xPress: Rethinking Design for Aging and Accessibility through a Voice-based Online Blogging Community

ROBIN N. BREWER, Northwestern University
ANNE MARIE PIPER, Northwestern University

Although many older adults are active online, certain age-related disabilities, such as late-life vision impairment, make sustaining online participation difficult. Motivated by the need for accessible online spaces for people experiencing vision impairment in older adulthood, we developed xPress, a voice-based online blogging community. Through a 10-week deployment with seven older adults with acquired vision loss, we analyze how this type of online community enables connecting with peers, sharing experiences, and offering social support in new ways. The design of xPress also highlights the importance of human voice in accessible social platforms and reveals expectations around community participation. We discuss designing for age and disability through the lens of intersectionality and offer design considerations for similar voice-based online communities.

CCS Concepts: • **Human-Centered Computing** → **Accessibility**; *Accessibility systems and tools*;

Keywords: Interactive voice response; older adults; vision impairments; accessibility; online community

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1 INTRODUCTION

Connecting with others and seeking support through online social platforms has become a pervasive part of contemporary daily life for people of all ages. Yet,, there are still groups of people for whom Internet use and this form of societal participation is challenging. In the United States, although increasing numbers of older adults are now online, individuals aging with disabilities are less likely to go online and have lower levels of Internet skill compared to their peers without disabilities [23,24]. One common form of disability that affects technology use, as well as many other aspects of life, in older adulthood is vision impairment. An estimated 285 million people worldwide have a severe vision impairment – ranging from low vision to no light perception – and many of these individuals are older adults [67]. Age-related macular degeneration, a common form of vision impairment among people over the age of 50, affected nearly 9.1 million Americans in 2010 and this number is projected to nearly double by 2050 [50]. Despite advances in accessibility features on computers (e.g., screen readers, magnification), these tools can be extremely difficult for older adults who are losing their vision to learn, maintain, and use [47], presenting challenges to online participation.

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Ensuring equable online access for older adults with disabilities is essential given that online interaction is a key way in which people offer and receive social support as well as seek and exchange information around shared health or disability experiences. While we know that younger people use online communal spaces (e.g., blogs, Facebook groups) to discuss health or disability related experiences [15,39,41], there have been few studies of how older people as a group engage in these practices [10,31]. Further, there are few online communities designed specifically to engage groups of older adults with shared disability experiences [4], and none, to our knowledge, that support older individuals with acquired vision loss.

This paper presents an exploration into the design and use of a voice-based online social community, called xPress, for older adults with vision impairments. The goals of this work are twofold. First, by introducing a new type of accessible online community, we are able to study the ways in which these individuals actively engage in content creation and social sharing. In contrast to much work characterizing older people with disabilities as disengaged from online life [16], our analysis highlights the ways in which participants readily made connections with peers, shared their own experiences, and provided social support to others. The second goal of this work is to use system design as a way of questioning the functional and social aspects of this online community. Our analysis of xPress reveals that audio-based accessibility tools, which prioritize efficiency and automation through synthetic speech, neglect the ways in which natural human voice provides cues about identity and supports social communication. Further, the xPress system was intentionally designed to integrate with an existing online social platform, Tumblr, so that sighted family members, friends, and others could interact with participants. Yet, participants rejected this aspect of the system, providing an interesting instance of technology non-use that helps reveal community values and emerging norms.

Our analysis of this voice-based online community makes two primary contributions to CSCW. First, our analysis calls attention to the concept of intersectionality [20] in the design of online systems. In the context of the present study, designing for accessibility or aging separately can neglect the complex technology use practices and values of older adults with vision impairments. Second, our work provides a case of an audio-only online social community that enables sharing of human voice as the primary media, which opens up new challenges and opportunities for the design of similar online spaces.

2 RELATED WORK

The present paper brings together literature on online participation among older adults with disabilities, access technologies for people with vision impairments, and the use of voice interfaces for online interaction.

2.1 Online Participation, Age, and Disability

Understanding the complexity of age and disability and how these factors affect online participation is an important but relatively unexplored topic in CSCW. Although increasing numbers of American older adults are now online [25], they exhibit lower levels of online engagement [65] and lower levels of Internet skill [24] compared to younger adults. While not all people experience disability in older adulthood, understanding online interaction becomes more complex with disability as an additional factor. Recent analyses of Internet adoption highlight a relationship between disability and lower levels of Internet skill [24]. Further, people with disabilities are less likely to use the Internet in their homes, access the Internet via a smartphone, and participate in activities such as receiving news and obtaining health information online compared to people without disabilities [23,24]. Nevertheless, there are considerable differences in online usage and skill depending on an individual's disability. In particular, people with vision impairments tend to go online less and have lower levels of Internet skill compared to individuals with a hearing disability [23].

Beyond issues of disability, Internet access, and skill, recent work understands the motivations of older people and online participation, particularly within online communities. For example, Lampe et al. showed that motivations for online participation may change over time, but one factor that remains consistent is a sense of belonging in the community [30] – and this finding has been replicated in work specific to older adults [11]. Recent work suggests that this sense of belonging may not persist across different online communities, particularly when older adults perceive that certain online communities are not made for them [9]. Other work calls attention to some older adults valuing personalization, reflection, and the ability to reciprocate and give feedback in ways that mainstream online social platforms (e.g, Facebook) may not support [28,32,35]. In contrast, blogging communities can provide a space for older adults to connect with peers and express themselves [10] as well as advocate for changing societal norms around aging and age discrimination [31]. Yet, there are

relatively few studies exploring the complexity of age and disability in online communities [4], and no work, to our knowledge, of online communities designed specifically for older adults with a shared disability experience.

