Understanding Guide Dog Team Interactions: Design Opportunities to Support Work and Play

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ABSTRACT
The visually impaired have been a longstanding and well-recognized user group addressed in the field of Human-Computer Interaction (HCI). Recently, the study of sighted dog owners and their pets has gained interest in HCI. Despite this, there is a noticeable gap in the field with regards to research on visually impaired owners and their dogs (guide dog teams). This paper presents a study that explores the interactions of guide dog teams revealing a rich, holistic understanding of their everyday lives and needs, across both work and leisure activities. Our findings inform and inspire future research and practices suggesting three opportunity areas: supporting working guide dog teams, enhancing play-interaction through accessible dog toys utilizing sensor technologies, and speculative and exploratory opportunities. This work contributes to the growing research on designing for human-canine teams and motivates future research with guide dog teams.

Author Keywords
Human-Canine Interaction; Human-Animal-Interaction, Animal-Computer Interaction; Guide Dogs; Visually Impaired; Interactive Systems Design; Team Interaction.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI)..

INTRODUCTION
According to the World Health Organization [46], 285 million people are visually impaired worldwide. An estimated 25.2 million adults (people over 18 years of age), nearly half a million children (people under 18) in the US and more than 836,000 Canadians have significant vision loss or vision difficulty [1,7].

Research and practice in Human-Computer Interaction (HCI) and design communities have recognized the visually impaired as a user group for decades [e.g.,4,14,18,20,28]. Accessible technology developments such as tools, applications and gadgets have been improving the lives of people challenged with visual impairment, enabling them to be more independent. One of the most common challenges experienced by people who are blind is their lack of independence while traveling. Different mobility aids have been developed to enhance their travel abilities. The most popular travel aid is the *long cane*; a mobility tool that users sweep back and forth in an arc on the ground in front of them to detect obstacles in their pathway. Nevertheless, research has shown that guide dogs are the most beneficial and appropriate travel aid because they provide safe guidance when traveling [22,42] and increased mobility and independence, while offering the additional benefit of companionship.

Studies from a range of disciplines outside of HCI have looked at what we refer to as *guide dog teams*: visually impaired guide dog users and their dogs. This body of work concerns itself primarily with the impact on identities of guide dog owners [34], the benefits of guide dogs [22,42], and the experience of their usage [43]. However, relatively little is known about how technology could be designed to enhance guide dog team interactions, and little work has investigated this issue in or outside of HCI. Importantly, technologies currently designed for people with vision impairment do not necessarily fit the needs of guide dog users and guide dog teams. On a more general level, the study of *sighted* dog owners and their pets has gained interest in HCI. Many studies have looked at computer-mediated human-pet interaction [e.g.,6,15,27,31,47] mainly focusing on connecting humans and their pets when apart.

To advance a deeper understanding of guide dog teams and the role technology might play in better supporting them, we conducted a two-part study involving an in depth expert interview and participant observations of twelve guide dog users. Findings revealed major opportunities for HCI and design research in developing this emerging design space. This includes 1) supporting working guide dog teams; 2) supporting play interactions of guide dog teams; and 3) speculative and exploratory opportunities. This paper makes two contributions. First, it advances the HCI community's understanding of guide dog teams, describing their experiences and challenges, and how digital and non-digital artifacts mediate their interactions. Second, it details several design opportunities and challenges for both interventions aimed at better supporting work and play situations of guide dog teams to help critically frame future HCI work in this emerging area. In this, we also illustrate how this work applies more broadly to other fields in HCI.

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GUIDE DOGS

Guide dogs are highly trained animals that provide better mobility and more independent travel abilities to their visually impaired users than the cane [22,42]. They respond to verbal commands such as "Forward", "Left", "Right", "Straight on", "Find the stairs", and "Find the door", and disregard commands when they could lead to a dangerous situation (e.g. a car backing up out of a driveway or an unsupervised construction site). When traveling together, the human is responsible for orientation and safety issues monitoring traffic and traffic lights; the dog is the guide to staying on track, avoiding obstacles, finding destinations (doors, stairs, chairs), and watching out for dangerous situations.

There are different guide dog schools that train and provide dogs for the visually impaired. They differ in terms of philosophy, training methods, size and, how well they support the dog-human partnership after initial training is complete [13]. There are currently 15 guide dog schools in the US and Canada accredited by the International Guide Dog Federation [17].

A guide dog owner, like any other dog owner has to provide for the physical and emotional needs of a dog. Dogs need food, several opportunities each day to relieve themselves, grooming, veterinarian visits, playtime and affection [13].

RELATED WORK

When looking at the interactions of guide dog teams, works from different research fields can be considered. This encompasses research within and beyond HCI.

