The Invisible Work of Accessibility: How Blind Employees Manage Accessibility in Mixed-Ability Workplaces

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ABSTRACT
Over the past century, people who are blind and their allies have developed successful public policies and technologies in support of creating more accessible workplaces. However, simply creating accessible technologies does not guarantee that these will be available or adopted. Because much work occurs within shared workspaces, decisions about assistive technology use may be mediated by social interactions with, and expectations of, sighted coworkers. We present findings from a qualitative field study of five workplaces from the perspective of blind employees. Although all participants were effective employees, they expressed that working in a predominantly sighted office environment produces impediments to a blind person's independence and to their integration as an equal coworker. We describe strategies employed by our participants to create and maintain an accessible workplace and present suggestions for future technology that better supports blind workers as equal peers in the workplace.

Categories and Subject Descriptors
K.4.2 [**Social Issues**]: Assistive technologies for persons with disabilities

General Terms
Design, Human Factors.

Keywords
Assistive Technology, Blindness, Collaborative Accessibility, Vision Impairment, Workplace.

1. INTRODUCTION
Access to employment is essential to providing independence for people of all abilities. In order to maintain a fair and equal society, individuals with disabilities must be able to find employment and to acquire reasonable accommodations for performing and maintaining their job.

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Figure 1. Our blind office worker participants addressed accessibility challenges through a combination of assistive technology and collaboration with sighted users. Here, a participant shows a paper form with the signature line marked by a sticky note placed by her sighted colleague.

In the past several decades, efforts to increase the rate of employment by people with disabilities have proceeded along two fronts. First, public policy efforts such as the Americans with Disabilities Act have provided improved support for requesting and receiving workplace accommodations. At the same time, advances in assistive technology (AT) have made work tasks more accessible [8].

Despite advances in both disability policy and accessible technology, the percentage of workers with disabilities in the US has declined in recent years [10]. There may be several reasons for this discrepancy. For example, even when existing policies support reasonable accommodations for workers with disabilities, workers may hesitate to request accommodations because they may believe that the request will not be honored, or because they do not wish to request too much help [1]. Additionally, while assistive technologies may be available to address particular accessibility barriers, users often choose not to adopt or to discard them because they lack the appropriate functionality [12] or may draw negative social attention [9, 17].

Addressing these challenges to equal employment for people with disabilities requires an approach that considers technical and social concerns simultaneously, because these concerns together shape if, when, and how assistive devices are used in the wild. For example, a blind person who encounters an inaccessible document in her workplace may need to decide whether to seek a technical solution to make the document accessible or to ask a coworker to read the document for her.

We present findings from a qualitative field study in which five blind employees who work in a mixed-ability workplace discuss accessibility challenges they encounter. Our paper documents the "invisible work" [19] that our participants perform to identify accessibility challenges and solutions, with special consideration to how the mixed-ability social context of most office settings affects access. We conclude with suggestions for extending accessible technology design to support more accessible workplaces and to enable collaboration between people with mixed abilities.

2. RELATED WORK

This paper explores the accessibility challenges encountered by blind office workers in shared workspaces. We briefly summarize prior work on assistive technology for blind office workers as well as research on the social and collaborative aspects of using assistive technologies.

2.1 Visual Accessibility in Office Work

Our present study focuses primarily on blind office workers. While assistive technology solutions may vary greatly across work domains, many of our participants used accessible computer technology, including screen readers, to perform their everyday tasks. Summaries of commonly used desktop and mobile accessibility tools for blind and visually impaired users are provided by Jacko et al. [8] and Kane et al. [9], respectively.

2.2 Use and Non-Use of Assistive Technology

Despite the availability of assistive technologies to address a variety of accessibility issues, many individuals choose not to adopt assistive technologies. Often, assistive technologies are not adopted or are abandoned because they provide inadequate functionality or are too costly [12]. Recent work from Kane et al. [9] and Shinohara and Wobbrock [17] have explored social reasons for choosing to use assistive technologies and found that individuals often avoided using technologies that drew unwanted attention to their disability. This paper extends this prior work by exploring the use or non-use of assistive technologies and accommodations in the workplace.

2.3 Accessibility as Collaborative Work

Much assistive technology research focuses on the relationship between an individual user and a technical system (e.g., [8, 18, 21]). However, a number of recent studies have explored how assistive technology use may be affected by social interactions.

