# "Is Someone There? Do They Have a Gun?" How Visual Information about Others Can Improve Personal Safety Management for Blind Individuals

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## ABSTRACT

For decades, researchers have investigated and developed technologies that support independent navigation for people who are blind. This has led to systems that primarily aid in detecting routes, landmarks, and building features. However, there has been relatively little inquiry regarding how technologies might support navigation around and in the presence of other *people*. What visual information, if any, do blind navigators wish they had about people on their path? To address this question, we surveyed 58 blind and low vision individuals and interviewed 10 blind individuals. We discovered our participants were interested in using visual information about others to increase their physical safety. For example, they wanted to know if a passerby was holding a weapon, if a presumed official had a proper uniform or badge, and how to describe visual aspects of a criminal to law enforcement. This paper presents one of the only reports documenting accessibility challenges related to physical safety posed by others, including how future assistive tools can empower individuals with disabilities to more actively increase their sense of safety. We call this emerging area *Personal Safety Management* and contribute a set of four broad subareas that deserve further exploration by researchers and designers working within the blind and broader disabilities communities.

## CCS Concepts

**• Human-centered computing → accessibility → accessibility technologies → accessibility systems and tools**

## Keywords

Visual impairment; blind; disability; assistive technology; facial recognition; violence; crime; police; personal safety management.

## 1. INTRODUCTION

People with disabilities are disproportionately targeted as victims of crime. People who are blind, in particular, are nearly twice as likely to be victims of violent crime than people without disabilities, according to the Bureau of Justice Statistics [19]. Yet, to our knowledge, there are no commercially-available assistive technologies (AT) that provide visual awareness cues to enable people who are blind to recognize when a person has a gun or knife, locate a police officer in uniform, or describe a criminal suspect or the scene of a crime. Further, a survey of the ASSETS proceedings reveals that relatively few papers have explored threats to physical safety[1]. Those that have broached the topic have tended to focus on environmental safety and obstacle avoidance [6,7,30–32], access to emergency services and alarms [11–13,33], health-risk mediation [14,25–27], and device-oriented safety [2]. But, there is an apparent paucity of literature about the concerns people with disabilities have regarding physical safety in relation to *other people*—here referred to as *interpersonal safety*––and what role AT does or might play.

The current research began as an investigation of navigation aids for people who are blind, and later took a turn to focus on interpersonal safety. Navigation aid research has been concerned with detecting routes, landmarks, and building features [6,7,32]. These concerns are also dominant in commercial navigation technologies such as Guide Dots[2] and BlindSquare[3]. Recent research has established that passersby are also important in navigation [1,31]. For example, a passerby can be a helpful source of on-the-fly directions or be disruptive by grabbing one's white cane [1,31]. This insight seeded our initial research question: what types of information do blind navigators wish they had about *people*—as distinct from landmarks or objects—on their path?

To address this question, we distributed an exploratory survey to 58 people with visual impairments. The survey included both closed and open questions to identify what types of information—particularly visual information about other nearby people—might be useful during independent navigation. The survey revealed that visual information about people was sometimes desired and that interpersonal safety was a critical use case. To further explore these issues, we conducted semi-structured interviews with 10 blind individuals. All 10 interview participants shared stories of times when their personal safety was threatened by others. They expressed a need for access to visual cues that could empower them to more effectively manage their physical safety. In this paper we document and unpack the significance of this finding. Specifically, we call for further investigation into an area we call *Personal Safety Management—informed, agential, and proactive participation in maintaining one's own physical safety*

[1] We use the terms "interpersonal safety," "personal safety" and "physical safety" throughout. Interpersonal safety is used narrowly to refer to (threat of) bodily harm caused by other people via, e.g., assault. Personal safety and physical safety are used generally and interchangeably to refer to bodily harm caused by, e.g., environmental obstacles, lack of access to emergency services, as well as actions of other people.

[2] http://www.guidedots.org/

[3] https://www.blindsquare.com/


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# 2. RELATED WORK

Our work contributes to the existing body of literature relating to how assistive technology (AT) can provide blind individuals with visual information about others through facial detection and recognition. Work in this space has largely examined recognition technologies as a tool to support prosocial interactions (e.g., by reading facial expressions [22,23]) or improve device accessibility (e.g., by taking better photographs of people [3,20]). We extend this work by exploring how recognition technologies can be used to provide visual information about other people that is relevant to assessing and identifying threats to personal safety.

While a great deal of research within the ASSETS community has addressed the unique safety needs of individuals with disabilities, few papers consider the threats to physical safety posed by others. We found that previous research has focused heavily on environmental safety (e.g., obstacle avoidance) or device-oriented safety (e.g., reducing risks associated with device use). In fact, the only paper we found that directly addresses interpersonal safety threats to people who are blind is a recent contribution within the Usable Security community [5].

Our findings complement and extend this corpus by expanding the variety of safety threat scenarios encountered by people who are blind and by offering a map to researchers and designers who plan to further explore this emerging area.

## 2.1 ATs for Identifying Visual Attributes of People

Prior research has investigated technologies that assist blind individuals with identifying, recognizing, and detecting visual information about other people. Approaches involving computer vision have been very common in this space.

### *2.1.1 Detecting Faces using Facial Recognition*

Prior work has shown that blind individuals, like their sighted counterparts, have a desire to take and organize photographs [3]. Researchers have developed several camera applications that integrate features, such as facial detection, to assist users with capturing better photographs of people and objects [3,20].