In Human-Computer Interaction

Designing technology for the visually impaired has been addressed by HCI-research for decades. For example, computers were made accessible through screen-reader programs such as JAWS [18] and VoiceOver [4]. Efforts have been made to make the web accessible [28], and many assistive technologies have been developed [14] including haptic technologies [20].

A few visually impaired rely on geographical information systems (GIS) that combine GPS with a digital assistant such as *Trekker Breeze* [16]. These technologies are developed to help orientation while traveling. However, technology gadgets are often too expensive for many people and they are not specifically designed to be used with a guide dog. In a study that examined the effects of guide dogs as mobility aids, only 16% of the participants (n=50) had used an electronic travel aid before and only 2% after acquiring the dog [22].

Although, not yet adopted by people with vision impairment, the first efforts at building a guide dog robot under the name of MELDOG were made in the 1980's [35]. Recently, publications looking at technology-assisted human-pet interactions have appeared at HCI-focused conferences. Britt et al. [6] built a tracking and communication system that consistently tracks the position, motion behavior, and orientation of a dog. Specifically, they focus on Canine Augmentation Technology (CAT) for search and rescue (SAR) dogs, and attempt to provide useful procedures for the analysis of dog trials and missions. Studies conducted by Tran et al. [38,39] provide more detail on the topic of CAT by analyzing current tools available to urban SAR teams, informing the design of their own CAT prototypes.

Focusing on human-canine interactions between people and their pet dogs, Paasovaara et al. [31] developed the 'paw tracker concept', which combines sensor-based dog created content with social media to connect a dog that stays home with a human who is working, enabling the human to check on the pet on an automatically updated blog. Similarly, Hu et al. [15] and Yonezawa et al. [47] introduce prototypes for remote pet control (or human-computer-animal interfaces), in one case combined with social media [47]. Neustaedter and Golbeck [30] investigate the design of systems for pet video chat for human-dog interactions. Wingrave et al. [44] introduced game-prototypes for strengthening the human-animal bond of dog owners and their dogs. Mancini et al. [26] explored how tracking technologies can reconfigure the relationships between humans and canines. Moreover, Weilenmann and Juhlin [41] conducted a study observing hunters using GPS devices to monitor their dogs, aiming to find out how technology assists the interactions of those human-canine teams.

A new field with an interesting overlap has recently been recognized in the HCI community: Animal-Computer Interaction (ACI). Mancini [24] provided an overview of ACI discussing key issues such as ethics and benefits. When talking about the benefits, Mancini points out that ACI could inform, "the design of technology that enables the animals we live and sometimes work with to effectively communicate with us, increase their participation in our interactions, and constructively influence our environments" [24 p.72]. This can be related to human-dog interaction between the visually impaired and their guide dogs, since those dogs are animals that partly work for their owners. It also points out, that considering the inclusion of animals into design processes can have beneficial effects. It is clear, the emerging field of animal- and pet-focused research offers much potential and will increasingly become a part of discussions within the HCI and design communities (see Mancini [24,25]).

Beyond Human-Computer Interaction

The American Veterinary Medical Association defines the human-animal bond as "a mutually beneficial and dynamic relationship between people and other animals that is influenced by behaviors that are essential to the health and well-being of both. This includes, but is not limited to, emotional, psychological, and physical interactions of people, other animals, and the environment" [5].

Surveying 749 dog owners, Dotson and Hyatt [8] showed that "dog companionship is a complex, multi-faceted phenomenon, in which various dog owners might possess varying levels of different dimensions" including symbiotic relationship, dog-oriented self-concept, anthropomorphism, activity/youth, boundaries, specialty purchases, and

willingness to adapt. More research exists on human-canine relationships, however we wish to further examine work explicitly focusing on guide dog teams.

Koda et al. [19] surveyed 55 graduates from a guide dog school in Japan to receive suggestions for improving guide dog training programs. Surprisingly, Japanese guide dog users spent a lot of time playing or relaxing with their dogs but only four participants (7%) suggested improvement of play interaction in training programs. However, they may have responded in such a manner believing that facilitating play interaction is outside the responsibilities of guide dog school training.

