"Pray Before You Step Out": Describing Personal and Situational Blind Navigation Behaviors

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ABSTRACT

Personal navigation tools have greatly impacted the lives of people with vision impairments. As people with vision impairments often have different requirements for technology, it is important to understand users' ever-changing needs. We conducted a formative study exploring how people with vision impairments used technology to support navigation. Our findings from interviews with 30 adults with vision impairments included insights about experiences in Orientation & Mobility (O&M) training, everyday navigation challenges, helpful and unhelpful technologies, and the role of social interactions while navigating. We produced a set of categorical data that future technologists can use to identify user requirements and usage scenarios. These categories consist of *Personality* and *Scenario* attributes describing navigation behaviors of people with vision impairments. We demonstrate the usefulness of these attributes by introducing navigation-style personas backed by our data. This work demonstrates the complex choices individuals with vision impairments undergo when leaving their home, and the many factors that affect their navigation behavior.

Categories and Subject Descriptors

H.5.2 **[Information interfaces and presentation (e.g., HCI)]:** User interfaces - *User-centered design*

Keywords

Navigation, Persona, Visually Impaired, Assistive Technology, Universal Design, Accessibility

1. INTRODUCTION

For most people, personal navigation technology is simply another modern convenience. But for many people with vision impairments, this technology can mean the difference between independent travel and social isolation. Over the past decade, we have seen many innovations in navigation technology, including smaller, more accurate GPS devices and access to information above and beyond turn-by-turn directions. While the adoption of navigation technology among people with visual impairments suggests that such technologies are helpful, we still have limited understanding of how people choose navigation technologies and use them in their everyday lives.

Designing technology for personal use requires a holistic understanding of the user, including their preferences, behavior, and activities. Significant progress has been made in developing navigation technologies to support blind users, but most prior research focuses on a singular viewpoint, whether the sensory output method (e.g., sound [16]), navigation scenario (e.g., unfamiliar indoor environment [9]), or suitability of specific technology (e.g., smartphone accelerometers [4]). Absent in this work are the role that individual differences play in choosing and using navigation technology; we should expect that people with vision impairments are individuals, with individual preferences, and not simply an aggregate collection of users. While a narrowed view may be necessary to focus technology development, we believe that designing appropriate navigation technology to meet users' individual needs requires an understanding of users' behaviors in context, how the user's physical and social environment affects their behavior, and the overall variations between individuals' navigation strategies.

To better understand the individual variations in behavior by people with vision impairments when navigating, we interviewed a large set of adults with vision impairments (*N*=30) about their prior navigation training, and current obstacles, strategies, and favorite (or least-favorite) technologies. Our participants showed diversity in their geographic locations, use of mobility aids, use of mobile technology, and navigation styles. While all of our participants had unique personalities, we found many commonalities: participants fell into distinct personality types, and often experienced similar environmental scenarios. Thus, to provide structure to our diverse participants, we identify these factors (*personality* and *scenario*) as core attributes describing our participants' navigation needs and strategies. We then use these categories to create example personas [2] that illustrate the variety of navigation behaviors and attitudes presented by our participants. These categories, and the accompanying personas, present a rich view of people with visual impairments, their navigation behaviors, and the environmental contexts that shape these behaviors.

2. RELATED WORK

2.1 Accessible Navigation Tools

People with vision impairments use a variety of tools to assist with navigation, from low-tech white canes, guide dogs, and human guides [1], to high-tech standalone GPS devices (e.g., Humanware's Trekker Breeze[1]), websites (e.g., Google Maps[2]), and smartphone applications (e.g., Ariadne[3]). Low-tech mobility and navigation aids (coupled with specific training) allow for safe and effective independent travel without the use of full clear vision. High-tech tools assist with pre-trip planning, identifying local points of interest, and providing turn-by-turn directions while en route.

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[1]http://www.humanware.com/en-usa/home

[2] http://maps.google.com

[3] http://www.ariadnegps.eu/

While most current navigation tools are limited to providing map data and directions between outdoor map locations, more advanced navigation tools, such as scene descriptions and obstacle detection, are topics of current research. Zhang et al. [18] provide a comprehensive summary of both user interfaces and localization systems present in this research. Also, because most navigation tools rely on GPS for location detection, they do not provide support indoors. A few commercially available tools have been introduced, such as SightCompass[4], which reads Bluetooth sensors placed within a building. However, no solution for tracking indoor movement has been widely adopted, and researchers continue to propose solutions that use methods such as computer vision [7], NFC sensors [6] or written descriptions of locations such as transit stations [5].