### *2.1.2 Describing People using Facial Recognition*

Most work regarding person recognition has been through the development of facial recognition technologies. However, research in this area has largely framed facial recognition as a tool to support effective communication, rather than one that can support personal safety.

In 2005, Krishna et al. [23] developed the iCare Interaction Assistant, a wearable device designed to help blind individuals identify non-verbal cues during social interactions with sighted peers. This initial work sought to identify the most accurate algorithm for this task [23]. Based on the premise that blind users often encounter socially awkward situations in the workplace, Kramer et al. [22] developed a wearable system to identify colleagues and discreetly announce their names to the wearer.

Krishna et al. [24] later contributed a list of eight non-verbal cues that are important but not always accessible to blind individuals. Beyond identifying faces, they note facial expression, eye gaze, and appearance as important cues.

### *2.1.3 Describing People using Crowd Workers*

Brady et al. [10] studied the types of visual questions that users of VizWiz Social asked to crowd workers. VizWiz [9] is a mobile application that allows blind users to photograph something; audio record a question; and then ask either crowd workers, people in social networks, or an image recognition engine to identify what is in the photograph. Brady et al. [10] found that a small portion of users were using VizWiz to ask crowd workers questions about physical appearance of themselves or others.

## 2.2 ATs for Increasing the Physical Safety of Individuals with Disabilities

Some researchers have discussed and attempted to solve issues around environmental safety and access to health-related services for people with disabilities. Few have examined these through the lens of physical safety, and even fewer have considered the problem of interpersonal safety. In the following sections, we provide an overview of the types of research in the ASSETS community that most directly address physical safety of people with disabilities.

### *2.2.1 Environmental Safety and Obstacle Avoidance*

Many AT researchers have looked at safety in terms of environmental factors that pose obstacles to independent wayfinding. This research focused on different scenarios and populations, ranging from collision avoidance of power wheelchairs for older adults with cognitive impairments [30] to the environmental dangers construction and cars present to people with visual impairments when navigating [6,7,32]. The impact of surrounding people during wayfinding (e.g., by interrupting one's route, offering unwanted directions, or grabbing arms or white canes without consent [31,32]) are referenced primarily as threats to independent navigation.

### *2.2.2 Access to Emergency Services and Alarms*

Past research has investigated the disparate access certain populations have to emergency alerts, alarms, and protocols, as well as to emergency services, such as those provided by emergency call centers or police officers. Bragg, Huynh, and Ladner [11] designed a mobile alert application for hard-of-hearing and deaf users, informed by a survey analyzing the auditory needs of deaf individuals. They noted that emergency alarms, shouting, and gunshots are cues that contain auditory information which can be perceived without sight, but may be missed by deaf or hard-of-hearing individuals. Zafrulla, Etherton, and Starner [33] designed smartphone software to provide more equitable access to emergency call centers for deaf individuals using teletypewriter (TTY) technology. Burton et. al [13] briefly noted ways in which the visual "language" of law enforcement uniforms is unavailable to individuals who are blind, making it impossible to distinguish uniformed police officers from other citizens. Branham and Kane [12] found that blind individuals in the workplace did not have the same access to emergency evacuation routes, emergency tools, and emergency signage as their sighted colleagues. These studies have largely focused on accessibility of general emergency response tools rather than anticipation and navigation of interpersonal safety threats.

### *2.2.3 Health-Risk Mediation*

Addressing health risks and using technology to mitigate them spans a wide range of research, from relieving sore pressure for wheelchair users [27] to combatting barriers to fitness for blind and visually impaired individuals [25,26]. One salient aim of past research has been assisting individuals with disabilities in safely identifying medications [16,17]. Consel, Dupuy, and Sauzéon [14] developed an assistive notification system for older adults that delivered critical and non-critical alerts to users. For example, the system supported reminders to take medication and get out of bed.

#### 2.2.4 Device-Oriented Safety

We use the term device-oriented safety to refer to work seeking to limit the harm that devices themselves can cause users. Devices have the ability to induce situationally-induced impairments and disabilities (SIIDs) when they increase the cognitive load of the user in noisy or crowded environments [2]. Distracting audio interfaces can make it more dangerous to navigate traffic, for example [6,32].

#### 2.2.5 Interpersonal Safety

Interpersonal safety, or physical safety threats posed by others, is currently not well documented for people with disabilities. Most reports that focus on interactions with strangers do not address physical safety concerns; for example, researchers have identified the threat of others eavesdropping [4], giving unreliable directions [29], or stealing assistive devices worn by the user [26].

One notable exception is a 2016 study by Ahmed et al. [5] which investigated privacy, security, and physical safety concerns of individuals with visual impairments. The portion of their findings related to interpersonal safety identified streets, public transit, ATM booths, and private spaces like the home as four critical safety settings. They offer implications for the design of future wearable devices that might indicate, for example, how many people are in the vicinity and what they are attending to.

Our paper extends Ahmed et al.'s [5] work by documenting new classes of physical safety concerns and scenarios, including how existing ATs impact security and the need for more effective communication with police officers. We additionally provide reflections on how this type of research might be approached and its implications for the ASSETS community.