2.2 Accessibility and Online Communities

Recent research has called attention to accessibility issues of online communities for older adults [2,40]. Arfaa and Wang, for example, analyzed how older adults use social networking sites and found that many experienced accessibility issues (e.g., "small text, confusing navigation, unclear terminology"). To address this, researchers have built systems aimed at making online communities more accessible by using interfaces that are familiar to older people. For example, interactive frames and printed photos improve learnability and help people feel more comfortable interacting online [18,33,48]. Challenges of accessibility and computer learning are exacerbated for older adults with vision impairments. Prior work established that screen readers (e.g., JAWS on a PC) and mobile accessibility tools (e.g., VoiceOver on an iPhone) are difficult for older adults who are losing their vision to learn to use and maintain [47].

Other work has examined non-visual access to existing online communities by younger people with vision impairments [60,62]. This research demonstrates that social networking sites still present accessibility challenges when representing visual content through audio, but people with vision impairments want to engage on such sites with their sighted friends [63]. However, this work focuses primarily on the experiences of younger users. Prior work has neglected the challenges older people with vision impairments face in online communities and has yet to consider new opportunities for system design.

2.3 Supporting Online Participation through Voice Interfaces

Although most digital platforms are graphical in nature, audio-based systems are on the rise. Digital assistants like Google Assistant, Amazon Echo, and Microsoft's Cortana allow users to interact online without the need for a graphical interface. Audio-based content is becoming more popular online with podcasts and video content shown on websites like Facebook and YouTube. These sites, however, are often difficult for older adults with vision impairments to access because they require an Internet-enabled device with accessibility software and knowledge of how to navigate these devices with accessibility software [47]. Moreover, these voice-based sites and services focus on information seeking rather than social applications such as self-expression, content generation, and sharing.

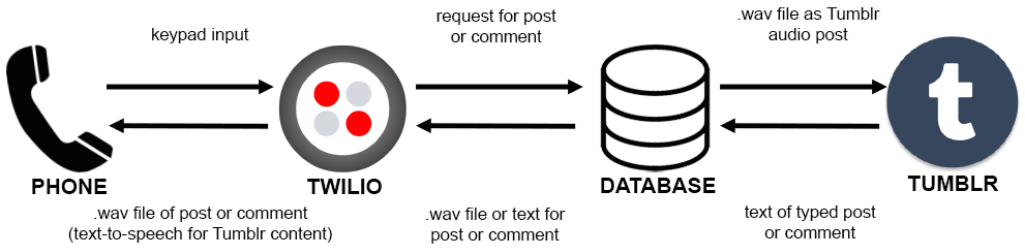

Figure 1. Design of xPress, an IVR system that supports audio-based blogging through a landline or cell phone.

In contrast to these commercial tools, recent research has examined interactive voice response (IVR) systems as one class of voice interfaces that can bridge gaps in online access, as these systems are accessible through traditional (landline or feature) phones. Thus, IVR systems do not require access to or knowledge of Internet-connected devices. Prior work established that IVR systems are useful for people in India with limited Internet experience and access [42,52], and people in "developed" countries who face similar barriers to Internet use [8,66]. The work by Brewer et al. [8] found that an IVR system for sending and receiving Web-based email worked well for older adults without Internet access in their homes or limited knowledge of computers. Other work demonstrated the use of an IVR system for younger people in India who are blind [60].

Voice-based online communities have the potential to address accessibility needs but have yet to be explored with older adults with vision loss. Further, we know that online communities can provide important social and informational support for individuals with disabilities or chronic conditions [15] and for older adults [10], but we know little about how older adults with a shared disability experience engage in these practices. The present study bridges these gaps in the literature through an exploration of a voice-based online community designed specifically for older people with acquired vision impairments.

3 SYSTEM DESIGN

We draw on the success of voice-based tools and technologies created for people with vision impairments (e.g., audio books and screen readers), recent IVR systems [8,38,43,44,60], and the importance of blogging as a form of online expression among older adults [10] to create xPress, a voice-based online blogging community for older adults with vision impairments. The goal of our system is to enable new forms of online participation among older adults with vision impairments and, in turn, use this system as a way of understanding the formation of an online social community among this understudied demographic.

3.1 Formative Design Inquiry

To inform the design of an online community for older adults with vision impairments, we first conducted a two-week formative study to understand whether and how people would want to create content and the type of content they would want to share. Five seniors with vision impairments participated in the study (average age=72.2 years old, min=60, max=96, male=3). Two participants were blind and three reported having low vision. We provided each person with an accessible audio recorder (Wilson Digital Voice Recorder, v5) to record content. Participants were instructed to record on any topic as often as they wanted for two weeks. In the post-interviews, we asked participants to share their experiences recording content over the duration of the study.