Many studies have focused on the abilities of guide dogs, their benefits and both positive and negative externalities. Sanders [34] studied the impact of guide dogs on the identity of their owners. His findings describe acquiring a guide dog as a 'transformative experience', changing definitions of self and enhancing personal identity. Wiggett-Barnard and Steel [43] conducted a study with the aim of understanding the experience of owning a guide dog. They grouped essences of guide dog owners experiences into eight themes: guide dogs improve mobility, provide companionship, necessitate personal change, can be a source of pride to the owner, are social magnets, get distracted sometimes which inhibits their abilities, guide dog ownership changes one's lifestyle, and the ignorance regarding guide dogs. Similarly, Miner [29] described the experience of using a dog guide with 4 themes: increased confidence, increased independence, changed public interaction, and additional responsibilities or inconveniences. Lloyd et al. [22] found evidence that guide dogs make independent travel easier compared to a cane, extend travel possibilities and are in fact the mobility aid with the highest positive impact. Whitmash [42] quantified the tremendous impact of guide dogs through a survey with 831 visually impaired people (404 of them were guide dog owners) arguing that guide dogs are the most appropriate mobility aid for people with vision loss. Moreover, Wirth and Rein [45] articulate cost positive impacts of guide dogs on the lives of their owners who require less formal care.

Gaunet published two studies exploring the differences between pet dogs and guide dogs when asking their owners for food or play [10,11] and found that guide dogs do not understand that their owners cannot see them. In some cases, they learn to trigger their owner's attention differently by adjusting their behavior toward the disability of their owners.

In describing related works within and beyond HCI we highlight how research on technology and guide dog teams is conspicuously absent across several intersecting disciplines. Our approach attempts to bring these different strands together by situating prior research on the relationship between dogs and owners in guide-dog teams within the purview of HCI, and by proposing new ways technology could positively enhance the everyday lives and interactions of these teams in the future.

FIELD STUDY METHOD AND PARTICIPANTS

In order to gain a rich, descriptive understanding of the interactions of guide dog teams, a two-part study was conducted. The first part was an in-depth interview with an expert on guide dogs. The second part consisted of semi-structured interviews and observations of several tasks and routines with twelve guide dog users.

Expert Interview

We recruited an expert whom is a founder of a guide dog school and has been working in guide dog training since 1977. Our two-hour interview probed issues such as guide dog training, processes, historical information, developments, and shifting trends. The participant gave insightful descriptions about guide dogs and shared stories of graduates. He also showed a ten-minute movie (made by another guide dog organization) about the history of guide dogs and samples of harnesses that he had been collecting.

Investigating Guide Dog Teams

For the second part of the study, we recruited participants through word-of-mouth, social media, the *Canadian National Institute for the Blind* (CNIB) and *Access for Sight Impaired Users* (ASIC). The twelve recruited participants lived in or close to a major metropolitan city in Canada, were aged 21 to 67, and used a guide dog. Eight of them were female and four were male. Five participants were *early blinds*, meaning they had been blind since birth or early after birth. Seven participants were *late blinds,* they lost their sight later in life.

Guide dogs are trained for two years, work for approximately eight years and retire. Three of the five participants were partnered with their first guide dog, four participants were with their second, two with their third, four with their fourth and one was with her fifth guide dog. The length of guide dog ownership ranged from one and a half to over 30 years. The dogs came from three different guide dog schools: *BC Guide Dogs* (Vancouver, Canada), *The Seeing Eye* (New Jersey, US), and *Guide Dogs for the Blind* (California and Oregon, US).

We conducted in-depth interviews and observations with the guide dog users. Interviews were semi-structured and conducted in the participants' homes. Questions were about the guide dog handlers, the dogs and their life, exploring routines, tasks, activities, play and challenges. Moreover, questions targeted the use of and relationship to technology. The observations explored interactions of guide dog teams both in the home and outside. In order to get a detailed understanding of their practices and routines we spent between 2.5 and 4.5 hours with each team, depending on their willingness and comfort.

Data Analysis

Handwritten notes were taken during interviews and observations. Interviews were also audio-recorded. Pictures and videos were taken during both sessions. All field recordings were reviewed and information most relevant to the study focus was transcribed. Through thematic analysis, we identified several pertinent categories within the data.

To provide a coherent narrative, we present the findings from both our expert (referred to as X01) interview and guide dog user (P01-12) interviews together.

In the next three sections we present the main findings from our study. We first divide the interactions of guide dog teams into two major scenarios, at work and off work, and explore their individual conditions. Second, we explore the unique bond of guide dog handlers and their dogs. Lastly, we describe the use of technology in guide dog teams.

TWO DISTINCT SCENARIOS

An important observation segmented interactions between guide dog teams into two main scenarios. They are either working or off work. A clear indicator for these modes is the harness, which the dog is wearing while working and typically not wearing while off work.

