Understanding the Needs and Challenges of Using Conversational Agents for Deaf Older Adults

Johnna Blair
jlb883@psu.edu
Pennsylvania State University
University Park, Pennsylvania

Saeed Abdullah
saeed@psu.edu
Pennsylvania State University
University Park, Pennsylvania

ABSTRACT

Conversational agents (CAs) with voice interfaces are becoming ubiquitous and are routinely used by a wide range of individuals. Users with vision and mobility issues can leverage the voice interfaces of CAs to complete tasks with increasing complexity. However, CAs with voice interfaces pose unique challenges for those with different accessibility needs – specifically, older adults with hearing loss. There has been little work to understand how deaf older adults leverage CAs and the challenges they face while using voice interfaces. To address this gap, we conduct in-depth qualitative interviews with 4 deaf older adults to understand how and why they use CAs. We explore their expectations for their devices and identify common challenges (e.g., default voices used by commercial CAs). We provide suggestions for designing CAs that can better accommodate a range of hearing abilities and provide the first step forward toward a more inclusive CA.

INTRODUCTION

Conversational agents (CAs) with voice interfaces are becoming increasingly ubiquitous in our daily activities, allowing users to interact through speech commands. Most mobile devices now contain

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embedded CAs with voice interfaces (e.g., Siri, Google Assistant). Furthermore, recent standalone devices (e.g., smart-speakers including Amazon Echo and Google Home) also include similar CAs. Smart-speakers, in particular, have seen significant growth in user adoption. By 2020, an anticipated 75% of households in the United States will have at least one smart assistant device playing a role in their daily routines [15]. Specifically, older adults (age > 55) are the largest group of "first adopters"– accounting for 33% of all smart-speaker users owning a device for a year or more [15], despite the notion that older adults can often be reluctant to adopt other new technologies [7].

Voice as an interaction modality has the potential to improve accessibility for a range of users. Those with visual impairments or mobility issues can use voice interfaces in CAs to perform complex tasks[14]. Using natural speech to interact with devices can also lower the barriers of technology use for those who are less familiar or have manual dexterity and vision-related issues with current interfaces and thus, can be particularly useful for older adults. However, CAs may pose challenges for the deaf and hard of hearing (DHH) community. Around 466 million people worldwide have significant hearing loss [12]. Some degree of hearing loss has been reported by 20% of US individuals (or 48 million) [11]. This disproportionately affects older adults. One in three individuals between ages 65 and 74 and 50% of those age 75 and older have difficulty hearing [10].

Previous CA studies have focused on the daily use [1, 3, 16] and challenges of voice interfaces across general audiences [8, 9, 13], as well as the barriers associated with other voice technologies for DHH users [2, 5, 6]. However, little work has focused on how older adults with hearing loss currently use voice interface CAs. We consider this to be an important knowledge gap, as older adults make up a significant fraction of CA users. Therefore, uncovering accessibility concerns that uniquely impact this large user group is essential for better technology development.

METHODS

We conducted qualitative interview sessions with four individuals who were deaf or significantly hard of hearing to gather a first-hand account of their CA use. Our inclusion criteria included deaf individuals who were currently using either a cochlear implant or hearing aids. All participants had used CAs in the past and were familiar with different features. The specific characteristics of each participant can be found in *Table 1*. Participants completed interviews using their preferred means of communication (i.e., most compatible with their hearing needs and devices used). One participant completed a phone interview with Bluetooth-enabled hearing aids. Two participants chose to use a text-based chat application and one completed the interview in-person.

A bottom-up thematic analysis was performed on interview transcripts by both researchers, using a Grounded Theory approach [4]. Each researcher reviewed transcripts separately and identified themes within participant responses. Then, researchers iterated on this process together – merging common themes and identifying consistent sub-themes across categories, until a consensus was reached.