Participants recorded on a variety of topics such as their hobbies and childhood, but they most often reflected on life with a vision impairment. For example, one participant recorded about an encounter with a sighted stranger:

> *"'Tell them you were helped across the street by a blind man.' And they looked at each other and they caught the irony and the one lady slapped my arm kind of gently and said, 'You know what? We will and thanks!' And I was laughing the whole way down to Micky D thinking, at least two people don't think we're stupid and maybe they got a little humor out of it. It was such a cool day."*

Also, participants reflected on the quality of their recordings, commenting that they wanted their posts to resemble that of audio content with which they were familiar, where quality was both a reflection of audio production and performance. For example, one participant said, "*Make me sound like a professional*." This participant was a musician. He enjoyed uploading music online and listening to music recorded by other artists on sites such as SoundCloud. Therefore, he wanted his recordings to mimic a similar level of audio-production quality. Interestingly, one person noted that the occasional "um" is okay, a reflection of his desire to maintain a natural, conversational flow to his recordings. We also found that participants were most interested in sharing their experiences with acquired vision loss and being older, which informed the design of xPress.

3.2 System Implementation

xPress is an IVR-based blogging system that allows users to record and listen to blog posts, comment on, and listen to comments added to posts. A user begins by dialing a toll-free number. Once the call has been initiated, Twilio routes users to a Python script, which checks a MySQL database to pull the profile information of the person who is dialing using their phone number to authenticate the account. This script then reads aloud a main menu using text-to-speech (TTS) and Voice XML. Users can either listen to others' new posts and comments, listen to their own posts and comments, or record a new post. They navigate the menu

through keypad input, as voice input navigation and open-ended prompts can present usability problems for older people [8,66].

PID	Age	Age of Vision Loss	Gender	Vision	Owns Computer?	Uses Internet Weekly?	Uses SNS?	Other tech use
Jim	65	50	M	Low vision	Y	Y	N	Owns iPad, iPhone, and Amazon Echo; Listens to audiobooks
Ray	92	82	M	Blind	Y	N	N	Stopped using computers after vision loss but listens to audio books
Frank	73	20	M	Blind, no light perception	Y	Y	N	Owns an iPhone and Amazon Echo, uses Siri, used to listen to blogs through email
Gary	67	52	M	Low vision	Y	Y	N	Does not own smartphone, listens to videos on YouTube; Used to blog, listen to blogs, and listen to audiobooks
Linda	95	92	F	Low vision	N	N	N	Owns iPad but does not use; Does not use Internet anymore but listens to audiobooks
Paul	71	56	M	Low vision	Y	Y	N	Does not own smart phone but uses Siri on iPad; Listens to audio books and used to listen to blog posts
Joyce	66	48	F	Blind, variable light perception	Y	Y	Y	Owns an iPhone and uses Siri; Listens to audiobooks and blogs by email

Table 1. Demographic information about participants. All names have been anonymized.

When participants listen to recorded blog posts or comments, they hear the .wav file of the post or comment through the user's actual voice recording. The system allows users to replay and re-record their posts and comments, as reflection and revision during content creation are important to existing older adult bloggers [10,29]. Participants can listen to comments on each of their own posts and comments other participants leave on posts that are not their own. After publishing a post, the address of the audio recording is stored in the database and later retrieved when a user calls in and decides to listen to a post.

Additionally, we designed the system so that an individual's audio blog is available on a traditional, graphical Tumblr page. We initiated a Tumblr blog for each participant at the beginning of the study as a way of sharing their posts with sighted family members and friends who were not using the IVR system and to make their blogs available to others on the Internet. Posts and comments are automatically published to that individual's Tumblr blog page using Tumblr's API. Integration with the Tumblr API is one major component that distinguishes xPress from other IVR systems, as prior research-specific online communities using IVR are separated from existing online platforms [43,52,60].

4 METHODS

We deployed xPress with seven older adults with vision impairments for 10 weeks during the Fall of 2016.

4.1 Participants

Seven older adults (mean age=75, SD=12.59; age range=65-95; 2 female) participated in the deployment. We recruited participants through e-mail list-servs for organizations for visually impaired older adults and word-of-mouth through support groups for older adults with vision impairments. There are many differences

between someone who has low vision and someone who is blind [56], but we use the term "vision impairment" to refer to people who are low vision or blind to varying degrees. All participants were required to live in or near a large Midwestern city and own a phone, which could include a landline, feature, or smart phone.

Participants were diverse in their age, type of vision loss, age of vision loss onset, and job and technology experiences (see Table 1). Of the seven participants, three described themselves as legally blind. The other participants described themselves as having low vision. Only one person (Frank) described losing his vision before the age of 50, although none had congenital vision loss. Some participants explained that their visual ability changed either depending on the day or progressively declined. While participants did not need to own or use a computer to participate in the study, all but one participant owned a computer in their home and all had used the Internet previously. Aside from graphical interfaces, participants were also familiar with voice-based interfaces. All participants listened to audiobooks, podcasts, or YouTube videos. Two participants owned Amazon Echo's and were familiar with Alexa (the voice that powers the Echo), using it for informational and action-based tasks. Four participants used Siri on their iPhone or iPad.