Guide Dog Teams at Work

At work, guide dogs wear a harness and guide their owners (see Figure 1). In this mode, the dog functions as an instrument, assuming the role of a working assistance dog. When working, the interactions of guide dog teams are limited. The owner knows where to go, gives the dog commands, and monitors traffic and lights. The dog guides the visually impaired owner safely wherever s/he needs to go, around obstacles and towards steps or doors. Ideally, the guide dog stays concentrated and focused, and does not get distracted. However, dogs can become distracted; the handler watches out for this, at times refocusing the dogs attention with a command and a medium strong leash pull.

Figure 1. Independent travel with guide dogs. Participants walking on the street.

Guide Dogs vs. the Long Cane

The abilities of working guide dogs were highly appreciated by participants, who all used a cane before acquiring a guide dog. During the interviews, they mentioned that traveling with a guide dog instead of a cane is less exhausting. Receiving less tactile feedback from their environment, the associated level of concentration and effort is greatly reduced with the guide dog as a mobility aid. Furthermore, a guide dog opens up more possibilities to engage with other people. For example, consider the following reflections from four different participants:

The dog has impacted my travel tremendously. […] When I think about my route into work. If I had to use the cane, I would need a nap when I got to work. It would be mentally exhausting. It is pretty remarkable to be able to travel that way. Pretty neat. [P04]

The dog looks out for you and you don't have to think as much compared to the cane. It's very different. I often do compare walking with him, what it would be like with a cane and he makes it a lot easier […] so it's nice to have him to help me with that. [P02]

A cane makes me feel disabled. With the guide dog I have confidence. She is my eyes. [P08]

The dog connects me to people, he is the perfect icebreaker. With the cane you become invisible. [P06]

Collectively, these reflections highlight how beyond appearing more practically beneficial than canes, guide dogs play significant roles in shaping owners' personal confidence and connecting them to their social contexts.

Awareness and Confidence Through a Unique Connection

Due to their visual impairment, guide dog owners perceive certain things differently. In a unique way, when working they are aware of their surroundings and confident about their dog's skills. By holding on to the harness, guide dog handlers get information about their dogs by feeling movements. We observed that even minor changes in movement were felt by the owner: while observing, one of our participants (100% blind) noticed a dog far away on the other side of the street just by slight changes in his dog's movement. The observer was surprised since she had not noticed either the other dog or the guide dog movement. In these cases, owners were able to predict moments of inattention in their dogs and react by correcting the dog with a command. One participant describes the significance of the harness in mediating this unique connection:

There is nothing that affects our relationship as a [working] team more than the harness. [P11]

Despite the expressiveness of the harness, all participants described experiencing challenges when traveling to new places. Usually, this required them to rely on information from other people around them (if any were present). This concern was summed up by one participant, describing he wished his dog could describe what is around them.

Guide Dog Teams off Work

When off work, the harness is taken off and guide dog teams rest, walk, play, and communicate together. The owner takes care of the dog, providing him with certain privileges that add up to a typical 'dog's life', which includes: feedings, several opportunities to go to the bathroom, grooming, attention and interaction (e.g. talking to the dog and giving him affection). Additionally, playing and free running is important. In this mode, guide dogs are pets with individual behaviors. Similar to the routines of non-visually impaired human-canine teams, the interactions of non-working guide dog teams can vary a lot. Some dogs

are more playful and enjoy off-work time to have fun, while others might like to rest more. One participant described:

When the harness is off, at home after work, he freaks out. He spins around. He makes snorting sounds. […] After 10 minutes he calms down again. [P03]

Lack of Awareness and Confidence

When off work, guide dog handlers are often unaware of the behavior of their dogs, both inside and outside of the home. In fact, in those off-work observations participants seemed to lack confidence in reading their dog's behavior. They often asked what their dog was doing and whether they were wagging their tail. Often, they mentioned they were not sure of the dog's mood. While conducting an interview in a participant's apartment, he mentioned:

I don't know what's going on [with the dog] usually he's excited when people are over. [The dog was sleeping at that moment.] [P02]

Figure 2. Play-interactions of guide dog teams

Play

Guide dogs are generally very playful, due to their breed's (mostly Labrador or Golden Retriever) character. However, there are no special dog toys for blind dog owners. Guide dog handlers end up using dog toys designed for sighted dog owners such as ropes, tug toys, balls, plush toys, squeaky toys, and bones. Play interactions within guide dog teams can vary. In Fig.2 we see two of our participants playing with their dogs in their home. In the first picture the participant petted her dog. In the second picture, the participant started playing with a dog toy that she got out of a closet, in which she keeps all her dog toys.