Our present research does not introduce new technology, but instead aims to broaden our understanding of users. Most studies involving navigation technology for people with visual impairments have featured relatively small evaluations (1-20 participants), focused on preliminary usefulness findings limited only to the intended interface or methodology. A notable exception is the MoBIC project [15], which began with open-ended interviews with 24 blind participants. While their findings share many similarities with our own, their work was conducted in 1995. Our work thus presents an update and extension to this prior work, accounting for advancements in GPS and smartphone technology. The present work also contributes an exploration of how personality types influence navigation behavior.

2.2 Navigation Technology Use and Non-Use
Much prior research has explored the reasons why people with disabilities fail to adopt, or choose to abandon, assistive technologies. Phillips and Zhao [11] surveyed 227 adults with various disabilities and found four significant factors to abandonment: lack of consideration for user opinion, easy device procurement, poor device performance, and change in needs or priorities. In their study, 29.3% of devices were abandoned. Research exploring public perceptions of assistive technology offers a plea for integration into universally usable devices to eliminate social stigmas such as exaggerated attention to one's disability [13]. And work specific to mobile device use by people with disabilities highlights situational challenges (such as weather or crowds) that are exacerbated by having a disability when using mobile technology on the go (of significant importance for navigation scenarios) [8]. Our research seeks to assist designers in accommodating users' individual needs, by cataloguing and classifying these needs allowing for user influence in design.

2.3 Personas
As designs often need to scale for hundreds up to millions of users, the identification of representative users (or "personas" [2]) helps designers to account for individual differences without becoming overwhelmed. Personas are fictitious characters whose attributes are derived from user data. Pruitt and Grudin demonstrated that using personas during commercial software development revealed design considerations that would have otherwise been overlooked [12]. Personas are also useful for identifying the needs of underrepresented user groups, such as "older adults" [10, 17].

In discussing navigation behaviors with our participants, we found many personality "clusters" that seemed to dictate navigation strategies. Thus, we felt personas could help describe the navigation behaviors of the personality types observed. Participants sometimes switched between different approaches due to contextual factors, however; thus we also provide examples of this adaptive behavior through scenario-based attributes.

3. NAVIGATION INTERVIEWS
3.1 Method
We conducted phone interviews with 30 participants from across the United States. Participants were at least 18 years of age and used a mobility aid (white cane or guide dog). Participants were recruited through e-mail lists targeted for people with vision impairments, and via snowball sampling. Interview topics included Orientation and Mobility (O&M) training, challenges in current navigation (outdoors and indoors), and their use of navigation technology. We used Grounded Theory [3] to analyze this data; responses were first open coded by the primary researcher, and then grouped using these codes.

Table 1 below summarizes participants' demographic data. Figure 1 shows where each participant lived at the time of the interview. Participant ID's are indexed based on the participant's primary mobility aid ("C" for white cane, "D" for guide dog, "I" for in-transition, that is, cane users obtaining another guide dog in the near future). We categorized the participants' current city into "urban", "suburban", and "rural" based on their personal assessment (generally based on population size and mass transit).

3.2 Findings
Participants shared their experiences of navigation training, described their use of mobility aids (canes or guide dogs), and commented on the role that social interaction played in their navigation behaviors.

3.2.1 Orientation and Mobility Training
Orientation and Mobility (O&M) training teaches people with vision impairments safe navigation techniques using a white cane. Typically children and teens receive training as part of their school curriculum and have gradual, age-appropriate lessons throughout the school year, every year until graduation. Adults who lose vision are responsible for obtaining training, which they receive over the course of a few months. People may also seek additional lessons after life changes, such as moving to a new city; people who obtain a guide dog attend separate, specialized training. Though training is standard among people with vision impairments, we found some variability in when it was obtained, the quality of instruction, and how the training is currently used.