Branham and Kane [4] used the term *collaborative accessibility* to refer to how blind people and their sighted companions worked together to create an accessible shared home environment. Branham and Kane found that many of the accessible resources in the home were created and managed through discussion, planning, and compromise. The present study also considers the collaborative work of accessibility, but in the context of office workplaces. We consider how achieving collaborative accessibility in an office setting may constitute "invisible" work [19] for the person with a disability. In other words, the visually impaired worker necessarily conducts additional work to create an accessible space, even though this work may not be openly discussed or considered part of regular work responsibilities.

Assistive technology researchers have also explored how interactions between individuals with and without disabilities can inform the design of better assistive technology. Williams et al. [20] studied how blind individuals interacted with sighted companions when navigating in order to design better automated navigation aids. Burton et al. [5] also explored how crowdsourcing could provide personalized and subjective feedback on fashion decisions for blind users of the VizWiz mobile application. Brady et al. [3] investigated how friends in a blind person's social network could answer visual questions using crowdsourcing techniques. The present study explores how blind workers leverage both technology and human connections to solve accessibility problems, with the goal of gaining additional insights into designing effective assistive technologies.

Recognizing that individuals with disabilities often use assistive technologies in the presence of others, researchers have reported on the design of systems that enable users with varying abilities to work together. Savidis and Stephanidis [16] and Plimmer et al. [15], among others, have studied multimodal user interfaces that enable blind and sighted collaborators to use a shared user interface. Piper and her colleagues have studied user interfaces that enable communication between people with disabilities and clinicians [13, 14]. Hailpern et al. [7] and Flatla and Gutwin [6] developed tools that simulate the experience of a person with a disability to help partners with different abilities better understand their experience. While we do not introduce new technology in this paper, our exploration of how coworkers with mixed abilities work together in office contexts may inform the design of new technologies to support mutual understanding and collaboration across abilities.

3. FIELD STUDY

3.1 Participants

We recruited five participants who were blind office workers. Participants were recruited from previous study contact lists as well as through snowball sampling. Four of five participants were government or state employees, owing to the proximity of participants to Washington, DC and the government's proactive approach to hiring people with disabilities. However, each participant worked for a different organization. In addition, four of the five participants worked in positions that were related to serving people with disabilities. All participants used screen readers. Two participants used service animals, while all others used white canes. We interviewed each participant (Table 1) across three sessions. During the second session, we were sometimes able to interview our participants' sighted colleagues (six total, all sighted) about their views of accessibility in the office. Sighted colleagues were identified by blind participants as the people with whom they worked most closely. Participants were compensated for their time.

3.2 Procedure

Three sessions were held with each participant, for a total of 15 sessions. The first and third sessions were held at a location convenient to the participant (e.g., their home), while the second session, which included a workplace tour, was held in the participant's place of work. The first session consisted of a semi-structured interview that covered topics such as the participant's occupation, their work environment, past and present accessibility challenges in the workplace, and how they met these challenges.

During the second session, the participant took the researcher on a walkthrough of their workplace and identified accessibility concerns. This provided background for findings in Interview 1 and helped the participants remember additional examples. To determine whether coworkers were also aware of accessibility concerns, participants asked one or more of their colleagues to take the researcher on a workplace walkthrough, as well. Walkthroughs were arranged so that participants and their coworkers could not hear each other's responses.

Between the second and third sessions, participants and their colleagues were asked to independently complete an online survey to see whether the blind and sighted coworkers identified similar accessibility challenges. The survey presented a list all accessibility issues identified by both the blind participant and their sighted colleague(s) during prior interviews. For each issue, participants were asked to identify which issues were previously unknown to them, and the blind participant was given an opportunity to flag items that were not, in fact, issues for them. One participant, Daryll, identified a coworker who was unwilling to participate in the walkthrough and survey, and so Daryll was not able to complete this survey. Another participant found three willing colleagues, for a total of 10 completed surveys (four blind participants and six sighted colleagues).

We report survey results related to the types of challenges participants and colleagues identified. Survey results were discussed with participants during the third and final session. In the third, semi-structured interview, participants reflected on their colleagues' contributions, identified any additional issues that may have come up recently at work, and suggested possible solutions to accessibility issues.

3.3 Analysis

All three sessions were documented with audio recordings and handwritten notes. Pictures and short video clips were taken during walkthroughs, with participants' permission. Notes taken during interviews were expanded following the completion of each interview and were thematically coded (e.g., "finding one's own accommodations"). Accessibility issues that were confirmed by blind participants in surveys were classified into categories (e.g., "inaccessible computer software"). Themes and categories were discussed between authors. Each audio interview, including pictures and videos, was reviewed in full, leading to additional themes and targeted transcription of representative examples.