Some of our participants mentioned several challenges with dog toys. First, it is hard to find a toy when the dog is not interested in picking it up or if the toy is out of reach for the dog (e.g. when it happens to be underneath a couch or stuck in a tree or bush). Figure 3 (left and middle) shows two participants searching for dog toys that are right in front of them. We observed several searches like this. Second, participants were unaware of the locations of some of their dog toys and they were often laying around on the floor as a potential hazard for the blind owner. Some tried to keep toys away or only gave their dog access to a few. Third, we found that all participants had stepped on dog toys before and two had seriously injured themselves as a result. In one case, a participant fell down stairs in her house because of a poorly placed dog toy. In Figure 3 (right), one participant showed us her dog's favorite toy; a bone, which she hurt herself on many times by stepping on the sharp edges when walking around her apartment. Fourth, as mentioned before, dog owners did not notice when their dogs became bored, tired or were no longer interested in playing (e.g. they became busy with other things such as sniffing). This caused confusion for owners due to the lack of response by their dogs.

Figure 3. Challenges with dog toys: Participants a,b) search for toys and c) shows a toy with sharp edges that led to injuries

Four participants articulated that they do not see challenges in their play interactions, because they feel they managed to deal with their situation of being a blind dog owner and have arranged themselves with the situation. However, three of them have sighted friends or partners who often play with the dog.

Free Runs

Guide dogs work hard when they are on-duty. The work needs their full attention and concentration. Free runs are stress-reduction for dogs and guide dogs require them too. As the guide dog expert explains:

It's stressful being a guide dog. They need stress-reduction. They need free runs. They have to have a life. [X01]

In fact, most guide dog schools tell their students that guide dogs need free running, however, this is one of the most challenging tasks for guide dog teams. Guide dog handlers lack reception of necessary information when their dogs are off leash. This includes things such as where the dog is, what mood he is in, what he is doing, (e.g. whether he is walking, running, sniffing or going to the bathroom). Handlers might not be able to prevent the dog from running away (i.e. in case s/he runs after a squirrel) and this can be dangerous for both the handler and the dog. The dog could get hurt and the handlers' mobility is dependent on the dog.

Nine participants give their dogs free runs by themselves in different set-ups, four of them outside of their home; they trust their dogs even off leash. Two of them regularly visit fenced dog parks by themselves (see Fig.4). The remaining five either have a fenced yard or sighted friends or family that help them out. One participant takes her dog off-leash by herself in a school parking lot every day and is confident the dog will not get into trouble because she stated her dog is afraid of cars. Yet after watching the scenario during our observations, we estimated the situation to be dangerous. The dog could have easily run across a street nearby and

Figure 4. Free Running. From left to right: A participant playing with her dog on a soccer field with a sighted person present and two participants visiting fenced dog parks.

been hit by a car. Some participants expressed their anxieties of having their dogs off-leash:

He would be unpredictable. [P02]

He might never come back to me. [P03]

I don't know what he is up to when he is off leash. It's too insecure. What if he behaves badly and I don't know or what if he walks away and I don't know why. It could be a squirrel he is running after. To be able to call him back at the right time, I need to know what he is up to. [P05]

Three participants do not give their dogs the possibility of free runs. One of them admitted that in his entire time with the dog (6 years), he has never given his dog the opportunity of free running. He explained:

A lot of guide dogs probably don't get free runs as often as they should. I don't play with him outside. I don't know what he would do. At [my university] there are no places I think without danger […] If he would get hit by a car it would be quite a setback. [P02]

Free runs need to be done in areas that are safe such as dog parks or big fields without traffic around. For visually impaired owners, it was challenging to find such places, as there are few dog parks in the location of study (and likely elsewhere as well). One participant called the city and found out there were only two fenced dog parks in the city, but neither of them were in in the area he lives in. In fact, only two of our participants lived close to one. Two participants described this challenge, stating the following:

I don't know where to find a safe place to let him off leash. [P05]

I don't know if there's a field around. […] It would be nice to have a dog yard. [P02]

One participant lived close to a soccer field, and with a sighted person accompanying her; she goes there frequently to give her dog free running. In Fig.4, we see her playing fetch. Interestingly, she was found to be proud about her dog retrieving well. Because this play is a routine for her, she gained *trust* in the play and in her dog.

DEVELOPMENT OF STRONG BONDS IN TEAMS

Most dog owners experience a strong emotional relationship with their dogs, often referring to them as a companion or best friend. Most participants felt that the human-animal bond of guide dog teams is stronger than the bond that evolves between sighted owners and their dogs. Three main reasons were mentioned for this:

First, guide dog teams spend a great deal of time together. As two participants described it:

They are with you all the time. You develop a very very strong bond. […] I spend more time with that dog than people with their children and husbands combined. [P04]

I consider him my friend […] I have an emotional attachment. I spend a lot time with him. Almost all day long. That in addition that he helps me get around makes it a strong bond. [P02]

Second, guide dog handlers conceive reliability and trust through their dogs working abilities; this was found to enhance their bond. As an example, one participant said:

I feel I can rely on him! I really feel I can trust him. [P03]

I really trust him. You can't have that working relationship when you don't have that ultimate trust. [P09]

Third, participants named the gratefulness and pride for their guide dogs work abilities and their positive impact on the lives of people with visual impairment as strengthening the bond between the dog and the handler.