## 3. Study Design: What Visual Questions Do Blind Individuals Have About Other People?

This study consisted of an online survey of 58 blind and low vision individuals followed by 10 in-depth phone interviews with blind individuals.

### 3.1 Survey Methods

We deployed an exploratory survey to investigate the types of visual information people who are blind have about others in their vicinity. Because facial recognition (FR) is becoming pervasive and is already in some degree of use within the blind community, we framed the survey as an exploration of the current use and prospects of FR technologies. Open-ended questions in the survey enabled participants to identify other, sometimes non-visual, types of information they wanted to know about people (e.g., a person's size or their criminal history).

#### 3.1.1 Survey Design

The online survey opened with a brief introduction to FR technology along with two applications: identifying any face in the user's surroundings (e.g., strangers and passersby) or recognizing familiar faces (e.g., specific friends, family members, coworkers). Through closed questions, we assessed whether participants had any previous experience using FR and if they would find either of these applications of FR beneficial for their independent navigation or social interactions. Following each closed question, participants were able to elaborate on their answers through free response. We ran the survey as a pilot with five blind participants and then revised the prompts for clarity.

#### 3.1.2 Survey Participants

Participants were recruited using a database of contact points of blind individuals who had consented to take part in future studies. There were 58 respondents (39 female, 17 male, 2 preferred not to disclose), ranging in age from 10-57 years (average of 26). To improve the representativeness of the sample, our survey was inclusive of 10 minors (people younger than 18 years old), for which we had IRB approval and parental consent. We refer to survey participants as "SP1" to "SP58."

#### 3.1.3 Survey Analysis

The third author reviewed and thematically coded participant responses to each open-ended survey question, generating over 40 unique codes. These codes were organized into high-level categories including physical attributes, demographic information, and nonverbal cues. Codes were iteratively refined in multiple weekly group meetings over a period of months. High-level survey findings are summarized in Section 4.

### 3.2 Interview Methods

To add context and depth to the findings in our exploratory survey, we conducted semi-structured interviews. We particularly sought examples of times when blind individuals desired visual information about people, including their faces, to improve their independence, social interactions, and safety.

#### 3.2.1 Interview Design

Interviews were organized into two sections. The first section asked questions about skills, techniques, and strategies blind individuals use to identify people in different contexts (e.g., navigating, social gatherings, work environments). It also asked participants to describe situations in which they failed to obtain the desired visual information about other people. Finally, it asked how the provision of visual information could (or could not) help them in those situations.

The second section asked questions about participants' familiarity and experiences with FR technology, the potential advantages or disadvantages of assistive aids that use this technology, and how this technology could help them in challenging scenarios mentioned in the first section of the interview. The protocol did not explicitly mention physical safety threats until the end, after most participants had already identified this as an important application without prompt. We ran a pilot interview prior to participant recruitment and made minor revisions to the protocol.

#### 3.2.2 Interview Participants

We recruited 10 blind individuals through our participant database and snowball sampling. Participants (six female, four male) ranged in age from 24 to 65 and had varying ages of onset of blindness (Table 1). We refer to interview participants as "IP1" to "IP10."

#### 3.2.3 Interview Data Collection and Analysis

Because participants were distributed, all interviews were conducted over the phone. The second author was the primary interviewer in all interview sessions. Most interviews were also attended by a secondary interviewer from the research team who asked follow-up questions and assisted the primary interviewer in taking notes. Interviews lasted approximately 60 to 90 minutes each. After interviews, the primary and secondary interviewers discussed key themes in the interview. Interview insights were presented in multiple weekly group meetings, during which the significance of physical safety threats was identified. The second author listened again to interview recordings and gathered the set

| *ID* | *Age* | *Gender* | *Visual Impairment Description* | *Mobility Aid* |
|---|---|---|---|---|
| ***IP1*** | 28 | Female | Legally blind since birth | White cane |
| ***IP2*** | 35 | Female | Blind since age 18 | White cane |
| ***IP3*** | 65 | Male | Blind since age 18 | White cane |
| ***IP4*** | 29 | Female | Blind since birth | White cane |
| ***IP5*** | 38 | Male | Blind since age 13 | Guide dog before, now white cane |
| ***IP6*** | 24 | Female | Blind since birth | Both guide dog and white cane |
| ***IP7*** | 36 | Male | Blind in one eye, some light perception in the other | White cane before, now guide dog |
| ***IP8*** | 51 | Female | Legally blind since age 13, totally blind since age 45 | Guide dog before, now white cane |
| ***IP9*** | 52 | Male | Blind since age 4 | White cane |
| ***IP10*** | 30 | Female | Legally blind since age 16, totally blind since age 24 | White cane |

**Table 1: Demographic descriptions of interview participants.**

of all scenarios in which participants described issues relating to interpersonal safety; these portions of the interviews were transcribed in full by the team. The second author then conducted an iterative card sorting activity with the first author to organize transcribed examples into the thematic categories and subcategories presented in Sections 5.1, 5.2, and 5.3.

# 4. Survey Findings: Interpersonal Safety is a Concern

Our survey sought to explore potential applications of facial recognition (FR) in the context of blind navigation. We found that 28 of 58 participants had already used FR technology through photography apps that could identify the presence of a face in-frame. Two participants had previously used FR technology that could identify a face and associate it with a name.

