

Teleconference Accessibility and Guidelines for Deaf and Hard of Hearing Users

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ABSTRACT

In this experience report, we describe the accessibility challenges that deaf and hard of hearing users face in teleconferences, based on both our first-hand participation in meetings, and as User Interface and Experience experts. Teleconferencing poses new accessibility challenges compared to face-to-face communication because of limited social, emotional, and haptic feedback. Above all, teleconferencing participants and organizers need to be flexible, because deaf or hard of hearing people have diverse communication preferences. We explain what recurring problems users experience, where current teleconferencing software falls short, and how to address these shortcomings. We offer specific recommendations for best practices and the experiential reasons behind them.

CCS CONCEPTS

• **Human-centered computing – Accessibility – Accessibility systems and tools;** • **Human-centered computing – Accessibility – Accessibility design and evaluation methods;**

KEYWORDS

Deaf, Hard of Hearing, Teleconferencing, Remote Participation, Sign Language

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1 TELECONFERENCE CALL ACCESSIBILITY

Teleconferencing relies on information and communication technologies to interact in real-time with others who are not in the same physical location. For instance, Zoom grew by over 500% in two months after national government lockdowns due to Covid-19 pandemic [3.], in part due to its user-friendliness for all people, including Deaf or Hard of Hearing (DHH) users. However, the public has come to realize that teleconferencing is more cognitively demanding than face-to-face work, as evidenced by the news and articles on teleconference fatigue [12.].

Under the Americans with Disabilities Act (ADA), hosts and employers must provide communication accessibility services for in-person meetings, such as on-site sign language interpreters or Computer Assisted Realtime Translation (CART). The form of communication must comport with the specific needs of each deaf or hard of hearing user. To meet their obligations under accessibility laws, public hosts should ensure that their services are fully accessible.

The situation is less clear for teleconferences – the ADA has not yet been tested for this scenario. The Twenty-First Century Communications and Video Accessibility Act of 2010 (CVAA) [1.] requires that interoperable video conferencing services must be accessible to users with disabilities, but both the definition of “interoperable” and what it means to be “accessible” are contested [7.]. An additional concern for teleconferences is that for DHH users, full access includes more than just providing visual access via interpreters or captions; it must also provide functional equivalency in terms of cognitive demands and participation. As such, DHH users benefit from picking from a range of communication preferences drawn on their previous teleconference experiences. They learn how to manage different aspects of the technology they use; for instance, they learn how to engage in certain conversational behaviors, or they learn how to interact in certain ways that highlight the abilities of that technology and downplay its limitations. Their focus is on maintaining the conversational and information flow.

Teleconferencing access has broad implications for the mainstream. Many non-disabled users benefit from teleconference accessibility; for example, many hearing users report that they prefer to read along as they listen, and they can fill in missing information, especially when the speaker is not clear to them.

The goal of this experience report is to share appropriate recommendations and guidelines for accessible teleconferencing, developed through hard-won experience. Most important, we also explain why each of our recommendations are the way they are. These guidelines do not only address concrete accessibility issues, but also help with reducing disparities in cognitive demand between DHH and hearing participants.

2 TYPES OF ACCOMMODATION FOR DEAF AND HARD OF HEARING USERS

Teleconference accommodations for deaf or hard of hearing users consist of services that provide visual access to aural information or communication. The simplest, but not necessarily functionally equivalent approach, for using these accommodations in teleconference meetings is to provide an audio bridge where DHH participants use video relay services (VRS) or captioned telephone services by calling in their telephone number. In practice, however, there are



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functional and procedural barriers that can arise when using relay services in conference calls.

Deaf or hard of hearing people (DHH) have diverse communication preferences but are united by the need to rely on visual information in part or whole. Even with visual accommodations, teleconferencing is less accessible than face-to-face communication because of limited social, emotional, and haptic feedback.

Recommendation: The provider should not make assumptions about providing accommodations and ask the deaf users about which accommodation they prefer. A Deaf employee may require an American Sign Language (ASL) interpreter with specialized knowledge of the subject matter being discussed while a hard of hearing employee may require captioning services. Providers should also incorporate procedural changes to reduce cognitive demands of using teleconference services for deaf, hard of hearing or hearing users.

2.1 Captions

Captions are a text representation of speech and provide visual access when the speech is unavailable to the user. As a visual accommodation, captions convey information at the speaker's pace, unlike note taking. Captioning can either be generated live by specially trained short-hand typists, called stenographers, or by automatic speech recognition. They may not provide functional equivalency in many circumstances, as the nature of text makes it hard to provide critical meta-speech information such as speaker identification punctuation, sentiment, tone, and ability to handle multiple speakers overlapping in a discussion.

Captioning accuracy declines with background noise or complex terminology or bad internet connections. Key words are rare in conversation, but they are the most important ones, such as nouns or identifiers. If key words are missed or not accurately transcribed, then users will not be satisfied even with high accuracy in other words.

Recommendation: Teleconference organizers should ask DHH users about their captioning preferences, or to provide online booking services that let them specify the captioning services they want, such as local captioners or captioners familiar with the meeting context. This would provide consistency in use of local vocabulary and better identification of speakers or their intent in teleconference software.

