknowledging the need for different flavors. In *The proceedings of the 13th international ACM SIGACCESS conference on Computers and accessibility* (ASSETS '11). ACM, 179-186. http://doi.acm.org/10.1145/2049536.2049569
39. Mike Oliver. 1990. The individual and social models of disability. In joint workshop of *The living options Group and the Research Unit of the Royal College of Physicians*, vol. 23.
40. Wendy Olsen. 2004. Triangulation in social research: qualitative and quantitative methods can really be mixed. *Developments in sociology* 20 (2004), 103-118.
41. T. Louise-Bender Pape, J. Kim, and B. Weiner. 2002. The shaping of individual meanings assigned to assistive technology: a review of personal factors. *Disability and rehabilitation* 24, no. 1-3 (2002): 5-20. http://dx.doi.org/10.1080/09638280110066235
42. Sarah Pink. 2015. *Doing sensory ethnography*. Sage.
43. Beryl Plimmer, Andrew Crossan, Stephen A. Brewster, and Rachel Blagojevic. 2008. Multimodal collaborative handwriting training for visually-impaired people. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '08). ACM, 393-402. https://doi.org/10.1145/1357054.1357119
44. Halley Profita, Reem Albaghli, Leah Findlater, Paul Jaeger, and Shaun K. Kane. 2016. The AT Effect: How Disability Affects the Perceived Social Acceptability of Head-Mounted Display Use. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems* (CHI '16). ACM, 4884-4895. https://doi.org/10.1145/2858036.2858130
45. Halley P. Profita, Abigale Stangl, Laura Matuszewska, Sigrunn Sky, and Shaun K. Kane. 2016. Nothing to Hide: Aesthetic Customization of Hearing Aids and Cochlear Implants in an Online Community. In *Proceedings of the 18th International ACM SIGACCESS Conference on Computers and Accessibility* (ASSETS '16). ACM, 219-227. DOI: https://doi.org/10.1145/2982142.2982159
46. Hernisa Kacorri, Kris M. Kitani, Jeffrey P. Bigham, and Chieko Asakawa. 2017. 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). ACM, 5839-5849. https://doi.org/10.1145/3025453.3025899
47. Marti L. Riemer-Reiss, and Robbyn R. Wacker. 2000. Factors associated with assistive technology discontinuance among individuals with disabilities. *Journal of Rehabilitation* 66, no. 3 (2000): 44.
48. Morgan Klaus Scheuerman, William Easley, Ali Abdolrahmani, Amy Hurst, and Stacy Branham. 2017. Learning the Language: The Importance of Studying Written Directions in Designing Navigational Technologies for the Blind. In *Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems* (CHI EA '17). ACM, 2922-2928. https://doi.org/10.1145/3027063.3053260
49. Kristen Shinohara and Jacob O. Wobbrock. 2011. In the shadow of misperception: assistive technology use and social interactions. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '11). ACM, 705-714. https://doi.org/10.1145/1978942.1979044
50. Kristen Shinohara and Jacob O. Wobbrock. 2016. Self-Conscious or Self-Confident? A Diary Study Conceptualizing the Social Accessibility of Assistive Technology. *ACM Trans. Access. Comput.* 8, 2, Article 5, 31 pages. http://dx.doi.org/10.1145/2827857
51. Piyanuch Silapachote, Jerod Weinman, Allen Hanson, Marwan A. Mattar and Richard Weiss. 2005. Automatic sign detection and recognition in natural scenes. *IEEE Computer Society Conference on Computer Vision and Pattern Recognition, CVPR Workshops*, 2005. http://ieeexplore.ieee.org/abstract/document/1565324/
52. Caleb Southern, James Clawson, Brian Frey, Gregory Abowd, and Mario Romero. 2012. An evaluation of BrailleTouch: mobile touchscreen text entry for the visually impaired. In *Proceedings of the 14th international conference on Human-computer interaction with mobile devices and services* (MobileHCI '12). ACM, 317-326. http://dx.doi.org/10.1145/2371574.2371623
53. Sarit Felicia Anais Szpiro, Shafeka Hashash, Yuhang Zhao, and Shiri Azenkot. 2016. How People with Low Vision Access Computing Devices: Understanding Challenges and Opportunities. In *Proceedings of the 18th International ACM SIGACCESS Conference on Computers and Accessibility* (ASSETS '16)., 171-180. https://doi.org/10.1145/2982142.2982168
54. Sarit Szpiro, Yuhang Zhao, and Shiri Azenkot. 2016. Finding a store, searching for a product: a study of daily challenges of low vision people. In *Proceedings of the 2016 ACM International Joint Conference on*