The survey asked participants to share *who* they would use FR to identify and *what* information besides names would be valuable to know. Of people to identify, friends and family were mentioned most frequently (28 and 29 statements, respectively), followed by people with whom the user has a professional relationship (25 statements). Twenty-nine statements mentioned wanting to know physical attributes of a person that can be perceived visually (e.g., size of person, hair style, eye color, distinguishing features). Twelve statements mentioned background information about the user's relationship with another person (e.g., how you know the person). Eight statements mentioned non-verbal communication cues that can be perceived visually (e.g., facial expression, eye gaze). Seven statements mentioned demographic information (e.g., age, gender, disability status) which cannot always be perceived visually. Only four responses noted an interest in nearby strangers—as opposed to friends, family, or professional acquaintances. These mentions included seeking strangers on the street in emergency situations, meeting someone for the first time, and finding attractive strangers.

When we asked participants to identify *situations* in which they felt FR could be useful, stranger interactions were much more commonly referenced. Across both types of recognition (recognizing any face or recognizing a particular face), 36 statements explicitly mentioned that FR technology would be useful in helping the user become aware of, or remain aware of, the presence of other individuals (e.g., silent people in elevators and store employees behind service desks). Thirty-five statements indicated that FR would be useful when looking for someone, oftentimes for the purpose of receiving assistance (12 of 35 statements). Another 19 statements mentioned using FR technology to interact with media (e.g., when looking at photos or videos). Ten statements mentioned using FR to assist with identifying non-verbal communication cues (e.g., to identify if a stranger is staring).

While we set out to identify what visual information blind individuals would want about other people in a broad sense, we found numerous responses related to personal safety. Nine statements explicitly mentioned that FR would be useful in promoting safety:

> *"Environments where random people move about. I would like to know immediately when a person enters or exits a room, or my bubble. This is imperative as a blind individual, in case of safety." –SP41*

Four statements mentioned being able to identify emergency personnel and another three mentioned wanting to know the criminal record of others:

> *"If they had a criminal record and what that criminal record would be, then I would make my judgment from there." –SP43*

Our survey findings suggest there may be an implicit connection between the visual information that participants were interested in knowing and decisions about safety. Moreover, personal safety is a distinct concern for people who are blind when they are in the presence of strangers.

# 5. Interview Findings: Interpersonal Safety Manifests in Multiple Contexts

To gain a deeper understanding of the contexts in which visual information about others might be valuable, we followed our survey with a set of 10 semi-structured interviews. Although our interview protocol did not allude to physical safety until the end, participants' responses raised the topic early and repeatedly. Due to being so rarely and disjointedly presented in prior work, we chose to focus our analysis and reporting on participants' stories of managing physical safety in the presence of others. Findings from our interviews follow.

## 5.1 ATs Impact Sense of Safety

Perhaps one of our more unexpected findings is that assistive tools can impact user perception of interpersonal safety, even though this is not their primary function. Some participants explained that using an assistive tool or service animal could help them feel safer. Others felt using an assistive tool could pose a safety threat.

### 5.1.1 ATs Can Increase Sense of Safety

Three participants (IP3, IP6, IP7) described examples where using assistive tools, including their white cane, guide dog or apps on their cellphones could help them feel safer in certain circumstances or in the presence of strangers. IP6 used an app (Aipoly Vision[4]) that leverages computer vision to identify objects and read text on signs, because it made her feel "more confident" and "less vulnerable." She shared an experience where she got off the bus at the wrong station in an unsafe area of the city. She used the app to read the bus numbers, which helped her get out of that area as soon as possible.

IP3 described a situation where he was walking alone late at night in an area of the city that was known to be unsafe gang territory. Suddenly, he could hear several young male voices ahead on the sidewalk. As he approached, he heard footsteps as the presumed gang members surrounded him. He stopped. When there was no greeting, he initiated conversation to examine the situation, but he did not receive any verbal response. Then one of the gang members, who had presumably noticed his white cane, called the others off by saying "not cool man." IP3 believed he was in danger, yet he was ultimately saved by his AT (white cane) signaling his disability to the young men. *"Blindness tends to temper that [threatening] situation,"* IP3 remarked.

IP7 similarly mentioned that his guide dog helped him feel safer while walking in unfamiliar and crowded areas with homeless people around. He believed his dog dissuaded others from approaching or harassing him:

> *"[As] a person with a guide dog, I would say that I … feel definitely a lot more safer knowing I have my guide dog, than being alone without one and having a cane … The majority of people whom I interact with … will not necessarily come toward me, thinking that my dog would be aggressive." –IP7*

Interestingly, IP7 believed that one form of assistive tool (a guide dog) could make him safer than another (a white cane). For both IP3 and IP7, navigation aids served a dual purpose by imparting a sense of protection from potentially threatening people while also helping them navigate.

### 5.1.2 ATs Can Increase Threats to Safety

While ATs can support feelings of safety, they can also pose threats to safety. Our interviews turned up one example from IP1, who described an incident in which she felt threatened by a person who she connected to through an app for remote visual assistance (Be My Eyes[5]). Using this app, blind users can connect to a network of sighted helpers through live video/audio communication. The agent on the other side of the line indicated that the image was blurry, making it difficult to answer IP1's question accurately. The agent then asked where she was located and suggested he come over to help her in person. Concerned for her safety, she immediately closed the connection and decided to never use this app or similar apps again.