One anomaly in discussing navigation training included when training began: our congenitally blind participants over age 45 began in middle or high school, but those under 45 began in pre-school and elementary school. Participants attributed the shift to a difference in philosophies within the blind community. Though most participants received a typical amount of training, participants C4 and C16 grew up in rural areas, and both expressed a lack of sufficient state funding and available O&M specialists that severely limited the number of sessions they received in school. C5 and C13, who received extensive O&M training, became O&M trainers themselves as a result of their positive training experiences.

Most participants found their training sufficient, if not excellent, and use the cane techniques as they were originally taught. However, some have adapted or even relinquished their training. For instance, I2 now "hates" her cane because she didn't retain

Table 1. Participant Demographic Information

ID	Sex	Age	Aid	City	Vision Impairment	ID	Sex	Age	Aid	City	Vision Impairment
C1	M	23	Cane	Suburban	Continued vision loss since age 14	C16	F	59	Cane	Suburban	Blind from birth
C2	M	27	Cane	Urban	Blind from 6 months	C17	M	60	Cane	Suburban	Blind from age 3
C3	F	28	Cane	Urban	Continued vision loss since age 8	C18	M	60	Cane	Urban	Blind from birth
C4	M	30	Cane	Rural	Blind from birth	C19	F	64	Cane	Urban	Continued vision loss since 20's
C5	M	30	Cane	Suburban	Born legally blind	C20	M	75	Cane	Rural	Blind from birth
C6	F	36	Cane	Urban	Light perception to total from age 24	D1	F	28	Dog	Urban	Blind from birth
C7	M	42	Cane	Urban	Blind from birth	D2	M	47	Dog	Rural	Legally blind to total from age 24
C8	F	45	Cane	Urban	Color perception to only light at age 44	D3	F	48	Dog	Suburban	Low vision to total from mid-30's
C9	F	45	Cane	Suburban	Blind from birth	D4	M	48	Dog	Suburban	Low vision to total from age 24
C10	M	48	Cane	Urban	Blind from birth	D5	M	56	Dog	Urban	Sighted to continued vision loss
C11	F	49	Cane	Urban	Blind from birth	D6	F	60	Dog	Urban	Blind from birth
C12	F	50	Cane	Suburban	Continued vision loss since age 30	D7	M	62	Dog	Urban	Blind from birth
C13	F	55	Cane	Rural	Low vision to total from age 9	I1	M	29	In-Transition	Suburban	Blind from birth
C14	M	55	Cane	Suburban	Blind from age 2	I2	F	38	In-Transition	Urban	Blind from birth
C15	M	56	Cane	Suburban	Low vision to total from age 8	I3	F	41	In-Transition	Urban	Blind from birth

Figure 1. Participant locations on U.S. map, categorized by location type.

her middle school training, due to bullying from classmates. I1 doesn't use the cane-tapping technique he was taught because he feels the noise it creates causes others to stare. And C17 has a keen sense of hearing that he used as a child (prior to formal training at school) that is now "ingrained" in him; thus he uses the cane to create sounds and give him feedback that wasn't part of his formal training, but aligns with how he has adapted navigation.

Lastly, participants D4 and C19 both lost vision later in life but did not immediately seek O&M training. D4 was initially in denial, but was provoked to seek training after he knocked over a store display and caused a great spectacle. C19 indicated she simply didn't know where to start and was relying on strangers for assistance. Her husband eventually found a local center where she obtained training several months after diagnosis. C5 works in the

navigation technology industry and finds many veterans and older adults do not obtain formal training, but rather rely on paratransit (door-to-door public transportation) or human assistance.

Implications for design: O&M training is intended to provide the ability to navigate environments without any technological assistance. However, some individuals, such as those who grew up in rural areas, or became blind later in life, may have inadequate O&M skills, and may require additional navigation support. Exploring O&M teaching methods and strategies may provide useful guidelines for developing navigation technology.