One participant shared a situation that made him feel both grateful and amazed, because his dog 'managed to make eye contact' with people they had met before and this way helped him to develop a bond with other people.

I went to a play at a theatre. A man and his wife sitting behind me noticed the [guide] dog. We had a nice chat. A couple of months after, I was at a presentation… [my dog] suddenly pulled me in a direction […] before I knew it, he [had taken] me over to the same people. [P02]

He shared more thoughts on that issue:

Being blind has the disadvantage that you can't really make eye contact with people. […] The dog is a conversation starter. A friendly dog does make people come over and well, you can meet a lot of nice people that way, even when their initial interest was for the dog.

Another participant echoed that:

"When you have a white cane nobody says 'oh hi, nice white cane you have', but people will say 'oh lovely dog'. [P12]

Another participant told us a story about when she felt grateful and proud for having her guide dog. She was visiting a mall to pick something up from a store and got lost. She knew malls are difficult for guide dogs to stay oriented in, because they differ a lot from streets. However, her dog found an escalator after a while, which was a difficult task for the dog, but got them out of the situation. After telling the story, she states:

When he takes me to where I need to go, stuff like that makes me so proud of him, I feel really lucky and taken care of. It makes me so happy that he can be so helpful. That kind of stuff makes me crazy about him. [P03]

Collectively, these reflections illustrate how bonding is essential in guide dog teams, because the handlers have to trust their dogs when they rely on them in work situations. Interestingly, the strength of the bond comes almost entirely through the working relationship of guide dog teams.

TECHNOLOGY USAGE OF GUIDE DOG TEAMS

All participants used computers and screen readers like JAWS [17]. Five of our participants used a smart phone (four an iPhone and one a Samsung S3), five used a regular cell phone, two of them would like a smart phone but could not afford it, and two participants didn't use a cell phone. The smart phone users described it as very helpful in that it replaces expensive tools like color-tracker, OCR (Optical character recognition) software and tools, and talking clocks, and it opens up new possibilities with apps.

Two participants use GPS technology when traveling outside, one on his smart phone, one as an extra device, but both expressed dissatisfaction with the tools especially with regards to using it while having the guide dog working.

Some participants had special tactile watches, talking clocks, tactile button stickers for appliances such as microwaves and stoves. Others used Braille tools, like typewriters and one participant had a Braille printer.

With regards to the dogs, one participant used a clicker with her dog, a device making a clicking sound when pressed to mark good behavior in a dog. Another participant used an "invisible fence", a system designed to keep the dog within an unfenced yard through the delivery of mild electronic shock by an electronic collar if its warning sound is ignored when the dog gets too close to the predefined boundaries. All guide dog handlers whether at or off work, used auditory cues, such as a bell on the dogs collar to tell where s/he is at; some used an additional bell inside their homes for the dog to let the owner know that he wants to go out.

In the former sections we discussed independence in work situations, and highlighted challenges in guide dog teams when off work, which affect their overall dog team relationship, and ultimately their lives. We also described their current use of technology and found no technology meaningfully supports or mediates play-interactions to date.

In summary, we found that guide dog teams interact differently together depending if they are working or off work, owners and their guide dogs have a strong emotional bond, and technology currently does not support guide dog teams and their interactions well.

DESIGNING FOR GUIDE DOG TEAMS

In what follows we discuss implications and opportunities for designing for guide dog teams, making clear how important it is to address this specific user group in future HCI and interaction design research. We suggest three types of opportunities: 1) supporting working guide dog teams; 2) supporting play interactions of guide dog teams; and 3) speculative and exploratory opportunities.

Supporting Working Guide Dog Teams

People who are challenged with vision loss are often independent in their activities of daily living. Guide dog owners extend this independence through the working relationship with their dog. In our study, all participants showed remarkable independence in and outside of their homes often not relying on the help of others. When guide dog teams are traveling (at work) they do not like interruptions in their human-dog interaction, especially through computer-mediated technology. For instance, participants did not answer their cell-phone when walking with their dog because it seemed distracting when they needed to concentrate on traffic, orientation and safety. All but one participant strongly disapproved of any changes in their working interactions. All participants found their dogs very *reliable* as travel aids, with one participant noting they are "*actually more reliable than technology*" [P1]. This helps make clear that designing for work situations of guide dog teams involve challenging design constraints. Nevertheless, we outline two possible areas for design improvements in working guide dog teams.