4. Findings

Our findings are organized into four sections. We begin by describing the types of accessibility issues that participants encountered. Next, we show that the degree to which a device or activity is accessible changes based on particular features of the office environment. We then describe how participants creatively addressed access problems. We finish with a demonstration of how communication breakdowns between blind and sighted colleagues can create a less accessible work environment.

4.1 Visual Accessibility in Office Work

In this section, we summarize the types of accessibility problems identified by participants and their coworkers via the surveys. Participants and their coworkers identified a total of 105 issues. We note which accessibility concerns were shared across multiple blind participants (e.g., three participants indicated similar concerns about using the JAWS screen reader when engaged in conversations with coworkers). Because Daryll's coworker was unable to complete a survey, this section documents responses from the other four participants only.

Accessibility challenges were sorted into four high-level categories defined and discussed below (Figure 2). All four blind participants who completed the survey experienced at least one accessibility challenge from each of these categories.

4.1.1 Inaccessible Environmental Features

We found that many of the "ambient" features of the environment were inaccessible to blind participants (23 issues). These items included resources such as work tools, safety equipment, furniture, decorations, and even entire rooms.

Table 1. Blind office workers who participated in our study. Participants provided their own pseudonyms.

Participant	Age	Occupation	Total Years Working	Years at Current Company	Office Environment	Visual Ability
Molly	25	Research Assistant	2.5	0.25	Works with 3 immediate colleagues, all sighted, in an office with over 100 people; job is related to research for people with disabilities; company has internal division for accommodations.	Blind since birth, no usable vision
Mary	29	Attorney	2.5	1	Works with 4 immediate colleagues, all sighted, in an organization of about 50 people; job is related to disability rights.	Blind since birth, no usable vision
Daryll	39	Customer Service Specialist	12	9	Works with 2 immediate colleagues, all sighted, in an office of over 100 people; company has internal division for accommodations.	Gradual vision loss since age 3, has used screen reader and white cane for past 9 years
Wallace	48	Executive Director	17	1	Works with 6 immediate colleagues, one of whom is blind, in an organization of about 100 people; job is related to accommodating people with disabilities.	Blind since birth, no usable vision
Catherine	54	Program Analyst	26	7	Works with 3 immediate colleagues, in an office of over 100 people; job is related to funding grants for people with disabilities; company has internal division for accommodations.	Gradual vision loss since birth, legally blind since age 16, no usable vision since 23

Multiple participants noted that awareness of safety equipment and spaces was not accessible. For example, Daryll was not aware of the existence of Designated Safe Area rooms, which were to be used in case of an emergency lock-down (Figure 2a). Even if the hall signs that identified them were made accessible with Braille, Daryll would not have known to feel for them. Mary learned for the first time during our walkthrough that the kitchen contained a fire extinguisher, a first aid kit, a recycling bin, a bulletin board, and some free snacks. Following our interview, Mary returned to the first aid kit to get some rubbing alcohol, but was unable to find it independently, and needed to ask the secretary to help her locate it. In another event between interviews, Mary's office had a tornado safety drill. She realized during the drill that she had forgotten the emergency evacuation route. Again, she was unable to make use of the visual exit signs or maps like her colleagues. Mary felt that these were serious, high-risk accessibility problems.

Several participants were unaware of the location and features of colleagues' offices. Catherine found navigating to cubicles difficult because there were no walls to guide her. Prior to our walkthrough, Mary did not know several of her colleagues had decorations in their workspaces (Figure 2b). When Mary learned that her adjacent coworker's desk was decorated with toy ducks, she decided she should decorate her own desk with butterflies.

This lack of awareness became particularly frustrating when a worker knew a resource existed and used to know where to find it, but could no longer access it because a colleague had moved it. For example, Molly's team shared equipment for running studies, and the team would regularly pack the equipment into a suitcase to transport it between different work sites. When the equipment was unloaded by colleagues, neither the equipment nor the suitcase was stored in a predictable location. Molly had to waste time looking for the strewn equipment and sometimes tripped over the suitcase when it was left in the middle of the floor:

> *"What I hate—and I think a lot of blind people hate this—is other people moving your crap all over the place." –Molly*

4.1.2 Inaccessible Print Materials

Print materials were a common source of inaccessibility (19 issues). This category included accessibility problems related to paper mail, faxes, files, handwritten signs (e.g., "sink out of order"), sticky notes, and whiteboard content that could not be independently or readily accessed.