3.2.2 Choice of Mobility Aids (Canes vs. Dogs)

Regardless of which mobility aid participants preferred, they agreed each had its advantages and disadvantages. D3 summarized, "a cane is [for] obstacle detection, a dog is [for] obstacle avoidance." As participants explained, a cane's contact with the ground and other objects provides more environmental information, but small obstacles may become large barriers when determining how to move around them, while easier pathways may be missed. Conversely, a dog can navigate around obstacles, but may need correction from their owner if distracted in crowds, or overly fond of objects such as doorways or escalators. Each participant found their preferred aid helped them navigate faster, and while participants were happy with their current mobility aid, a few cane users would consider a dog in the future if their hearing or vision deteriorated.
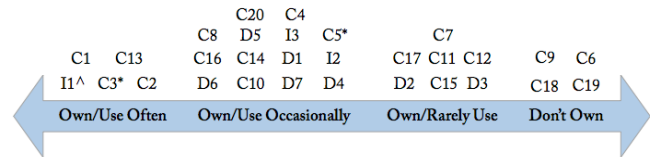
Though a guide dog is a primary mobility aid, dog users occasionally switch to using a cane. These occasions included in very familiar areas, if they anticipated a large crowd or tight space, at a concert where it may be too loud, or a movie theater where the floor is very dirty. They also switched to a cane if their dog was sick or near retirement. Finally dog owners had to use a cane during transition periods (usually lasting several months) between a dog retiring and obtaining a new dog (hence the participants "in-transition").

Differences in mobility aids also extended to social interactions. I1 expressed the "jarring" feeling of being grabbed by people as he walks with a cane; with a dog this didn't happen. Other cane users also mentioned not being spoken to (as in pleasant conversation), having advice offered while trying to concentrate on traffic cues (because it looks like they're just standing), and having assistance offered when they actually want to independently learn an area (that is, bump into things). Dog users, on the other hand, didn't often receive offers for assistance, but were talked to more and asked by strangers if they can pet the dog. While this is annoying to some, other participants, such as D2, liked the increased social encounters.

Implications for design: Guide dog and cane users differ significantly in their approach to navigation: cane users seek out obstacles, while guide dog users want to avoid them. Upon entering a room, a cane user may immediately seek out a wall, whereas a guide dog user will move directly toward the doorway. In both cases, users have learned to rely on specific forms of feedback. When possible, navigation technology should stay out of the user's way, only providing information that is not already provided by their navigation aid. Users may sometimes be without their chosen navigation aid, and may require additional support. Also, designers should consider how their device design would impact how the user is perceived in public.

3.2.3 Technology Usage

We asked participants to tell us which, if any, electronic navigation technologies they used. One of the primary mailing lists we used for recruitment was for visually impaired iPhone users, and thus most participants owned an iPhone. However, given the popularity of the iPhone, we see our findings are representative of the U.S. blind population [15]. Not all participants were iPhone users or even navigation technology users; Figure 2 shows the spectrum among the participants.

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                      C20  C4
                C8  D5  I3  C5*              C7
   C1  C13      C16 C14 D1  I2      C17 C11 C12     C9  C6
   I1^ C3* C2   D6  C10 D7  D4      D2  C15 D3      C18 C19
 ◄── Own/Use Often   Own/Use Occasionally   Own/Rarely Use   Don't Own ──►
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Figure 2. Study participants' responses regarding navigation technology ownership and how often it was used (if they owned it). Participants used iPhones for navigation, except for those marked * (Trekker Breeze) and ^ (Android).

Only four of our participants did not own any type of navigation technology. Two of these participants, C18 and C19, stated they were uninterested in acquiring new technology, although C18 later mentioned that he might be willing to adopt a smartphone if they were less expensive. The other two participants who did not use navigation technology (C6 and C9), cited cost of a smartphone and data plan as a prohibitive factor. Other participants also raised concerns about the costs of owning navigation technology, and often pointed out the low employment rate among adults with vision impairments [14].

Seven participants who owned iPhones did not use the phone's navigation features frequently. Four of these participants (D2, C11, C12, and C17) even purchased them for use as navigation aids, but had difficulty using the available applications. When prompted for specific problems, none gave a concrete example but C12 and C17 felt there was constant interaction necessary to hear directions, C11 felt it didn't enhance her navigation experience as she hoped, and D2 simply felt it was an extra (non-essential) tool.

Of those participants who used their navigation devices frequently, the majority used smartphones. All smartphone users had several (typically 3 to 4) navigation applications that they used for varying levels of feedback, for example, exploring a new area vs. needing turn-by-turn directions. These smartphone applications primarily included both popular GPS applications such as Apple Maps, MotionX, and Google Maps, and specialized navigation tools for people with visual impairments, including Ariadne, BlindSquare, and Sendero LookAround.