## 5.2 Communicating with Police or Officials

Half of our participants shared experiences in which they wanted to have better tools to identify and communicate with police and similar security officers. This included being able to locate an officer, being able to communicate effectively with police, and being able to describe criminals to authorities.

### 5.2.1 Identifying Police Officers and Officials

Five participants (IP1, IP4, IP5, IP8, and IP9) gave examples of times when they felt a need to locate a police officer or security guard for protection in threatening situations, or to verify that they were communicating with a real official. IP4 described being on the train with "all manner of people" and walking on the street alone at night with "people shouting or yelling." When these situations arose, she stated that she would take a longer path to avoid them. She believed that if she were better able to find and identify a police officer, it would put her mind at ease.

Another concern (mentioned by IP1, IP4 and IP8) related to situations in which participants would like to verify if the person communicating with them in a public area was a real authority. IP8 shared a story about a time when she was in a train station, and someone who sounded to her like an official was helping her to find the train:

> *"I thought he was someone who worked at the train station and he said he was gonna walk me to the train … so we started walking off and another guy ran out from behind the counter, and said "Whoa, whoa where are you taking her?" and it turns out he's just a guy that hangs out." –IP8*

IP8's example shows how inaccessible visual signals—like official uniforms and badges that sighted people rely on to discern who they can trust—may put blind individuals in awkward or even dangerous situations.

### 5.2.2 Communicating Effectively with Police

Two participants pointed to situations in which they had difficulties communicating effectively with police officers. IP7 described an incident when his apartment was broken into and he needed to communicate with the investigating officers. He explained that the robbery left him feeling "violated", but then he had to deal with critical logistics of talking with an authority:

> *"It would have been nice to also determine what kind of facial expression they were doing too … You are talking to a cop. Facial expressions are really important. I don't know if he is writing something down, or if he is waiting for more information." –IP7*

Similarly, IP5 explained a case when an Uber driver avoided giving a ride to him because of his wife's guide dog. The situation escalated and the police were called. He indicated that awareness about the facial expressions of the police and the driver could have helped them better understand the dynamics of the situation:

> *"Facial expressions would have been really, really helpful, just to know how the driver was reacting … if she's just annoyed or … ready to get physical. … Are [the cops] sympathetic to our needs or are they more leaning toward what the driver wants?" –IP5*

Like IP7, IP5 was interested in knowing more about the facial expressions of others when communicating with police. Proper communication was considered to be critical to aiding police in documenting a crime (and therefore potentially catching a criminal and recovering damaged or stolen items), as well as protecting their rights and physical safety through persuasive, defensive dialogue.

### 5.2.3 Describing a Suspicious Scene or Person

IP7 and IP8 pointed to situations where they needed to describe a suspicious person or scene in a potentially dangerous incident. IP8 shared two deeply troubling stories of public indecent exposure and sexual harassment in which she was the target and subsequently needed to communicate the crime to police. She had

[4] Aipoly Vision: http://aipoly.com/

[5] Be My Eyes: http://bemyeyes.com/

been on the train with a friend when they discovered that a man sitting in front of them was masturbating while ogling her. The other incident was nearly identical and took place in a public park. IP8 noted that she would not have realized what was going on if she had been alone. Furthermore, she lamented: *"Even if I get threatened or harassed in such situations, I cannot describe the person to authorities."* For IP8, lack of appropriate visual information led her to feel unsafe and unable to help authorities identify the criminal.

## 5.3 Assessing and Navigating Threats

Participants recounted numerous times they wished they could construct a safer space while navigating. They had concerns about assessing the degree of a threat, dealing with silent or suspicious strangers, navigating public areas safely, getting out of threatening situations, and avoiding them altogether by projecting confidence.

### *5.3.1 Assessing the Degree of Threatening Situations*

Participants shared incidents in which they wanted to know if there was a real threat to their safety and, if so, how to proceed. For example, IP5 described a time he was in a supermarket and heard someone yelling, "He's got a gun!" Without visual information, he could not quickly assess the threat:

> *"I suddenly heard, "He's got a gun!" And so when I heard that, I was like … we gotta get out of here, let's go. But you know, if I had seen facial expressions, I might have seen people [who] had a kind of fearful, anxious expression, and might have been able to take a cue from that."–IP5*

One technique for assessing threat identified by participants is to listen to the tone of voice of strangers. When seeking assistance from a stranger, IP8 would only ask people who sounded "happy" for directions while intentionally avoiding people who sounded "suspicious." However, she also felt that these auditory cues could be misleading or not provide sufficient information to make accurate judgements about a person' trustworthiness:

> *"Some people could be acting friendly but doing things that are suspicious, I mean they could be talking to you friendly while they're really looking at your wallet." –IP8*

In this case, lack of awareness of eye gaze evoked anxieties about strangers' true intent. IP5 had similar concerns about seemingly friendly people "pulling one over" on him. In one incident, he was walking home from the store with grocery bags in hand when a woman on the street approached and asked him for food. Despite wanting to help, he felt threatened because he could not assess her body language or whether her jacket pocket bulged with a gun:

> *"And I just really felt conflicted because I like to help people if I can, but I'm blind so I don't have that kind of information. So, I just kept on walking … because I don't wanna be taken advantage of. I got a family to think of, too." –IP5*

In absence of visual information about the degree of threat, IP5 had to choose between honoring his identity as person who helps others and his identity as a person who refuses to be a victim.