4.2 Procedure

We conducted a 10-week deployment to understand how participants used the system and to understand how they would engage with each other over time. Participants were interviewed prior to using xPress and at the end of the deployment. Interview questions focused on their prior technology experience, current communication practices, and experience blogging. Throughout the deployment, participant's interactions with xPress were logged by the system. These data logs included interactions such as new call, new post recording, and new comment recording. Over the 10-week deployment, participants created 75 recordings (posts = 54, comments = 21, average per person = 13[1]). Also, a researcher called participants every 1-2 weeks to capture intermittent feedback about their use. The post-deployment interviews aimed to understand their overall attitudes and experiences with xPress.

Prior work describes the challenges of starting online communities (e.g. [29]). Therefore, we took several steps to avoid newcomer hesitation. First, we gave participants a tutorial of xPress and allowed them to practice using it and ask questions before the deployment began. Second, we explained this was a new system they would be using with other older adults with vision impairments with no constraints over the type of content that they could share nor the frequency with which they needed to use the system. Third, we added initial prompts to the system that would give users examples of topics (e.g., the most vivid memory of your childhood). The prompts were populated based on prior work of other researchers [19], our formative study with audio recorders, and topics participants discussed in the pre-interviews during the first week of the deployment. Finally, we invited existing older adult bloggers to also contribute content to xPress, which we describe in more detail below.

4.3 Data Analysis

All interviews were audio recorded and transcribed. We used a constructivist grounded theory approach [14] to understand how and why older adults used xPress. Participants' individual responses from the pre-deployment interviews and interim phone interviews informed the questions we asked of them in post-deployment interviews. We analyzed their recording transcripts (posts and comments) alongside the interview data. Our analysis involved iterative open coding and constant comparison between the codes and categories to identify emergent themes, which we highlight in our findings. In addition to interview data, two researchers coded the audio post and comment transcripts for the main topic of each recording. We iteratively refined our coding scheme and discussed disagreements in coding until reaching agreement across the entire dataset of

[1] Because one participant did not record posts or comments due to a phone malfunction (Paul), this is the average of six participants.

posts and comments. We identified and coded six topic categories: disability, independence, politics, sports, technology, and lifestyle.

5 RESULTS

The design and use of xPress enables a case analysis of how older adults with vision impairments connect with peers, seek support, and share resources in a voice-based online community. Also, we analyze what these individuals value in terms of accessibility and participation in xPress.

5.1 Connecting and Sharing in New Ways

Introducing xPress through a long-term field deployment revealed the ways in which these older adults with vision impairments engaged this online social platform. We observed that xPress provided a unique space not bounded by physical place or time and enabled this user group to connect with others and share experiences.

5.1.1 Connecting with New Peers through Shared Experiences

Participants described being part of other communities, mainly offline, that allow them to connect with and share advice with others with vision impairments. For example, Ray is part of several support groups for people with vision impairments. He is "*on a monthly call with the National Federation for the Blind"* and has "*a low vision class here in [city] once a month.*" Jim started his own support group for people with vision impairments and described how "*It's only for the baby boomers – the visually challenged...*" Frank is a member of "*The American Blind Bowlers Association*" and Joyce belongs to "*several guide dog lists so that I can learn and hear and share my experiences with other people as far as guide dogs.*" She describes being part of this community not only to learn new information but also to share advice.

Although participants described the value of sharing their own experiences through these support groups, this form of in-person community support and sharing requires accessible transportation and was often constrained by limited time and scheduling (i.e., support groups are formally structured and limited to a few hours per week). Using xPress, in contrast, fostered opportunities for connecting with new peers in an asynchronous fashion that did not require transportation or coordinating schedules. For example, Jim said when using xPress, "*there's more time to communicate. It's not like you're down there (at a center for people with vision impairments) for an hour, and you take a class, you've got ten minutes to talk to somebody before the bus comes.*" He also said that using xPress "*was a different method of connecting with people with the same challenges*". Similarly, Ray contrasted social interaction through xPress to that of his support groups, saying "*you don't have to leave the house.*"

Because xPress is an asynchronous communication platform, participants were not limited by busy schedules or needing to coordinate a time to interact with each other. Participants like Gary and Joyce took advantage of this opportunity and described how they would blog late at night before bed. Both Gary and Joyce were active computer users but appreciated the ease of using the phone. Lastly, Frank liked "*that you could do it on the phone, you didn't need any equipment or anything*", supporting findings on ease of use and affordability of similar systems [8].

Several participants described xPress as a space for forming new relationships with people with shared experiences. Gary was excited for the potential to "*talk with [someone] and I bet you she'd get off on me and next thing you know, we'd be best of friends and she'd be inviting me over for dinner.*" Jim said xPress was an easier way to "*meet [someone] cold. Maybe this way, they could listen a few times, and say, 'You know what? The voice sounds caring, and maybe I'll answer her or him, and say, "Listen, I've got the same challenges. What would you do to this, how did you accomplish this, or how did you overcome this?'"*

Participants also described that it was difficult for them to develop emotionally fulfilling friendships with others due to issues of stigma related to vision loss and perceptions of sighted people. Interactions would quickly transform into an assistance-based relationship in which a sighted person would ask to help regardless if the person with vision loss needed help, or a learning-based relationship in which a sighted person would want to learn more about what it is like to live with vision loss. For example, Ray said, "*A person that's*

handicapped in any way, [it is] very hard to communicate to other people how you are." Participants described frustration when sighted people focused on their disability. Jim mentioned, "*if I'm walking on the street, you would say, 'Hi, can I help you?' That was all you would do. You wouldn't say, 'Hi, how are you?…*" Similarly, Linda described how stigma associated with aging and disability affects the ways in which she communicates, saying, "*Before, I was writing, writing letters. I like to write letters… I think I grew up, I changed… I think I was more energetic, positive. Right now, I feel nobody care about the handicap. So, I am out of the daily life of the country because I am old. I am what they call super old. [sic]*"