The smartphone users did regret not having just one application for all of their navigation needs. All admitted the process of switching applications (and keeping up with new ones) could be cumbersome, but valued the cost savings and functionality in the single smartphone device. Participant I1 noted that, when using the smartphone, "all the information is available; you just need to put in the work to get it." Conversely, participants who chose the dedicated navigation device, Trekker Breeze (C3 and C5), valued the ability to use the phone and GPS device simultaneously, and appreciated not having to "[use] 10 different apps to get [the] same function as one device" [C5].

Although many participants used GPS frequently, GPS itself was not always helpful, even when outdoors. Several participants noted that their GPS devices could be inaccurate, and could be off by more than 10 feet. When GPS fails, participants rely on their

O&M training skills to discover the route and/or ask others for help. Some areas, such as college campuses and outdoor shopping centers, lacked appropriate mapping data for use with GPS.

Implications for design: Cost and complexity remain significant barriers to adopting navigation technology. Cost can be an especially significant barrier to people with visual impairments. The popularity of smartphone-based navigation apps, and the fact that users toggle between the apps, suggest that users desire different types of navigation support in different contexts. Finally, GPS feedback is helpful, but is not always accurate. Providing feedback about the system's estimated accuracy can help users decide whether to trust the system or rely solely on their mobility training.

3.2.4 Navigating Outdoors

We asked participants to describe situations in which it was difficult to navigate outdoors. While our participants lived in a variety of urban, suburban, and rural areas, some obstacles were universal. Nearly all participants identified street crossings, construction areas, and overhead (eye-level) obstacles as significant challenges. Several participants described injuries or near injuries that occurred when crossing the street, including C17, who was hit by a car when a man drove the wrong way on a one-way street. Participant I3 stated that, when crossing the street, "You pray before you step out," because you simply cannot be sure drivers are obeying traffic laws. Construction areas often require participants to find an alternate route. Even when a participant is able to pass through the area, the loud noise can be severely disorienting. Or worse, if the construction site is not active (thereby making no noise), it may contain unknown hazards.

Some obstacles were unique to our participants' home environments. Participant C13 lives in a rural mobile home community in which the homes change location/layout without notice. C15 lives on a small island where there are no raised sidewalks and curbs, only flat (and indistinguishable) terrain that he has had to memorize. D6 and C18 live in a city with structured street grids and plentiful mass transit, but struggle to navigate through the large crowds of pedestrians.

When navigating outdoors, weather can also greatly impact navigation. For example, C11 moved from the relatively mild West Coast of the U.S. to the Midwest. Upon encountering the severe winter weather there, she noted that, "snow changes everything," as using a cane is next to impossible in deep snow. Severe wind or rain can cause noise or damage electronics. Bright sunlight can reduce a person's vision, especially if their vision is already impaired.

While most participants described challenging scenarios without hesitation, many of the younger participants who used technology frequently expressed less angst about the navigation challenges (or even initially said they didn't experience any). For instance, C2 felt he would always arrive safely at his destination; if something went wrong, there was always the option of "hopping into a cab." Participants acknowledged that much of this confidence comes from trust in technology, but also in their own skills. Conversely, I2 (who had the bad O&M training experience, "hates" her cane, and uses technology infrequently) finds navigation stressful and feels "nervous" while alone outdoors.

Implications for design: Outdoor navigation presents a wide array of challenges and obstacles. Some obstacles move (e.g., people, cars, and mobile homes). Routes can also change due to construction or weather. When possible, devices should be robust to changing weather and light conditions, and should provide multiple possible routes in case the primary route is unavailable. There are also varying views of navigation that will impact the amount of information needed. For instance, someone confident may only need confirmation of what they already know, while someone nervous may desire more constant feedback.

3.2.5 Navigating Indoors

When navigating indoors, participants are protected from challenges such as street crossings, extreme weather, and construction. However, indoor navigation presents its own set of challenges. As previously mentioned, navigation technology is not typically available indoors, thus participants often relied upon sighted guides.