IP8 described a situation in an elevator where someone's abnormal behavior contributed to her to desire to have more visual information. Like IP5, she considered body language an important indicator. She also wanted to know about others' clothing:

> *"The way people dress, or if they are covered in tattoos maybe, or if they are skulking in the corner with a hoodie pulled over their head, because they know the consequences of certain ways of dressing and acting. So I'm gonna assume that because they chose to dress or make those motions, that's the message they want to send out." –IP8*

Across these experiences, we see that feedback about fearful or anxious facial expressions, eye gaze fixated on one's valuable possessions, and other non-verbal aspects of self-presentation was desired for assessing the degree of threatening situations. Moreover, lack of visual information was a source of anxiety and manifested as a lack of agency for blind individuals.

### *5.3.2 Judging if a Silent Person Poses a Threat*

People who are blind are often aware of the presence of others nearby. However, in crowded environments, it may be difficult to detect other people and assess whether they pose a threat. Six participants (IP1, IP2, IP3, IP7, IP8, IP10) expressed concern about silent people around them. Specifically, they stated that they were unable to know the direction silent people were looking, their distance, and their facial expression.

> *"It isn't really normal for people to just be quiet." –IP8*

> *"Quiet people may be mysterious and spooky. You don't know if they are looking at you or they are not even in the room. You cannot track people when they are quiet and know if they are a threat." –IP3*

Participants felt that silent people could pose a potential threat due to their unclear intentions, making it difficult to know if their safety was in jeopardy. Participants indicated that not knowing about silent others was a source of discomfort and vulnerability.

### *5.3.3 Detecting Threats in Crowded Public Spaces*

Participants believed that navigating crowded public areas lent itself to threatening situations. IP3 noted that in big public areas and busy streets, any prompt from a stranger could be threatening. He shared an experience about a time he was nearly attacked by a man while walking with his sighted friend. On a crowded street, he unknowingly walked into the personal space of the stranger. His sighted friend interpreted the stranger's "evil" expression and suddenly pulled him out of harm's way:

> *"It looked like he was about to whip out a gun and shoot me or stab me or punch me or whatever, and I had no clue that was going on. This was the kind of dude that people who can see, they stay clear of … He was looking threatened and … defensive." –IP3*

As an independent traveler who regularly uses public transit, IP10 revealed that having more information about nearby people would help her feel more safe. She gave the example of a stranger walking on the grass next to her, who she could not recognize due to the sound of busy streets, as being a potential safety concern:

> *"If I am walking around by myself at night … everyone wants to be more aware of things at that point. And, sometimes the bus transit centers, there are people that hang out, they can be creepy or scary." –IP10*

These examples demonstrate that crowded or noisy areas pose a particular threat because they put pedestrians in close quarters with numerous, unpredictable strangers and make it more difficult to disambiguate aural cues.

### *5.3.4 Escaping Threatening Situations*

Four participants described being in threatening situations that they felt they had to escape. IP1 explained a situation where she was offered help by a stranger via a shortcut to her destination. When he told her they arrived, she realized this was not a short cut and that she was lost and alone with the man. She wanted to find a police officer or citizen to help her, while concurrently trying to

conceal her fear from the person who led her there. She was able to convince him to turn around and take her back.

IP9 shared a similar experience where he felt he was being followed by two people and he could not discern their intentions:

> *"A couple of people were following me … But I was fortunate because somebody fell into step next to me … and she called over a friend and that person called over a cousin and somebody else called over somebody else and by the time they got done, there was like half dozen people between me and the people who were following me. And I felt a lot safer, because these were the people who tended to police their neighborhood." –IP9*

The lack of information about strangers in the vicinity made IP9 feel unsafe. Like IP1, he sought help from others nearby and was thankful that locals patrolling the neighborhood came to his aid.

IP2 described numerous situations where she was targeted by predatory men interested in using her blindness to their advantage. Below, she described having to use physical force to escape one:

> *"He tried to put on force against me and so he took my cane away, because he knew that I would need that. And so when I told him to leave me alone and give me back my cane … he told me that it was my fault because I was beautiful. And so that to me is someone who is an attacker … I am gonna deem that situation as someone who's trying to … make me the victim and I'm not gonna stand for that. So I kicked him in his knees and he fell and I grabbed my cane and I left. I got myself out of the situation, but it was a little scary." –IP2*

IP2 noted that it would not always be possible to seek help, so she made efforts to prepare to resist attackers by carrying pepper spray and checking her surroundings regularly to ensure no one was following her. She believed that nefarious others might explicitly target blind individuals, presuming it would be easier to conceal their identity and evade repercussions.

IP6 explained a time when she got off the bus in an unsafe area of the city by mistake. While she was focusing on tracking the next bus to a safer location, she would have found it useful to receive notifications of visual information about surrounding people, including whether they were carrying a weapon-like object. All participants mentioned that if more information were provided to them in the moment, they might have been able to manage the situation more effectively. In the absence of critical visual information, participants had to take the risk of escalating the situation themselves or hope that others were nearby to intervene.