Public displays were a common form of inaccessible print material. For example, Mary's office hallways were lined with numerous photographs and accompanying signs describing famous civil rights cases (Figure 2c). However, Mary could not access them. Similarly, Molly's office hallways were lined with research posters summarizing the work of colleagues (Figure 2d), which were likewise inaccessible. Mary said that she wished she could read the posters to stay in tune with related research.

4.1.3 Inaccessible Hardware and Electronics

Our participants' offices were filled with hardware and electronic devices that lacked appropriate feedback to be accessible to participants (16 issues). These devices often used touch screen input and visual-only output. Printers, scanners, fax machines, phones, microwaves, vending machines (Figure 2e, reported by Catherine), thermostats, and more fell under this category.

Inaccessible office telephones were the most prevalent problem in this category, accounting for nearly 50% of all reported hardware and electronics problems. Participants reported that they were usually able to access their phone's basic features, such as dialing a phone number. However, because many phones looked like Daryll's (Figure 2f), with a mix of physical buttons and visual-only displays, accessing functions such as mute, hold, and call transfer was difficult if not impossible. Additionally, caller ID, missed calls, and new voicemail notifications were almost universally inaccessible. Inaccessible phones can lead sighted outsiders to perceive the blind worker as inattentive or unresponsive. Wallace explained the social implications of this inaccessibility:

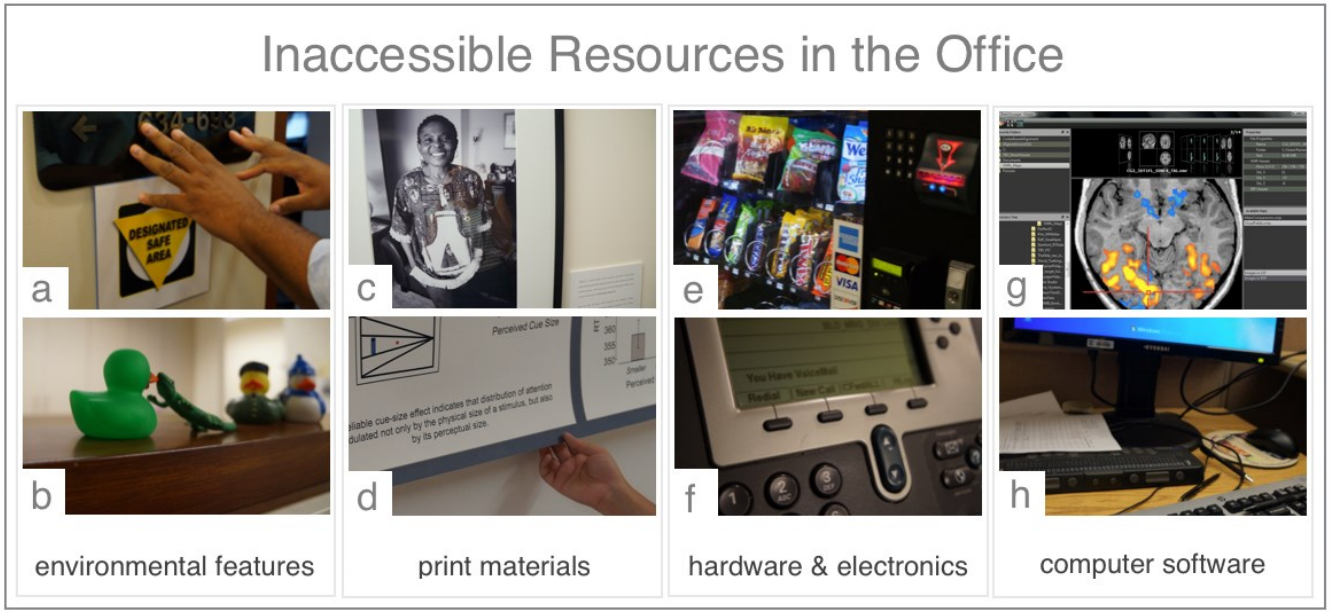

Figure 2. Examples of the types of inaccessible resources participants identified through workplace walkthroughs and accessibility surveys. We explored four categories of inaccessible resources: environmental features (e.g., a refuge room, office decorations); print materials (e.g., photographs, posters); hardware and electronics (e.g., vending machine, desk phone); computer software (e.g., MRI scan viewer, screen reader without headphones).