They emphasized how stigma associated with both being older and having a vision impairment decreased the likelihood of potential social relationships with sighted people. In contrast, participants welcomed the opportunity to connect with peers with similar experiences of having a vision impairment or being older. As part of the process of connecting with others, a few participants shared information about themselves, such as their experience learning Braille or being a grandparent. However, outside of these similarities, participants were unsure what else they had in common with their audience. They said that knowing what others in the community wanted to hear would help them to share topics better targeted to their audience. Overall, participants' experiences show how xPress addresses gaps in community needs, providing them with opportunities to meet new people and develop relationships over time without the challenges of in-person communication.

5.1.2 Seeking Support and Sharing Information

Interaction through xPress also provided ways for participants to seek support and share information on their mutual experience of vision loss and becoming older. Participants viewed xPress as a community where they could learn from each other by sharing resources, and all participants shared some type of resource with one another through their blog posts or comments. Participants indicated that the most engaging posts were those that were specific to the visually impaired community and invited conversation. The posts that garnered the most comments from participants, either through xPress itself or in the interviews, were posts on challenges that participants faced or experiences they encountered with a vision impairment. Specifically, 29.3% (22/75) of the recordings were about disability and 28% (21/75) were about lack of independence participants experienced. Participants also shared specific resources in 11 recordings, of which eight recordings were about resources for people with disabilities.

This online community provided a space for reflecting as well as sharing disability experiences with others. Participants noted the importance of sharing their experiences with others in a similar situation. Jim described how society is centered around having vision and that it can be difficult to reflect on the experience of vision loss. Paul described this as one of the benefits of xPress and said, "*just the sharing is so good. It's so healthy. That's just the beauty. I need to connect with that.*" Many of the posts and comments on independence and disability were in response to Ray who recorded a series of posts about driving cessation. Participants commented on Ray's posts offering support and described their own experiences navigating changes due to vision loss. For example, Joyce left this comment for Ray:

> "I was sighted and drove a car and actually chose to stop driving because of safety, my concern that I might not see somebody out of my peripheral that I could have hit even though I could sit in the doctor's chair and had 20/40 or 20/50 vision which is really good. Many people drive with worse vision than that with no correction so anyway it was really tough. I don't live in the city and public transportation is not accessible here. I have a senior transportation service in our community that I have to call and make a reservation for. It's a nuisance. They're not always available or convenient for me. There's no evening hours so ugh. That is the worst part of my vision so that's my thoughts for now. If you have anything to say or want to continue, we can chat back and forth."

Frank also related to Ray's experience and contributed to this discussion through a subsequent post, which focused on sharing resources:

> "…I stopped driving when I was like 19 so I only drove for a few years and it was difficult at first, but you get used to it. And as far as transportation goes, you need to look into where you live. There's all kinds of services. I'm in [city name] and there's uh regular paratransit, the township has a service that'll take you places. Plus, there's a little dollar 75 dial-a-ride thing you can get that anybody can use so you really need to research and see about getting yourself around."

Other participants shared similar transportation resources available where they live, benefits of using learning new ways to communicate (i.e., Braille), and experiences using accessible voting booths in the U.S. presidential election.

Some participants used xPress as a way of sharing how they were misunderstood by sighted people. Joyce did this through the following blog post:

> "…earlier this week, I went to a senior luncheon event that was a costume party. I happened to be the only one that attends that's visually impaired and I work with a guide dog. We decided to dress up for our event. I was the wicked witch and my guide dog was the scarecrow… We ended up winning but people at my table said 'how do I put makeup on my face?' Of course, being the witch I had green makeup and I said 'how do I put it on? With my hands.' And they thought that was kind of funny and I laughed. I wasn't trying to be insulting at all but it's…amazing that sighted people think that when you're visually impaired or blind that there's many things that we can't do. Simple little things like if you're female like putting makeup on your face… Just wondered if any of you ever experienced anything like that that are just common things like putting or makeup or shaving… I mean gosh it's part of everyday living."

In this example, Joyce shares her experience interacting with sighted people as a way of relating to and seeking support from others in this community. Similarly, Ray responded to a post made by Gary and offered support by saying, "This is [Gary]. I completely understand how sighted people don't understand how we get along in life."

Prior work of Pfeil et al. indicates that many older adults, regardless of experience with the Internet, find it difficult to ask for support offline [45]. Other research highlights the importance of trust for connection and relationship development to encourage participation in new online communities [36,49]. People are likely to participate online if they perceive there is someone in the community they can trust, or at least someone with similar interests [1,32]. With xPress, participants related to one another through their shared experience of acquired vision impairment, which they saw as difficult to do on other social networking sites where older people and people with disabilities are not the dominant voice. As such, participants viewed xPress as useful for "*anybody who's had vision loss,*" which they contrasted with congenital vision loss. Jim explained, "*because if they had sight and lost it, whatever reason, it's a challenge no matter what age you are, no matter what it is, no matter how old you are, let's put it that way.*" Joyce said, "*Cause when you're sighted and you lose your vision… you have to learn a new way to do what you did before*." Jim also called this experience the "*most challenging challenge, for people who have had their sight and lost it, because their world is over*". Thus, our analysis provides some of the first evidence that a voice-based social community is both an accessible and appropriate space for connecting with new peers, seeking social support, and sharing information.