In general, most participants relied on sighted guides when navigating unfamiliar indoor spaces. Over time, they memorized the layout of familiar locations, and could then navigate without help. However, some indoor environments were always difficult to navigate, such as wide-open spaces that cannot be easily explored by cane, and crowded spaces. Participants often relied on sighted guides when visiting the mall and other stores, as these locations rarely offered accessible maps. Participants also frequently relied on sighted guides when visiting supermarkets, as store layouts changed frequently and many store items were difficult to identify without assistance. Our participants often relied upon store employees for assistance in the supermarket, but found it frustrating due to the employee's speed, lack of training, or communication difficulties.

Implications for design: Most current navigation tools do not function indoors, and thus people with visual impairments are required to ask for help, memorize the location's layout, or rely significantly on their O&M training skills to explore. While supporting indoor localization and navigation may currently be difficult, navigation technologies could still help users by augmenting their existing O&M training, or assisting them in memorizing the layout of frequently visited locations.

3.2.6 Interactions with the Public

Social interactions with strangers are inevitable when navigating public spaces, and, as mentioned in prior sections, this often takes the form of receiving sighted assistance from strangers, or conversations regarding mobility aids (particularly guide dogs). This social interaction brought about a spectrum of views: from participant D3, who preferred not to use navigation technology because she was never alone and enjoyed speaking with strangers, to participants C6 and I2, who felt very uncomfortable in public, and avoided interacting with strangers whenever possible.

Concern for safety was expressed as a barrier to seeking assistance from sighted guides. Participant C12 stated that she lived in an unsafe neighborhood, and thus did not typically seek help from strangers. On one occasion, she asked a stranger for directions to a shop in her neighborhood. This person offered her directions that matched her recollection; however, two other young men heard her request and called out directions toward the back of the building. After realizing that the directions from the young men were false, she became much more careful.

Participants also cited safety concerns as a reason not to use navigation technology in public. Using an expensive gadget in an unsafe location can attract unwanted attention. When sharing her concerns about the safety of her neighborhood, participant C12 stated that she owned an iPhone, but was often nervous about taking it out in public. The wife of C7 had her iPhone taken while talking on it, and his friend's iPhone was snatched when a bus

dropped him at the wrong stop in an unsafe and unfamiliar neighborhood.

Implications for design: Even in rural settings, our participants were rarely alone. Thus, it is often possible to ask strangers for assistance, whether to supplement or provide information. However, asking a sighted person for help can often be stressful or dangerous. Thus, remote assistance may sometimes be a desirable option. People are often concerned about exposing expensive technological devices in public. Technology that can provide subtle feedback, such as vibration from within a pocket, or personal audio, might be desirable in situations where individuals are hesitant to carry their devices in public.

4. CLASSIFYING NAVIGATION

Our interviews revealed diverse personal and situational attributes not often seen in other assistive technology research. We compiled our findings into two dimensions that may be beneficial for envisioning and evaluating technology for diverse users. Though not intended to be exhaustive, these dimensions reflect issues that were highly prevalent in our interviews.

Table 2 provides a full description of our set of personal and scenario attributes. Below we describe the categories in more detail and, as an example of how the categories may be used, we provide three examples in the form of personas.

4.1 Navigation Attributes

While we interviewed only a moderately sized group of participants, we made an effort to include participants with a diversity of ages, geographic regions, and socioeconomic backgrounds. As we have shown, our participants offered a wealth of personal experiences and perspectives regarding their navigation behavior.

To attempt to capture the types of experiences and behaviors that our participants expressed, we identified two primary attributes that describe the major influences of how that individual makes decisions surrounding navigation. **Personality** attributes describe the individual's personal views and characteristics, including their attitudes toward technology. **Scenario** attributes describe the characteristics of the trip itself, including the geography of the location and the participant's relationship to it.

Combing the individual's personality traits with the environmental context allows us to describe and compare different navigation behaviors in context. Note that most individuals do not fit neatly into one category, and instead lie somewhere upon the continuum. Furthermore, participants will often adopt different personal behavioral attributes depending on the scenario; for example, individuals are more likely to be confident navigators in familiar locations.

4.1.1 Personality Attributes

Attitude Towards Exploration describes the individual's feelings about navigating on their own away from home. *Apprehensive* navigators feel anxious about traveling and are likely to create extensive plans before leaving home. In contrast, *Confident* navigators are willing to explore to reach their destination, and deal with obstacles when they encounter them.