"If you called me and [my sighted colleague] on Monday, and we're out, and you left us both a message, [my colleague] comes in Tuesday morning and she sees the flashing light. I don't see anything. I can call my inbox and see if I have messages, but there's no prompt… [My colleague] gets a prompt and I don't. But your perception from the outside is [Wallace's colleague] returns my calls, and I don't." -Wallace

So, in addition to making more work for a visually impaired user who wants to know if he has new voicemail, inaccessible phones have negative social implications; they can lead sighted outsiders to perceive the blind worker as inattentive or unresponsive.

4.1.4 Inaccessible Computer Software

The most commonly reported accessibility challenges were related to computer software (47 issues, 42.6%). These reports included inaccessible web sites needed for work (e.g., for booking business travel), in-house software (e.g., timesheet reporting software), inaccessible features in office software (e.g., Microsoft Word's track changes feature), and documents in inaccessible formats (e.g., some PDF files, MRI brain scans).

We found that highly specialized software—either of a homegrown or highly technical nature, was often the least accessible and required significant intervention. For example, Molly's job required the use of computer programming tools like MATLAB. However, Molly ran into compatibility issues between MATLAB, the custom hardware needed for her research, and her screen reader. Molly also wanted to use special MRI exploration software, like BrainVoyager, just like her colleagues (Figure 2g). However, BrainVoyager software was completely inaccessible, excluding Molly from contributing to MRI analysis in her research team.

Other reported problems often involved JAWS or similar screen reader software (Figure 2h, reported by Catherine). In surveys alone, participants reported 11 distinct problems arising from the fact that screen readers could cause disruption, especially when used during activities requiring a clear audio channel. Participants noted that using JAWS without headphones distracted other office workers, but that using JAWS with headphones could block out important peripheral noise, make the blind worker look cut off from their coworkers, discourage impromptu conversations, and make note-taking during meetings difficult. Use of JAWS during collaboration can also cause coordination difficulties:

"One thing I learned when I was working with sighted people is they would talk while I was still listening [to my screen reader]… I can't listen to two streams at the same time. So, I'll hold my hand up like this ("stop"). I have to teach them." -Catherine

4.2 Accessibility in (Social) Context

Before we explore the ways blind workers problem-solved inaccessible work environments, we briefly introduce findings that challenge and expand traditional ways of talking about accessibility in the office. At the core of these findings is the notion that accessibility is not an essential quality of a particular device. Instead, accessibility is affected by sociomaterial aspects of the context. In other words, a device that is accessible in one setting may be rendered inaccessible in another due to social and organizational factors.

In this section, we explore how accessible technologies fail in mixed-ability settings. Accommodations that were appropriate for use by a blind *individual* sometimes caused friction in a sighted, *collaborative* office setting. For example, using a screen reader (JAWS) during *synchronous* collaboration with sighted colleagues was sometimes disruptive to all parties:

"The hardest thing for me is when we are in meetings with a client. [Sighted attendees] can go back to a paragraph in the complaint and refer to it. But I can't as easily. I didn't have a laptop at that time, and it's hard to listen to JAWS and other people at the same time." -Mary

To address this problem, some participants used a Braille-based note taker to take notes during meetings without audio interference from a screen reader. However, these special purpose devices could present their own usability problems and sometimes violated workplace security policies.

In addition to reducing the blind worker's attention, use of a screen reader could also distract sighted coworkers:

"I think it's interruptive [to sighted people] to keep the VoiceOver [screen reader] on while the admin was fixing my computer for me because the keystrokes are different. So, I'll turn it off. So, at that point, I am, as it were, blind to what they are doing, but that's what I have to do because it's just better for all [other] parties involved." -Daryll

A third challenge occurred due to the fact that sighted coworkers could not easily follow what the blind worker was doing when using a screen reader. Often the sighted and blind workers saw the same content differently, leading to confusion. Catherine explained one scenario in which she was sharing an MS Word document with a sighted colleague, but only she could see the document content:

"She said 'there's nothing on that document.' 'Yes there is, I can hear it.' Well, somehow the document had changed to white text on a white background, so it took us a while to figure that out." -Catherine

Other challenges occurred when sighted coworkers preferred software that was less accessible to more accessible alternatives. For example, Molly (who is blind) preferred to edit spreadsheets using Microsoft Excel and the JAWS screen reader, while her sighted colleagues preferred to use Apple's Numbers program. Because Molly used different spreadsheet software than her teammates, sharing files became more difficult than it would have been if everyone had used the same software.