### *5.3.5 Distractions in Critical Situations*

Two participants (IP9, IP10) discussed being distracted from their navigational task or startled by people in their vicinity. For example, IP9 was halfway across the street, fully focused on listening to traffic, when a stranger approached him and grabbed his arm—presumably to help. The situation caused IP9 to "flinch", both causing him to worry about the unknown intention of the stranger—perhaps to "steal"—and to lose his concentration on crossing the street safely. He noted that having more forewarning about when other people reach out for him can help prevent unwanted contact and may enable him to stay focused on safe navigation.

### *5.3.6 Projecting Confidence to Increase Safety*

Appearing confident and maintaining awareness of surroundings were two objectives cited by IP1, IP6, IP7, and IP9. They believed this could help them stay safe in unsafe areas. For example, when taken to the wrong location by a stranger, IP1 indicated that projecting calm could facilitate safety: *"I don't want to alert the person I am with that I am scared."* Having access to currently inaccessible visual information through technology may play a role in increasing confidence. Using the Aipoly Vision app on her phone to recognize objects and text, IP6 said:

> *"…knowing more makes you feel more confident. I feel if I am confident, no one will push or grab me. I really like this app because it makes me confident, independent, and less vulnerable, because I am a step forward and have more information about my environment." –IP6*

This suggests that having more information about the situation not simply about reactive defense (e.g., getting on the first bus to a safer place). Feeling or at least appearing confident is an important preventative strategy for avoiding threats.

## 6. ATs for Increasing Physical Safety is a Nascent Research Area Worth Exploring

After years of investigating accessibility needs of people who are blind within our own research team, we were surprised this study was the first to reveal the significance of interpersonal threats to physical safety. A literature review of the ASSETS contributions over the last 18 years suggests this is an underexplored research topic. As one indication, searching the Proceedings of ASSETS on the ACM portal turned up zero results for search terms "violence," "police," and "law enforcement"—central themes reported here. Instead, papers broaching safety fell into four different categories: environmental safety and obstacle avoidance [6,7,27–29], access to emergency services and alarms [11–13,33] health-risk mediation [14,25–27], and device-oriented safety [2]. In the few cases where interpersonal safety concerns were reported, it was mentioned briefly, as in Williams et al. [31]. This indicates an opportunity to explore how ATs can support *Personal Safety Management—informed, agential, and proactive participation in maintaining one's own physical safety*—not only for people who are blind, but also for people with other or multiple disabilities.

Surprisingly, the only report we found that directly addresses physical safety issues for people who are blind was published in 2016 within the Usable Privacy and Security community. Ahmed et al. [5] present a set of testimonials from blind individuals about how lack of access to visual information can compromise both their physical safety and information security. Notably, our results confirm the threat introduced by others entering one's personal "bubble"; the desire to provide visual details to police to help identify criminals; and the need to support better sense-making in potentially dangerous situations so one can navigate to safety [5]. Our results expand and build on Ahmed et al.'s [5] foundational study by describing how existing ATs already affect real and perceived safety; the need for better ways to interpret and negotiate communication with other citizens and police in contentious situations; the need to support increased confidence as a means of staying safe; and the dual concerns of maintaining safety in crowded areas, as well as areas where it is unclear whether anyone else is around.

HCI has recently begun exploring its role in righting deep social inequalities and power imbalances through incorporating feminist [8] and intersectional [28] theory and contributing to activist technologies that address violence [15] in this vein. People with disabilities are significantly more likely to be targets of violent crime and are often more likely to underreport these crimes to authorities [19]. Our participants tended to raise the topic of interpersonal safety threats after being asked the broad question

"What types of visual information would you like to know about other people?" This suggests that interpersonal safety is a leading concern for people with vision impairments. We therefore see a tremendous opportunity for the ASSETS community to contribute to this space, bringing its values and sensitivities to shaping a research agenda that empowers people with disabilities and demonstrates inclusive excellence. Below, we outline a set of opportunities going forward.

## 6.1 Opportunity: Answer Visual Questions to Increase Interpersonal Safety

The most basic finding of our study is that many people with vision impairments desire access to visual information about others nearby to increase their personal safety. Like Ahmed et al. [5], we gathered examples that spanned various settings, including crowded public spaces, presumed vacant public spaces, the street, public transit, and one's home. Also like Ahmed et al. [5], we found that participants might benefit from knowing information about how others are moving and behaving around them. This includes how many people are nearby, how far away they are, if they are walking towards them or following them from behind, if they are reaching out toward them, if they are on a collision course, and where they are looking.

Our study adds additional categories to those identified in prior work. Some are visual, others not, and they primarily seek to answer the question "Does this person pose a threat to my physical safety?" These categories include facial expression and emotion, other nonverbal conversational cues, gender, body posture and body size, clothing (e.g., hoodies or official uniforms/badges), indecent exposure, objects-in-hand (particularly weapons like knives and guns), and criminal records.

For designers of AT for the blind, these findings can inspire new tools that leverage computer vision and facial recognition (FR) [5], albeit in less traditional ways (i.e. as more than a conversational aid). We caution, however, that one risk of these technologies is their susceptibility to discriminatory exclusions and characterizations based on personal identities like race and gender. For example, our participants wanted to know if people are in the vicinity. But, in 2015, FR algorithms used by Flickr and Google made headlines by misidentifying black people as "apes" and "gorillas" [18]. The benefits of using FR to increase safety of people who are blind should therefore be weighed carefully with drawbacks related to lack of inclusivity. This may mean taking extra measures to develop inclusive datasets for FR training or seeking alternative technical solutions, like infrared distance and motion sensors.