Redesigning the harness

The harness is a strong connection point between the guide dog and its user. Our participants have had different harnesses, depending on when and from which organizations they got their current guide dog. Some participants pointed to design issues with their harnesses and one participant secretly kept and used an older harness because he disliked the new one he got. Overall, the harness designs of our participants seemed traditional and potentially outdated to us. Looking at more modern harness designs, for example, for avalanche rescue dog teams [e.g., 33], we see the opportunity to conduct further studies leading to new harness designs, including explorations of different and new materials. This also presents a potential avenue for embedding technology in such garments, which may also be considerable for enhancing the mobility of guide dog teams (see next section).

Travel Aids for Guide Dog Users

Even though our participants felt challenged when traveling to new places they disliked technological distractions while 'working'. We see this as a possibly overlooked area of mobility aids specifically designed for visually impaired that use guide dogs for traveling. Technologies to enhance

independent travel of people with vision impairment have been a research focus in the past. However, we believe guide dog users may have more nuanced needs that bring along new design constraints for future work in mobility enhancing travel aids for guide dog owners and teams.

Supporting Play-Interactions of Guide Dog Teams

Our findings revealed significant challenges when guide dogs are 'just pets' suggesting several opportunities for design interventions to support guide dog teams in 'off-work' situations, including enhancing play-interactions with toys.

Creating Accessible Dog Toys

To date, there are no interactive artifacts, such as toys, applications, tools or gadgets specifically for guide dog teams. In particular, this forces guide dog owners to use available dog toys targeted towards sighted dog owners. This suggests an opportunity for creating tangible prototypes of *accessible dog toys* aimed at supporting and enhancing play interactions within guide dog teams. For example, dog toys utilizing sensor-technologies could record and communicate situational information, such as locations and distances to the dog owner. Moreover, they could use auditory signals to indicate when a dog picked up or dropped a ball. Additional sensors could track the dog's proximal location, and communicate its relational distance to the owner and the toy.

However, when designing wearable technologies for guide dogs, the form factor of any attachments must be kept small and unobtrusive, so that the dog does not interpret it as a harness. This is particularly important as the harness differentiates work time from non-work time for the dog. For example, the design of Wingraves [44] tracking prototype for dogs would not be suitable for a guide dog since its shape is very similar to a harness. Technologies implemented into toys will need to be safely protected from the dog. Furthermore, when working with animals, ethical issues need to be carefully considered. Technology should not be invasive and augmentations of animals ought to be ethically deliberated (see also [40]).

These design directions suggest several areas for future research in the HCI and interaction design communities, such as: conducting form studies of accessible dog toys, location capture of dogs and toys, and how information can be practically and aesthetically communicated to visually impaired dog owners. This also raises several questions about what kind of feedback modalities would be suitable and pleasing for both, humans and dogs. Emerging and ongoing research exploring auditory feedback [e.g.35] and vibro-tactile interfaces [e.g.12] could support future research and design initiatives in this area.

Better Supporting Free Runs

Free running is a major challenge for guide dog handlers. Taking a guide dog off leash is one of the most challenging tasks for their owners. This creates a major dilemma that guide dog owners have; they are supposed to offer free runs to their dogs but cannot do it independently. The observed lack of information owners experience when having a guide dog off-leash or even just off-harness suggests a major opportunity for interactive technology designs. Similar to the opportunities with accessible dog toys, tracking and sensor technologies can be used to locate the dog and communicate information to the dog handler. For instance, a virtual free run zone could be created with a tracking and boundary system combining location sensing with auditory clues based on GPS.

As an alternative to device-level interventions, there exist opportunities to engage the broader local community. For example, sighted volunteers could meet up with guide dog teams for free runs and monitor the dog. Research and design developments could maintain services like this with digital tools such as calendars, forums and mobile apps facilitating a community of both sighted volunteers and visually impaired members. Additionally, cities could address the issue with more fenced dog parks, potentially maintained through digital tools informing dog owners about park locations and specifications. These suggestions present ways that leverage pre-existing social technologies in ways that could support social connection and interactions with and around guide dog teams.