Pervasive and Ubiquitous Computing (UbiComp '16). 61-72. https://doi.org/10.1145/2971648.2971723

55. Anja Thieme, Cecily Morrison, Nicolas Villar, Martin Grayson, and Siân Lindley. 2017. Enabling Collaboration in Learning Computer Programing Inclusive of Children with Vision Impairments. In *Proceedings of the 2017 Conference on Designing Interactive Systems* (DIS '17). ACM, 739-752. https://doi.org/10.1145/3064663.3064689
56. Marynel Vázquez and Aaron Steinfeld. 2012. Helping visually impaired users properly aim a camera. In *Proceedings of the 14th international ACM SIGACCESS conference on Computers and accessibility* (ASSETS '12). ACM, 95-102. http://dx.doi.org/10.1145/2384916.2384934
57. Michele A. Williams, Amy Hurst, and Shaun K. Kane. 2013. "Pray before you step out": describing personal and situational blind navigation behaviors. In *Proceedings of the 15th International ACM SIGACCESS Conference on Computers and Accessibility* (ASSETS '13). ACM, Article 28, 8 pages. http://dx.doi.org/10.1145/2513383.2513449
58. Michele A. Williams, Caroline Galbraith, Shaun K. Kane, and Amy Hurst. 2014. "just let the cane hit it": how the blind and sighted see navigation differently. In *Proceedings of the 16th international ACM SIGACCESS conference on Computers & accessibility* (ASSETS '14), 217-224. http://dx.doi.org/10.1145/2661334.2661380
59. Jacob O. Wobbrock, Shaun K. Kane, Krzysztof Z. Gajos, Susumu Harada, and Jon Froehlich. 2011. Ability-Based Design: Concept, Principles and Examples. *ACM Trans. Access. Comput.* 3, 3, Article 9 (April 2011), 27 pages. http://dx.doi.org/10.1145/1952383.1952384
60. World Health Organisation. 2017. *Disabilities*. Last retrieved 06.09.2017 from http://www.who.int/topics/disabilities/en/
61. Shaomei Wu, Jeffrey Wieland, Omid Farivar, and Julie Schiller. 2017. 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* (CSCW '17). ACM, 1180-1192. https://doi.org/10.1145/2998181.2998364
62. Rayoung Yang, Sangmi Park, Sonali R. Mishra, et al. 2011. Supporting spatial awareness and independent wayfinding for pedestrians with visual impairments. In The proceedings of the 13th international ACM SIGACCESS conference on Computers and accessibility (ASSETS '11). ACM, http://dx.doi.org/10.1145/2049536.2049544
63. Georgios Yfantidis, and Grigori Evreinov. 2006. Adaptive blind interaction technique for touchscreens. *Universal Access in the Information Society* 4 (4), 328-337. http://rd.springer.com/article/10.1007/s10209-004-0109-7
64. Yuhang Zhao, Michele Hu, Shafeka Hashash, and Shiri Azenkot. 2017. Understanding Low Vision People's Visual Perception on Commercial Augmented Reality Glasses. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems* (CHI '17). ACM, 4170-4181. https://doi.org/10.1145/3025453.3025949
65. Annuska Zolyomi, Anushree Shukla, and Jaime Snyder. 2016. Social Dimensions of Technology-Mediated Sight. In *Proceedings of the 18th International ACM SIGACCESS Conference on Computers and Accessibility* (ASSETS '16). ACM, 299-300. https://doi.org/10.1145/2982142.2982190

[i] http://www.sports-innovation.org.uk/
[ii] http://vizwiz.org/
[iii] https://www.mturk.com/mturk/welcome