In some cases, participants owned relevant accessible software, but had difficulty using it during collaborative activities because it could not be installed on shared devices. For example, due to budget constraints, Molly's workplace provided only a free trial version of the JAWS screen reader on her group's shared computer. This trial version timed out every 40 minutes, after which the computer needed to be restarted. Because the computer was shared, other problems arose when Molly's coworkers forgot to activate the screen reader or to reset the timer, leaving the computer in an ambiguous and potentially unusable state:

"I really get annoyed, it is just something that inherently annoys me when a bunch of people are using the same stuff as me, because I can customize things the way I want. So when people f--- around with the settings—which is totally how I feel about it!" -Molly

4.3 The Invisible Work of Accessibility

In general, our participants expressed that they were able to access the tools needed to perform their jobs. However, participants often described additional work that was required on their part in order

to create an accessible workspace. This work was "invisible" [19] in that it was additional to their required job functions and largely unnoticed by coworkers and supervisors.

In surveys, we found that blind and sighted participants had different understandings of the accessibility problems around the office. That is, there was little alignment between the accessibility problems perceived by blind participants and the sighted colleagues with whom they worked most closely.

First, on average[1] 47% of accessibility issues identified by blind participants were completely new to the sighted colleagues. Second, on average 27% of the accessibility issues identified by sighted colleagues were not deemed to be problems by blind participants. In other words, sighted colleagues have limited understanding of what is and is not an accessibility problem in the office. Finally, on average fewer than 9% of problems were the same between blind and sighted colleagues' lists. Lack of substantial overlap suggests that the most significant accessibility problems from the perspective of blind participants are not as visible or salient to sighted colleagues. This interpretation was indicated verbally by most blind participants during interviews:

> *"I am surprised at how much [my sighted colleague] didn't realize. [Sighted people] take [access] for granted and they don't realize I can't tell those things." -Mary*

Consequently, most participants felt a need to actively communicate accessibility setbacks to colleagues so that delays could be better understood:

> *"I think it is easy for [sighted] people to take for granted something will just work…. If it takes me longer to get things working it is not because I am incompetent or because I am lazy. It is just because there is an extra process, and if you guys just bear with me I will make it work. It is just something that I have had to learn, that communicate, communicate."-Molly*

When encountering an accessibility problem, participants were faced with the decision of whether to try and solve the problem themselves or to seek help. Below, we share examples of each approach.

4.3.1 Finding One's Own Accommodations

Participants described a number of examples in which they investigated and solved their own accessibility problems in the workplace. Often, participants had to invent new strategies for overcoming accessibility problems:

> *"People who are using adaptive technology interfaces have to be a little smarter and a little better at problem solving than their colleagues, or they would not be able to function in a work environment." –Wallace*

Some accessibility issues arose out of malfunctioning assistive technology or compatibility issues with other software or hardware. In part, participants solved access problems on their own because they had more experience than their coworkers in debugging assistive technology. For example, Molly experienced a confusing error that none of her coworkers had encountered, so she had to troubleshoot it herself:

> *"I am pretty good at figuring out obscure solutions for problems. For example, …I had written this code and… it was working fine and… every time a participant came in it would crash... So, just through trial and error… I finally figured out I am going to leave the same pair of headphones in and mute VoiceOver and now it doesn't crash at all." –Molly*

Another participant, Wallace, invented a solution to the problem of monitoring multiple devices at once. Because he could not use multiple displays, he instead wore multiple pairs of headphones to monitor audio from multiple devices at once (Figure 3).

Daryll, whose job relies heavily on his office phone, took it upon himself to research and negotiate the adoption of an accessible "soft phone" for his workplace that supports all the functionality of his desk phone on his computer using JAWS:

> *"The phone, at one time, was truly an inaccessible option… The accessibility issue was resolved because I had an opportunity to observe a new startup that was developing a new technology to make phone services accessible… Then, I worked on the pilot project to test run it in our system. … We have a 508 [accessibility compliance] department, who deals with technology assessments. They didn't take as much as a direct role as I expected… I took more of a lead on that project." –Daryll*

In all of these examples, we see how the blind coworker has encountered accessibility problems and creatively identified and implemented workarounds, notably absent of institutional support.

Figure 3. Wallace has developed a creative solution for the need to simultaneously monitor multiple displays, a problem long addressed by HCI researchers for sighted users. He simply layers over-ear headphones atop his earbuds to receive updates from his computer and iPhone, respectively.