Asking for Help describes the individual's willingness to engage with others when they need assistance. *Reluctant* individuals avoid asking others for help, while *Personable* individuals often rely on sighted assistance.

Reliance on Technology reflects the user's willingness to trust in information technology. *Independent* users may feel that technology cannot be trusted. They may avoid using information technology entirely. If they do use technology, they will make sure to have a backup ready if something goes wrong. For example, an independent person may use a GPS to navigate, but carry a Braille paper map as a backup. *Reliant* users feel confident that they will be successful in using technology, and are willing to rely on technology to navigate, even in unfamiliar places.

Technology Adoption refers to the user's eagerness to obtain and use new technology as it is released. *Conservative* adopters wait until a technology has been proven before adopting it. They may wait for new products to become less expensive. In contrast, *Upgraders* are eager to adopt new technology as soon as it is released. They are willing to put up with unreliable devices in exchange for the newest features.

Preferred Mobility Aid is simply the aid used while navigating - *White Cane*, *Guide Dog*, and (optionally) *Another Person* (sighted or blind). As noted above, people with visual impairments often prefer one mobility aid, but may use alternate mobility aids, or even no mobility aids, in certain contexts.

4.1.2 Scenario Attributes

These attributes may reflect inherent characteristics of a location (e.g., terrain), as well as an individual's relationship to that location (e.g., whether it is familiar or unfamiliar).

Terrain describes the overall layout of the location. Terrain may be flat, wide open, bumpy, or dense. For simplicity, *Wide Open* spaces are those with few distinguishing characteristics (e.g. airport terminal hall or rural outdoor expanse). Though open spaces may seem easier to traverse, they are actually difficult because they do not provide cues or landmarks for confirmation. *Dense* spaces contain several items/landmarks in the area but these can also become obstacles (e.g., New York City sidewalk or small neighborhood grocery store). This can also include hazards such as construction zones.

Familiarity is the individual's familiarity with, and memory of, a specific location. *Unfamiliar* locations are visited once or very infrequently, and thus must be explored carefully. These locations may become more familiar after repeated visits. *Familiar* locations are those that the individual can comfortably navigate, such as frequently visited stores or restaurants. One extreme is when a participant is in his or her "home turf" (e.g., at home or work). In these locations, many of our participants often went without any navigation aid."

Weather includes a spectrum from *Calm*, which typically does not affect the situation, to *Extreme,* which includes wind, rain, or snow. Extreme weather can force individuals to alter their route. Additionally, snow piles or flooding from rain may create unexpected obstacles. Weather can also damage devices.

Crowd Density is the number of other individuals around. When the location is vacant, the individual can wander freely, but may have difficulty finding assistance. Crowded spaces can be quite difficult to navigate, loud, and disorienting.

Transportation Availability refers to the efficiency and accessibility of public transportation (e.g., buses, trains, paratransit) in a given area.

GPS Availability describes whether the given location can be tracked by GPS. Most indoor locations and "off grid" locations like outdoor malls do not provide accurate GPS tracking.

Table 2. Our navigation attributes, and examples of how they may impact the design of navigation technology.

DIMENSION	ATTRIBUTES	EXAMPLE DESIGN IMPACTS
Personality		
Exploration Attitude	Apprehensive to Confident	*Apprehensive* – needs constant feedback for reassurance *Confident* – needs high level instructions & confirmation
Asking for Help	Reluctant to Personable	*Reluctant* – self-contained technology, no need to engage *Personable* – allow collaborative interface to engage with strangers
Technology Reliance	Independent to Reliant	*Independent* – prepared with back-up navigation if technology fails *Reliant* – depends on device function; devices should have back-up mode
Technology Adoption	Conservative to Upgrader	*Conservative* – choose technology for cost, reliability *Upgrader* – choose technology based on features
Mobility Aid	White Cane, Guide Dog, Human Guide, None	*White Cane* – expects guidance based on environmental objects *Guide Dog* – expects guidance based on doorway openings and directional cues
Scenario		
Terrain	Wide Open to Dense	*Wide Open* – requires constant information to aid in staying on-course *Dense* – benefits from minimal, timely, non-distracting information
Familiarity	Unfamiliar to Familiar	*Unfamiliar* – users may benefit from pre-planning, e.g. virtual exploration *Familiar* – provide information on unexpected/unusual environment changes
Weather	Calm to Extreme	*Calm* – no extra support needed *Extreme* – provide weatherproof hardware, multiple I/O methods, alternate route information
Crowd Density	Vacant to Crowded	*Vacant* – provide assistance when requested by user *Crowded* – provide navigation information before entering crowd
Transportation Availability	Limited to Frequent	*Limited* – optimal route for combining multiple destinations *Frequent* – provide selection of paths based on time, price, number of transfers
GPS Availability	Precise to Unavailable	*Precise* – provide explicit information to final step of destination *Unavailable* – provide supplemental information, e.g. landmarks