Using Smart Phone Apps

In addition, we suggest considering smart phones and mobile apps as a platform for future work to enhance the play-interaction of guide dog teams. Smart phones such as the iPhone are now reasonably accessible for blind users [4], and researchers and companies are designing accessible apps. For example, *vizwiz* [2] allows blind users to receive quick answers to questions about surroundings based on online crowd sourcing. Remarkably, the economic side effect for the visually impaired using a smart phone can be tremendous as it can replace pricey gadgets such as talking clocks, calculators and phones, color detection devices, money sorters, a scanner and OCR (Optical character recognition) software, or electronic magnifiers. There are naturally many more opportunities for apps specifically designed for guide dog owners.

With regards to the aforementioned design suggestions for guide dog play, smart phones can play an important role in new design interventions. Specifically designed apps could promote playful dog-owner interaction and possibly receive and transfer information from tracking and sensor devices. Smart phones could be used by guide dog owners to find lost toys that are equipped with sensors, be part of the previously mentioned virtual free run zone or support connecting people through social media platforms.

Overall benefit of supporting play

Interventions enhancing play interactions of guide dog teams offer strong potential to positively shape and nurture the general relationship between guide dogs and their owners. As noted, guide dog teams develop a strong bond evolving through *awareness, pride, trust, reliability, confidence* and *predictability* mainly in their working relationship. However, when off work, those attributes are mostly missing. The design suggestions discussed above

illustrate concrete ways of helping better support the aforementioned attributes of experience and bonding within into the play-interactions of guide dog teams. For instance, *awareness* could be gained by guide dog owners through knowing about surroundings, locations and distances of the dog and toys. *Pride, trust and reliability* could evolve when smooth off-leash play is routinely practiced; at the same time, handlers could enjoy play more and gain *confidence* in off-leash play. We see design directions emerging from this as being parallel to ongoing research calling for the value-sensitive design of technologies [9].

Speculative and Explorative Opportunities

Dogs can get bored, tired or excited; however, these emotions can sometimes be hard for guide dog owners to infer. Sighted dog owners can look at their dogs and read their moods. It is imaginable that future technology could represent this in some way, making information about the dog's mood accessible for visually impaired dog owners. This would help the owner to more easily *predict* some of the dog's actions (sniffing, looking at something, going 'to the bathroom') and eventually lead to more *trust and reliability* towards the dog in off-work situations. In order to provide accurate information about the moods and needs of dogs, we need to better understand how the different related data could be captured. It is imaginable that information about canine heartbeat, temperature, and body language (calm, aggressive, excited or happy postures) could give insights about the dog. New inventions utilizing biometric sensor technology could give access to that information, which could potentially be used for predicting actions or moods.

Moreover, we want to point to an opportunity for more personal use scenarios, using technology to record memories, interactions and experiences with dogs. This would give guide dog owners possibilities of creating 'scrapbooks' of memories, perhaps in some ways not unlike sighted dog owners who take pictures of their dogs to capture moments in life. One of our participants maintained an altar-like set up with collected objects of her previous guide dogs to preserve memories of them, presenting an alternative to pictures. For future work in this area, we see potential for utilizing smart phones but also envision a design agenda for open-ended explorations of new interactions in guide dog teams (see e.g., [21]) to explore possibilities of preserving memories, belongings and possessions [see e.g., 3].

Team-centered design for human-animal teams

Lastly, our work points to a more team-centered approach in future design work, which can possibly be pursued not only when looking at guide dog teams but also other human-animal teams and generally inform computer supported human animal team coordination. This highlights broader considerations of our work, presenting a possibly overlooked aspect in HCI and CSCW work with teams and expanding the emerging animal-computer interaction community.

CONCLUSION

The goal of this paper was to investigate the interactions of guide dog teams to uncover insights and challenges, and discuss possibilities for future research and design initiatives. Our study revealed details about guide dog teams, including major differences in their two distinctive interaction scenarios (at work and off-work). This led to a discussion of possible improvements in their activities through interaction design. We suggested: *harness redesign*, *enhanced travel aids*, *accessible dog toys*, *interventions to better support free runs*, and *the integration of smart phones*, as design opportunities to guide future research in HCI. We also pointed to more speculative and explorative design directions, and lastly discussed benefits of team-centered approaches in HCI research.

Our paper contributes to the intersection of HCI, accessibility, and human-canine interaction. Although we see the testing of actual prototypes with guide dog teams as a potential validation of some of our discussion points, considering the relative newness in HCI research on this inter-relation, we aimed to first offer rich, descriptive findings of our participants' experiences and challenges to inform and inspire new design opportunities, and to nurture this emerging design space to guide future research and practice in HCI. Ultimately, we hope this study makes clear the importance of recognizing the practices, needs and requirements of guide dog teams and the opportunity that the HCI and interaction design community has to positively benefit this group, and more generally human-animal relationships in the future.

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