Wallace, an accommodations expert, offered some insight into this sort of self-accommodation, which can be interpreted as both a burden and an opportunity for self-advocacy. The ADA almost requires self-accommodation, he explained, because it says that no one needs to be accommodated if they do not disclose a disability. Without this stipulation, employers might push unwanted technology onto an employee that effectively segregates them. On the other hand, this places the burden of identifying assistive technology needs on the individual with a disability, requiring that person to become an expert at finding their own accommodations:

> *"[As an employee], you don't want to be an AT specialist, you just want to do your job… [But, the non-expert] ends up at a disadvantage." –Wallace*

[1] Averages were calculated across totals for each workplace. Responses from Catherine's three sighted colleagues were combined. Daryll's workplace was omitted because he and his colleague did not complete the survey.

Wallace proceeded to give an example of how he once placed trust in a supposed specialist who advised him to buy a very expensive and—unbeknownst to him—very outdated piece of assistive technology. Thus, even when companies provide accessibility specialists, actual assistive technology users may need to route around those specialists to find the best solutions for their own needs.

Wallace further explained that someone who cannot find one's own accommodations might be overlooked for opportunities to contribute to their team at work:

> *"I think what sometimes happens is 'Oh, well, you can't do this task or use this software, so you don't have to.' And everybody else does it… No one can figure out how—including me. It's actually kind of benevolent. 'We'll just take you off of that task,' maybe they'll give you another task." –Wallace*

We call this phenomenon the *double-edged sword of self-accommodation*; finding one's own accommodations empowers one to find the best solution, but also requires work beyond official job duties. Self-accommodation was only one approach used by blind participants to gain access. Another approach was to solicit support from sighted colleagues. Involving others in the problem-solving process made access issues more visible to particular colleagues:

> *"Several of the things [my sighted coworker] said [in the survey] are things that I ask her to help me with or that we collaborate on." –Catherine*

We describe this type of collaborative accessibility below.

4.3.2 Seeking Support

When participants encountered accessibility problems that needed immediate resolution, or when they did not have an obvious or convenient technical workaround, they often sought help from colleagues and friends.

Participants offered various reasons for choosing to seek help. Catherine, a program analyst and a relatively senior employee in her organization, worked extensively with a reader assistant, and often delegated tasks to him. She explained that delegating these tasks increased her efficiency, but that she also enjoyed the opportunity to work with another person:

> *"I am more interested in efficiency than absolute independence. So, with [my reader], we'll do [inaccessible tasks] together." -Catherine*

As mentioned in the previous section, sighted coworkers often could not help solve accessibility problems, as they lacked experience with accessible technology. In these situations, participants sought help from other blind workers at different companies who were part of their social network. For example, Mary worked at a law firm that used the LexisNexis search engine for legal cases. Because her employer had a contract with LexisNexis, they were unable to provide her with WestLaw, alternative software that is widely known among blind law students and practitioners to be more accessible. So, Mary reached out to one of her blind friends to borrow a license.

Wallace similarly acknowledged that there is a culture of sharing accessibility workarounds through social networking:

> *"Social networking offers one kind of answer to [sharing accessibility tips and tricks]. I know people who... make a point of saying 'I figured out how to use this and here's tips and tricks' and they'll put something on Twitter." -Wallace*

In some cases, technology in the office was simply inaccessible to the blind worker without sighted assistance. When Wallace needed to know more about the state of his telephone, he relied on sighted colleagues:

> *"If I put my phone in a state that I don't understand, [my sighted colleague] comes over to help. Everybody in the office is probably used to being solutions to these [accessibility problems]. " –Wallace*

Sometimes the blind worker asked for help but was able to offer something in "trade" in order to feel like less of a burden. For example, Catherine worked closely with a sighted wheelchair user to complete a number of tasks that neither could complete independently, but that they could complete together:

> *"[My sighted colleague] and I often do collaborative disability assistance. I'll do stuff for her because she's mobility impaired, and she'll do stuff for me." -Catherine*

> *"We developed a collaborative cafeteria plan. We'd go downstairs and scare the [expletive] out of people because I'd push her wheelchair or get food for her and carry stuff back for her, because she can't… I'll say '[Coworker], do I have schmutz on my pants?' It takes a lot of time and friendship to get to that arrangement." -Catherine*

Problems arose when a participant needed help with tasks that were personally important to them, but not critical to their official work functions. In these situations, participants were hesitant to disrupt colleagues from work and risk being seen as needy or complaining:

> *"Things like pictures on the wall, I don't really know how to talk about that. I don't know of anything exists to fix that… because I don't want to be too difficult and seem like I'm complaining…. 'Can you explain every picture on the wall?' [It would] take a lot of time and it's not really important to work." -Mary*

Asking for assistance at the office was further complicated by the nature of professional relationships and a large community setting. Participants expressed that it was more difficult for them to collaboratively manage accessibility with colleagues at work than with family members at home:

> *"There's too many people at work, you can't make a deal with 20 people [to keep the dishwasher door closed]… you can't expect people to remember all the time. I'm not as close to them [as I am with my roommate]… the office is less accessible than home, because at home I can label my own things, I can put them in a certain spot without them being moved, I know what my own dishes feel like. There's things I can do at home that I can't do at work." -Mary*

5. DISCUSSION

While our study included a small number of participants, we uncovered a large number of accessibility issues in the workplace, including many issues in disability-friendly workplaces. Rather than being static, these accessibility problems changed over time and were continually being renegotiated by employees. This finding supports our prior work that has shown that maintaining the accessibility of a shared space involves ongoing collaborative accessibility work from those who use that space [4].

Furthermore, we have found it useful to consider accessibility problem solving as "invisible work" [19], because it was usually not recognized as part of any employee's core responsibilities. As a result, many accessibility challenges became the responsibility

of the employee herself. When a blind worker requested help from a coworker, this activity was often considered to be a favor rather than the responsibility of any specific employee. As noted by Petrick [11], "[p]rior to any legislation providing civil rights for people with disabilities, the responsibility to fit into a sighted workplace fell solely on the blind person." Our study suggests that blind workers must still bear the burden of their own accommodations. Moreover, addressing this issue may be complicated by the fact that self-accommodation is also a right, one that, if removed, could diminish their own sense of freedom and independence.

As reported in our prior work studying collaborative accessibility in the home [4], we found that managing the accessibility of the shared workplace was a task that was shared by the inhabitants of that space. However, because the office settings are generally shared by a large number of colleagues that have professional rather than personal relationships, many participants found that activities that were accessible at home were not accessible at work. The decision of whether to ask colleagues for support was always carefully weighed in terms of necessity, practicality, and the depth of the relationship. Fear of being seen as needy or as a complainer was ever-present and also discouraged participants from seeking out collaborative solutions. Comparing collaborative accessibility practices at home and at work presents an exciting opportunity for future research.

5.1 Opportunities for Design

Although we did not directly address technology design in our interviews and observations, our findings illustrate a number of persistent accessibility challenges that can inform design.

First, our participants frequently stated that they preferred not to ask coworkers for help with accessibility problems. This echoes prior work that showed that blind individuals often preferred asking unknown crowd workers for help over their own friends and family [3]. Also, our participants often felt that they could not ask their coworkers for help with assistive technology problems, as their coworkers lacked expertise in that area. Thus, there may be opportunities to provide blind workers with remote help with using assistive technology via crowdsourced question answering [2]. This may require pairing blind users with crowd workers who have expertise in accessibility as well as the appropriate professional domain.

Second, blind participants often lacked awareness of resources in the environment. This lack of awareness included both necessary resources, such as emergency signage, but also elements that contribute to office culture, such as personal decorations and shared snacks. While these items might be identified using visual question answering, the user must know that there is something to look for. This suggests opportunities for designing tools to support ambient awareness of the items in the environment such as talking signs or other "discoverable" resources.

Finally, many technologies that were technically accessible raised significant social challenges for participants. Subtle issues like a voicemail system that requires noticing a blinking indicator light might lead to unfair assumptions about a blind worker's responsiveness or efficiency. The same can be said of a tricky bug arising from incompatibilities with accessibility software; sighted coworkers might attribute productivity delays to the blind worker being incompetent or lazy. There may be opportunities to develop technologies that enhance communication between blind and sighted workers that may lessen the blind workers' concerns about being seen as complaining. We also found that assistive technology can be isolating. This was particularly true of screen readers, which demanded the users' listening attention and interfered with conversations with coworkers. Screen readers and related technologies might be redesigned to be more socially aware, providing feedback to sighted coworkers about when the blind worker's attention is elsewhere.

6. CONCLUSION

Equal access to employment has benefited both from advances in accessible technology and disability rights policy. Our study illustrates that, despite the relative availability of accommodations, workers with disabilities still encounter numerous accessibility challenges in the office setting. Our participants showed resourcefulness as they developed their own accommodations and sought support from colleagues. This additional work needed to create an accessible space is unfortunately rarely seen by coworkers and supervisors, potentially leading to negative and misguided interpretations of the productivity of blind workers. Perhaps the most daunting challenge to designers identified by our study is that an accessibility solution that works in one social setting may not work in another. Our study motivates continued research surrounding how technology functions in various in-the-wild settings, particularly in mixed-ability social situations.

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