5.2 Understanding Values through Design

Beyond demonstrating the accessibility and appeal of xPress as a space for online interaction, our design inquiry also challenges the status quo of using synthetic voices in access technology (e.g., screen readers) and understands the boundaries of participation within this community.

5.2.1 Accessibility and the Importance of Human Voice

Speech-based accessibility tools help people process vast amounts of text-based digital information. The widespread availability of these tools has transformed information access for people with vision impairments. Yet, improving screen readers and other accessibility tools focuses on efficiency and automation of information access through text-to-speech conversion using synthetic voices speaking at rapid rates (e.g., 500 words/minute [3]). Navigating existing online social spaces (e.g., reading blogs, Facebook,) through accessibility tools provides a similar experience – text read aloud rapidly through synthetic, computer-generated speech. The design of xPress purposefully challenges this interaction paradigm by integrating natural human voice.

We found that the availability of actual human voices was important for social aspects of online interaction. Participants contrasted the "human" nature of interacting through this system with "real voices" to synthetic (i.e., text-to-speech) voices common in screen readers. Although two participants described being part of existing e-mail-based groups for people with vision impairments, they appreciated the integration of audio recordings in xPress. Jim said, "*At least you know if they were sincere or not sincere, or if they were terribly mad, and couldn't care less what you told them.*" For him and others, emotion could be interpreted by listening to their voice and "*it's a lot better than reading something off a computer*" because "*you really get a better understanding of what they're trying to say*" (Frank). Joyce, an active computer and smartphone user, compared synthetic voice to human voice saying, "*I know there's all kinds of voices (in screen readers), and it doesn't matter, you don't get the inflection… you can't hear that in a written message, or written blog, or a written Listserv, or email or anything. But, you can hear it in someone's voice. You can hear the laughter, or the joy, or the sadness, or whatever, the frustration.*"

For these participants, the intonation and affect detected in another person's voice provided important social cues but also helped participants give that person an identity. Three participants described using voice to help them "visualize" what people were like. Further, for people with vision impairments, someone's voice is a primary identifier for recognizing that person. Joyce explained, *"When I meet people they'll say, 'oh, you recognize my voice?' Or if I don't, if they don't have a distinguishable voice, then I will tell them, 'well, if you see me or if I see you in town please don't think I'm ignoring you because I don't recognize your voice.'"*

Voice interaction conveyed rich emotional information while also providing cues about other people's identities, which are not available in accessibility tools that use synthetic voices. This finding also echoes prior work that suggests some older adults view phone communication as meaningful because it facilitates "real" conversation and is more intimate and personal than text-based interactions online [8,22,28,35].

5.2.2 Understanding Boundaries of Community Participation

Another function of studying xPress was to understand expectations around community participation. Many technologies designed for older people focus on helping users connect with existing social ties, such as family members and friends [6,18,37,51,61]. In the case of xPress, participants could share the URL of their voice-based blog with their family members and friends through a graphical interface connected with the Tumblr platform. Additionally, we invited sighted older adult bloggers to contribute content to this community. These design and methodological decisions help us understand participants' expectations and values around interaction in this particular community.

First, we designed the xPress system to be intentionally open and available to other individuals outside older adults with vision impairments. Specifically, integration with the popular Tumblr platform made it possible for participants' (sighted or visually impaired) family members and friends to listen to and comment on participants' posts through their regular computer. That is, a participant's audio recordings were automatically uploaded to Tumblr as audio posts for others to hear and leave comments. Despite introducing this feature to participants on multiple occasions, they rejected this aspect of the system: all participants said they did not want to share their Tumblr page with existing contacts nor have researchers share the link with their contacts. This interesting case of technology non-use [5] reveals expectations and values within this particular community. Most participants explicitly described not sharing with existing contacts because they already share and communicate with them in other ways. For example, Frank said "*I don't think any of my kids would*

be interested… I communicate with them and tell them things anyway." He described how he perceived his family would not benefit from participating in the xPress community because he communicates frequently with them offline. Intentional non-use of this aspect of xPress aligns with prior work that documents older adults' desires to maintain a separation of audience in online communities [10,57], but also suggests that there may be aspects of the content on xPress that participants do not want to share with other social contacts.