4.2 Navigation Personas

The term "people with vision impairments" certainly describes a group of people with medical conditions that prevent full and clear vision. But it should not be the only term used to describe a technology's user base. Our interview findings, even with only a moderate number of participants, show that there are significant differences among individuals in this group. Given the history of assistive technology abandonment, basing assistive technology designs on a strong foundation of user data is imperative. Using the navigation attributes as a checklist, we have created example personas (illustrated below) that demonstrate the diversity of navigation styles displayed by our participants. While preliminary, these personas demonstrate how personality and scenario attributes can help us envision future technology, by illustrating the diversity of user needs and preferences.

Urban Upgrader *(I1, C2, C18)*

Introduced to navigation technology by O&M Specialist. Now uses iPhone apps for nearly every activity: mass transit updates during work commute, directions to weekend events, restaurant locations, & more. It seems the city is constantly changing and he needs technology to keep up, plus it's difficult to stop and ask others in such a crowded, fast-paced area.

© Tony Alter

Exp Attitude	Tech Attitude	Tech Adoption	Mobility Aid
Confident	Reliant	Upgrader	White Cane

Social Navigator *(C20, D3)*

Lives in typically sunny suburb where navigation routes are fairly routine and pedestrian. Not afraid to ask for help, however, especially at the complex intersection on his route to work. On unfamiliar routes, he likes to explore using iPhone apps that announce what's around and/or talking with other people. The suburb is not too crowded but there are generally pleasant people around for casual conversation.

© Daniel Oines

Exp Attitude	Tech Attitude	Tech Adoption	Mobility Aid
Confident	Cautious	Conservative	White Cane

Conscientious Owner *(D6, D7)*

Loves having a guide dog but it adds complexity. A standalone navigation device was great with a cane, but needs to carry more with a dog, so now she uses an iPhone. But the phone is not as easy to use so doesn't really use at all. Switches to cane when dog may be bored, or when traveling on airplane for work. Switching to cane is difficult and causes more reliance on human guide.

© Sarah Stierch

Exp Attitude	Tech Attitude	Tech Adoption	Mobility Aid
Apprehensive	Moderate	Limited	Guide Dog

5. DISCUSSION AND CONCLUSION

We interviewed 30 adults with vision impairments about their navigation strategies and experiences. From these interviews we coded key findings that are unique to navigation technology features and use, and also provide a deeper view of the range of personality- and scenario-based factors that impact navigation. Using these findings, we developed a list of categorical descriptions that navigation technology developers can use to guide user requirements and design scenarios, particularly through the use of personas, which we demonstrated with three examples.

We acknowledge that our participant group is small, but feel our participants' diversity in key areas of age, gender, technology usage, and location, provide an adequate basis on which to develop scenarios for future work. The spectrums created from the varying user responses provide insight not typically seen in navigation research, which typically focuses on the single user type and usage scenario for which the technology is designed.

Future work will include creating a formal design toolkit to further promote user-centered design processes; further analysis into the impact of O&M training, user personality, and preference on attitudes toward navigation; and using this work as a foundation for future navigation technology products that encompass and address the user diversity presented in this work.

Though our focus is people with vision impairments and their specific technology needs, our findings support universal design approaches, as many of these navigation challenges affect everyone. Our main contribution, however, is a description of the wide range of personality and situational characteristics that impact navigation technology development for people with vision impairments.

6. ACKNOWLEDGMENTS

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