Table 1: Participant Characteristics and CA Use

Participant	Age	Gender	Hearing Device	Hearing Status	CA Use
1	53	Female	Cochlear implants	Profoundly Deaf, Childhood hearing loss	Mobile CAs, Daily use
2	56	Female	Hearing aids	Recently Deaf, No prior hearing loss	Mobile CAs, Daily use
3	59	Male	Hearing aids	Profoundly Deaf, Adulthood hearing loss	Mobile and Smart Speaker Frequent use
4	63	Female	Cochlear implants	Profoundly Deaf, Childhood hearing loss	Mobile and Smart Speaker Discontinued

RESULTS AND DISCUSSION

CA Expectations and Challenges

Participants primarily used phone-based CAs for tasks shown in prior work to be common across general users [3, 16], such as web searches, GPS, weather, reminders, games, and calendar events. Participants strongly associated home-based smart speakers (e.g. Amazon Echo, Google Home) with mainly music-related tasks, and therefore these standalone devices were perceived as less useful. As stated by P2, *"music sounds very different through aids, so it's not something we'd be seeking."*

The most commonly reported challenges were related to the characteristics of the voice used in each device. A female persona is the default for most devices, like Alexa and Siri, but these higher-pitched voices were often difficult to hear with hearing aids or cochlear implants. *"Depending on a male or female voice and their pitch determines how much I hear,"* noted P4. Participants preferred lower tones as they were more compatible with the comfortable frequency range of their hearing devices. However, their hearing aids were often readjusted, which altered their audible frequency ranges, and therefore changed their ability to use their CAs over time.

Participants also found the speed at which their CA responded to be challenging, depending on the length of the device's answer. CAs were most useful when they provided concise responses. Lengthy responses provided more opportunities to miss words. Because of this, participants reported often having to ask CAs to repeat their responses. This was less of a concern when using phone CAs, as the screen feedback helped fill in any gaps. Others developed their own strategies or shortcuts to avoid potential errors. For example, one participant completed simple tasks with his Amazon Echo, but *"the screen on the [Amazon Echo] Show let [him] do more"* complex actions easily (P3).

Lastly, participants expressed a desire to use CAs for certain tasks when not using their hearing aids. They wished to relay commands using voice and receive visual, screen-based feedback, but devices did not respond as well to commands or reliably provide as much visual information as expected.

Flexible Accessibility Features

There is a wide range of hearing needs across the DHH community, as well as within individuals over time, as hearing devices change. Participants voiced their concerns for CA use that went beyond their own experiences, but about others within the DHH community, such as those who primarily use signing languages. In this case, voice inflections and speech patterns of some DHH users may not match what CAs are trained to anticipate. Additionally, grammar and sentence structure can differ between those who use American Sign Language and Sign-Exact English. These factors may affect how devices respond to commands if not properly included in voice recognition models [2].

Based on these experiences, there is no singular path to increased CA accessibility. Instead, new features should be considered to increase the level of flexibility and customization given to CA users. We suggest providing users with options to create a custom device voice across multiple factors: *pitch, volume, and speed*, during device set up. Users should also be afforded easy ways to recalibrate their device voice over time to adapt to changes in hearing frequencies, in a similar manner to audiograms – responding to words and pitches heard, to determine an optimal voice.

We also suggest incorporating new modalities to improve overall usability for DHH users. For instance, connectivity options for Bluetooth-enabled hearing aids would allow users to have more direct connection to their CA device and eliminate potentially distracting background noise. Additionally, all participants stressed the need for dual feedback, rather than relying on verbal responses alone. Providing more clear and intuitive expressive light communications and screen-based feedback in standalone smart-speakers would not only allow those with hearing devices to more easily fill in any auditory gaps, but increase accessibility for DHH individuals who do not use hearing devices.

FUTURE WORK

In summary, we have gathered an initial understanding of the challenges and expectations of CA use by DHH individuals. To better inform the design of a more DHH inclusive CA, we propose the following steps: a longitudinal look at real-time CA usage data to uncover additional usability challenges, a survey to address concerns for DHH users on a wider scale – including younger users, and leverage first-hand knowledge of DHH users to iterate on new features through participatory design.

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