For the broader disabilities community, there are no doubt different classes of information that will be deemed useful to increasing safety. For example, we can imagine that people who are deaf or hard-of-hearing may benefit from a system that identifies the sound, direction, and distance of gunshots [11]. Existing technologies for Personal Safety Management may be universally valuable. For example, we can imagine the Hollaback! app [15]—which empowers victims to use photographs and storytelling to counter street harassment directed at women—being appropriated or adapted by people with disabilities. Further investigation into the varying safety scenarios and needs of these populations is necessary to design effective tools.

Open research questions in this area include:

- What types of inaccessible information do users want in order to increase interpersonal safety?
- How can assistive devices deliver this information in ways that are appropriately disruptive yet private?
- What technologies are pragmatic in terms of cost, data privacy, and social stigma?

## 6.2 Opportunity: Continue to Explore the Relationship Between ATs and Safety

We found that assistive tools—including white canes, guide dogs, and apps like Be My Eyes and Aipoly Vision—contributed to an increased or decreased sense of safety. This reaffirms prior findings about how AT can make people feel more safe and confident [7] on the one hand, and put them at higher risk of being grabbed [31] or even mugged [29,32] on the other. Notably, these devices are not explicitly designed for Personal Safety Management. Yet, they impacted how others perceived the blind user or even how the blind user saw themselves, projecting physical vulnerability in some situations and confidence in others. In cases where the device increased a sense of safety, it reinforced the participant's desire to use the technology; the opposite was true for devices that decreased a sense of safety. This suggests that device adoption and abandonment, well-established research topics [1,21,29], may be significantly impacted by concerns about interpersonal safety.

Open research questions in this area include:

- How do we design assistive devices to bolster a sense of confidence and interpersonal safety?
- How can effectiveness be measured?
- How do existing and pervasive ATs already impact users' feelings about safety?

## 6.3 Opportunity: Explore How ATs Might Facilitate Communication with Police

Several of our participants described situations in which identifying police officers and communicating effectively with them required inaccessible visual information. These findings confirm and build on Ahmed et al.'s [5] documentation of blind individuals' desire to visually describe perpetrators and crime scenes to officials by adding additional scenarios: finding officers in the vicinity, verifying that an individual is a police officer, and communicating effectively and persuasively with police.

Due to various communication challenges outlined by the US Department of Justice [34,35], particularly for people with disabilities, interactions with police are high stakes and can literally be life or death situations. The recent national conversation about deteriorating police-community relations has brought attention to improving the treatment of people with disabilities by law enforcement with programs like COPS[6]. The 2015 Final Report of the President's Task Force on 21st Century Policing[7] notably calls for law enforcement policies prohibiting discrimination based on disability, officer trainings that confront implicit bias and systemic deficiencies in the way police interact with people with disabilities, and adoption of new technologies that will help police better serve people with disabilities.

Open research questions in this area include:

- What visual information can be reliably discerned by AT and how should it be presented for seamless communication?

[6] https://cops.usdoj.gov/PolicingTaskForce

[7] https://cops.usdoj.gov/pdf/taskforce/taskforce_finalreport.pdf

- How can technology improve training for police to reduce miscommunication and unnecessary violence?

## 6.4 Opportunity: Design AT to Empower People to Be Proactive in Safety Management

Our study confirms Ahmed et al.'s [5] finding that additional awareness cues may enable blind individuals to independently and more accurately assess the level of threat in various situations. Our participants wanted to know: *Are silent others present? Are they looking at me? Do they have aggressive or predatory expressions and body language? Are they carrying a gun, knife, or other potential weapon? Are they committing a crime? Are other people noticing the crime, and can they assist me? What's the best route of escape?* They believed that answers to these questions would open new opportunities for them to be *proactive* in their own safety management.

Open research questions in this area include:

- What are the accuracy requirements of ATs that mediate sense-making in potentially critical, dangerous situations?
- Can AT help people with disabilities mount more successful physical self-defense?
- What other sources of information, like live social media posts, might serve this need?

# 7. LIMITATIONS

While our participants provided many rich stories of their own successes and struggles with safety management, our interview sample size of 10 participants is limited. Since research participants in our sample tended to skew towards relatively higher socio-economic status, there are many scenarios that are unaccounted for and beyond the scope of this investigation. Due to the unexpected focus of semi-structured interviews on physical safety, we missed opportunities to collect demographic information (e.g., race and location) that we believe could have lent additional nuance to our analysis regarding police interactions or general risk of encountering criminals. We look forward to incorporating these insights into future work.

# 8. CONCLUSION

Despite years of investigating accessibility challenges for people who are blind, our research team was surprised to identify significant concerns surrounding physical safety that are relatively undocumented and unexplored within the ASSETS community. We call this area Personal Safety Management. In this paper, we have laid out a set of examples and resonant themes regarding safety tools, behaviors, and needs as communicated by our participants. We have provided a preliminary map to four promising research opportunities we believe can be explored with other disability populations: 1) understanding interpersonal threats to safety, 2) understanding how pervasive assistive devices already affect safety, 3) understanding accessibility challenges when interacting with law enforcement, and 4) developing AT that empowers people in the safety management process. We hope this map will be a useful guide to researchers and designers working within the blind and broader disabilities communities.

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