To further understand expectations around community participation and diversify the content available to users, at week six we invited two existing bloggers to participate and contribute content through xPress. They were asked to read posts from their computer-based blogs by phone for participants to listen to and comment on. These bloggers were over the age of 65 but were sighted and told that the other participants in the study were visually impaired older adults. These sighted bloggers first listened to posts within the community and then recorded a total of nine posts, many of which were about their day-to-day encounters such as experiences hiking, going on road trips, and movies they watched. Initially, participants expressed interest in hearing the blog posts of the existing, sighted bloggers. However, after listening to their posts, their expectations for community participation became apparent. Jim explained:

> "*I can get that anywhere. I don't need to have a certain site that's just for the visually challenged to have everybody else in there… I don't have to listen to somebody who's still out there, has their sight, and doing everything… I don't think normal people who have sight would understand what we're going through. To spin your wheels on talking to somebody what they don't understand…is an effort in futility.*"

This participant explained that it would be acceptable for sighted people to use xPress if "*they have a relative or somebody that they were looking for some help with that…"* Other participants described how their blogs could educate people outside of the visually impaired community. In addition to Jim, three other participants said they could see the benefit if sighted people could listen rather than create posts. Joyce described how sighted people "*want to learn what it's like for us.*" Similarly, Frank said, "*…this would be a good way for them to maybe learn about blindness, or blind people. 'Cause we are just regular people…*" In a sense, the posts of people with vision impairments could serve as advocacy messages, calling attention to the needs of people with vision loss. This is similar to how other groups of older adults use their blogs to advocate for the views of older people more generally (i.e., around ageism) [31]. Frank and Joyce also described how they spend much of their lives educating sighted people on the abilities of people with vision impairments. In one of his posts, Frank describes the work of constantly educating sighted people:

> "…I [volunteered] for five years and I think maybe once or twice there were people who had experience with blind people, who knew anything about blindness… that's what you're doing all the time in life is you're educating people around you…"

These findings suggest a strong desire by participants to have a closed and protected space of their own for sharing their experiences. Further, our analysis suggests that perhaps the best role for sighted people – both for existing and new social contacts – is of information consumer, providing them with the opportunity to learn about the unique experiences and challenges of late-life vision loss through peripheral participation in this type of online community.

6 DISCUSSION

We have demonstrated that a voice-based online social community provides an accessible and meaningful space for older adults with vision impairments to connect with peers, seek support, and share information. Further, our design inquiry highlights the importance of human voice and maintaining participatory boundaries in fostering an online community for this user group. We now provide critical reflection on designing similar voice-based communities.

6.1 Rethinking Design through the Lens of Intersectionality

Designing new technologies to foster online participation among older adults with disabilities is a complex challenge. To help understand this, we use the theory of intersectionality to reflect on the use of xPress. The concept of intersectionality, a product of critical feminist theory, emphasizes how the experiences of people who belong to two separate marginalized or stigmatized groups may not be the same experiences as people whose identity lies at the intersection of these two groups [20]. That is, the notion of intersectionality attends to the holistic experience of being an older individual with a vision impairment rather than treating older age and disability as distinct and separate experiences. Thus, intersectionality provides an instructive lens for reflecting on the design and use of xPress in two key ways.

First, intersectionality calls attention to assumptions in how systems are designed to support the goals of older adults with age as the primary aspect of an individual's identity. As part of this, certain relational goals have been the emphasis of prior work, which focuses on supporting connections with family and close social ties (e.g., [17,35,61]). This work frequently draws on lifespan theories of development, such as Carstensen's socio-emotional selectivity theory (SST) [13], to frame research questions and design. SST asserts that people who perceive themselves to be closer to the end of life tend to shift their relationship goals from knowledge-based (i.e., information seeking, learning, obtaining new social contacts) to emotion-based (i.e., strengthening existing emotionally fulfilling relationships) [12]. System design may conflate the idea of 'perceiving the end of life to be near' and the experience of being an older adult, leading designers to overly focus on supporting intergenerational familial interaction and maintaining existing strong ties [6,18,37,51,61]. Even in our own work, we intentionally created xPress to be an open community that participants' family members and existing social contacts could access. We encouraged use of this part of the system on multiple occasions and were met with disinterest. Instead, participants reported satisfaction with their ability to connect with close social ties and stated a desire for connections with new social contacts with similar experiences. They also sought and shared information while attempting to develop meaningful relationships. Thus, designing to support life-long online engagement among older adults with disabilities is about far more than connecting with existing ties (e.g., [17,33,48,61]). Without careful reflection, system design may inadvertently view age and familial ties as the most salient aspects of an individual's experience and neglect fostering connections with new peers during the experience of late-life disability.

A second way in which the lens of intersectionality is instructive for design is through challenging the notion of accessibility, which tends to highlight designing for disability over other aspects of an individual's identity. Existing accessibility tools for people who are blind or low vision largely focus on bridging functional gaps from an impairment, although issues of stigma [53], learnability [47], and access [23] are relevant to understanding the adoption of access technology. Yet, access technologies (i.e., screen readers) prize efficiency and automation of text-based content rather than socially important cues, such as affect and identity, that are conveyed in actual human voice. While prior work examines voice personalization for people with speech-language impairments [58], limited work understands how integrating actual human voice in accessibility tools impacts the social and emotional goals of people with vision impairments. In our study, participants recognized that both existing accessibility tools and xPress provide access to information and support online communication, but they noted that preserving an individual's voice provides a more human and emotionally rich experience for connecting with other people. Indeed, the perception of natural voice interaction via phone as a "real" conversation that is more intimate and personal than text-based interactions is a well-known finding in studies of older populations [8,22,28,35]; however, integration of natural voice is not often a key element of technology design for people with vision impairments. The theoretical perspective of intersectionality emphasizes the importance of attending to how multiple facets of an individual's identity interact and can be supported holistically through design.

6.2 Designing Future Voice-Based Communities

Our exploration of xPress along with research on other voice-based online communities [43,59,60] calls attention to the underexplored nature of human voice – compared to text, photos, or videos – as the central media in an online social platform. Voice-based communities present both challenges and new possibilities for design, which we describe below.

6.2.1 Voice as a Personal Identifier

Human voice is a personal, intimate, and distinguishable form of communication. Like penmanship, voice can serve as a unique identifier for its owner. In our analysis, participants used the natural affordances of voice to identify others within the community. Research on the imagined audience emphasizes that people are more comfortable talking about in-depth, personal topics if they know and trust the audience [46]. Voice provided one cue about audience, and participants even used the qualities of an individual's voice to visualize what they were like. Prior work establishes that human voice can help foster increased and richer communication for older adults [8,22,28,35]. Further, related work indicates that relationship development through text-based online communication takes more time than face-to-face communication because of reduced cues [21,54,64]. An empirical question for future work is whether natural human voice in an online community helps facilitate relationships and trust more quickly than text-based interaction alone.

In terms of future design, voice-based online communities could leverage the richness and identification of human voice by prompting users to create audio profiles. Others could listen to the audio profiles as a way of learning more about people in the community. Yet, voice-based profiles should be dynamic and easy to edit so that people can share details about themselves as trust develops, and users can learn more about others in the community over time. Voice profiles also open up new and interesting questions around online self-presentation [26]. The way an individual speaks or sounds may have unforeseen effects on how their audience perceives them (e.g., perceiving one voice to be "older" than another). Additionally, it is worth considering that some users may desire the anonymity of synthetic speech for asking highly personal questions or to avoid being identified by others.

6.2.2 Emotion Rather than Efficiency

The design of xPress stands in contrast to the widespread use of synthetic voices in mainstream voice-based agents (e.g., Siri, Cortana, Echo) and accessibility tools people use to read online communities like Facebook. Indeed, text-to-speech access technology has revolutionized accessibility for people with vision impairments. Prior work on voice interfaces for people with vision impairments focuses on increasing reading speed [3,7,27,55] to make tasks like scanning large quantities of text more efficient and understanding differences in synthetic speech speed preferences by age and vision loss experience [7,55]. Despite these advances, natural human voice may be more appropriate for certain forms of online interaction, such as cases where the goal is to connect with others and form relationships. Specifically, participants valued the emotion they could detect in the recorded content, and none mentioned the time it took to listen to recordings as a negative aspect of interaction. While it may not be scalable or practical for all voice-based communities to incorporate human speech, future systems could integrate human voice in places where conveying emotion is important.

6.2.3 Interaction as Conversation

Using human voice as a mode of interaction has an inherent conversational quality, and xPress's posting and commenting features helped enable back-and-forth dialog among community members. Participants noted that they enjoyed responding to other people's blog posts as part of a back-and-forth conversation, but they also wanted the system to scaffold more engaging opportunities for feedback, expression, and communication. They emphasized that the most unengaging posts were short and about the author's day-to-day activities, whereas posts that had broad appeal and fostered dialog often concerned disability, sports, and politics. Participants did not want to engage in passive, lightweight interactions; rather, they preferred a depth of conversation and reciprocal dialog that would evolve over time [28,34]. While each participant's content was organized on their own blog, interaction seemed to bleed across multiple blogs and at times blur what was a post versus a comment. Future systems should consider new ways of organizing and curating audio content so that others can follow and participate in an ongoing conversation. Allowing users to submit questions or topics as prompts to facilitate engaging conversation is another promising possibility for promoting the in-depth conversation that participants desire.

6.2.4 Audio Audience Listenership Cues

Participants emphasized wanting a better sense of what their audience liked and disliked gauging whether their posts would be of interest to the community. Aside from wanting to know the interests of others to target posts to those topics, they also wanted indicators of who listened to their posts and how frequently, similar to the design features in [60]. Just as some sighted older adult bloggers use tools like Google Analytics to understand trends in readership [10], voice-based communities could provide information about listenership. Comments provide one source of feedback, but lack of comments can be a signal that no one listened to a post and therefore did not find it meaningful. In our study, several participants noted that they enjoyed listening to many posts but chose not to add comments. Simple measures of listenership (number of partial or full listens) could provide feedback that someone's contributions are valued by the community. Further, participants wanted more details about who was listening to their posts. Along with voice profiles, information such as what other posts listeners find interesting could provide a more holistic picture of one's audience. However, revealing activity patterns of particular users to others in the community may violate expectations of privacy.

7 CONCLUSION

Older adults with late-life vision loss face many barriers to connecting with peers online and sustaining an active online social life as vision loss progresses. The present case study contributes new understandings of how a voice-based community can effectively support online engagement among this population. While study participants described challenges with developing relationships offline, they used xPress to connect with others, seek support, and share resources pertaining to the experience of acquired, late-life vision loss. The design of xPress challenged accepted conventions in accessibility (i.e., synthetic speech) and the boundaries of participation by sighted others. Our case analysis of this online community helps reveal the complexities of designing for aging and accessibility in a holistic way. Further, our inquiry raises new challenges and opportunities for the design of online communities that leverage human voice as a medium for social sharing, thereby supporting specific relational goals, needs for social support, and values around accessible interaction.

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