2.2 Sign Language Interpreters

Sign languages are visual languages, and therefore accessible to DHH users who rely on visual communication and are fluent in that sign language, e.g., American Sign Language. If the user prefers to participate via ASL, the option to use Video Remote Interpreting (VRI) is preferable as the interpreter will be visible to all other teleconference participants, not just the DHH user. Furthermore, VRS call assignments draw from a random pool of interpreters whereas the employer can request a specialized interpreter well versed in the subject matter from the VRI provider. If the meeting is all audio, then VRS can be appropriate.

There can be functional equivalency issues in using interpreters in teleconferences. For instance, using an interpreter from another region may lead to misunderstandings, as ASL has regional dialects

and inconsistent specialized vocabulary. Many interpreters may not have prior knowledge or advance preparation and be unaware of speaker names or locations on the teleconference screen.

Recommendations: Teleconference organizers should ask DHH users about their interpreter preferences, or to provide online booking services that let users specify interpreters they want, such as local interpreters or interpreters familiar with the meeting context. This would provide consistency in use of local vocabulary and better identification of speakers or their intent in teleconference software.

3 MAKING TELECONFERENCES ACCESSIBLE

We go beyond interpreter and captioning accommodations, and cover other accessibility challenges that DHH users experience, along with recommendations for how to resolve or minimize them (cf. §3.1). These experiences have been collected through a large variety of meetings over close to a decade, with a strong emphasis on the Covid-19 pandemic. They include small team gatherings, committee meetings, online classes, large teleconferences, international working meetings, webinars geared toward deaf and hard of hearing consumers. The systems and services used to inform this experience report include simple audio teleconference bridges, Zoom, GotoMeeting, Google Meet, Microsoft Teams, Cisco WebEx and Adobe Connect. We occasionally name specific services to highlight areas of concern, but none of these mentions should be construed as an endorsement of any particular platform. Meeting procedures are a key part of making teleconferences accessible and inclusive of people with disabilities. They can also compensate for sub-optimally implemented accessibility features in meeting platforms. Their importance is such that we cover them in a section of their own (cf. §3.2).

3.1 Deaf/Hard of Hearing User Experience

In this subsection we describe a number of teleconferencing experiences through a DHH lens, along with recommendations for how to accommodate them. These recommendations are complementary to the meeting procedures, which we describe in greater detail in the next subsection.

3.1.1 Teleconferences are Complex for Users. DHH users have to juggle many visual elements during a teleconference session. These can include speaker video for users who rely on lip-reading for access, interpreter video for users who rely on sign language for access, captions, presentation materials such as slides, videos or other types of screen shares, chat boxes for text communication, hand raising tools for turn taking, and more [4., 14.]. While many teleconferencing services offer support for all these elements, each user's communication needs are unique. As a result, users' needs for arranging the elements on their screen(s) and resizing them to maximize access also are unique and differ from person to person. For example, one user may prefer to keep all video of sign language participants open at the same time along with the speaker, while another person may prefer to enlarge the currently active sign language interpreter to the exclusion of everything else. To make matters worse, every type of teleconferencing service has its own way of supporting the elements mentioned above.

All this results in a steep learning curve for DHH users, and they may struggle to optimize their viewing experience. Even experienced users can get tripped up; for example, in a recent online four-day class taught via Zoom, some participants did not know that they could hide non-video participants on their screens in order to give more space to active signers on video. In another instance during a multi-day international meeting, an older deaf adult struggled with keeping videos of the sign language interpreters enlarged on the screen while the conference host dropped in and out of screen shares in Zoom, and it took them a full day to become sufficiently comfortable with the mechanism to follow the meeting. In yet other cases, some meeting platforms (e.g. Zoom, GotoMeeting) offer a side-by-side view of screen shares and video, but participants frequently have to be educated on their availability.

Recommendation: Keep meetings as simple as possible and consider whether advanced features of the meeting service are needed altogether. Have fallback mechanisms for participants who may be struggling with advanced features. For example, provide slides and other documents in advance for offline viewing, and provide alternate means to support turn-taking if a participant cannot figure out how to use the built-in hand raising tool. Be prepared to invest significant time for participants to learn the ropes.

3.1.2 Troubleshooting Technology Remotely is Hard. Murphy's Law apocryphally states that things that can go wrong will go wrong, and teleconferencing is no exception, especially in light of the technical complexity of teleconferencing services. For example, in a presentation held via Microsoft Teams, the button to provide ASR-based captions showed up only for some participants, but not others. In a class taught online via Zoom meetings, one student was able to view only the instructor, and unable to view the gallery of all participants. As a result, they missed out on much what the other students signed during the meeting. In yet other cases, providing a link to the meeting failed to launch the meeting application from the web browser, and participants had to launch the application manually and enter the meeting number manually – not doing so would relegate them to a much more limited experience in the web browser; among them an inability to resize videos.

In none of these cases, it was obvious to the meeting organizers as to why some of the participants were struggling. This became clear only after an extended troubleshooting session, with many questions asked; and in some cases, participants needed to share screenshots before the source of the problem became clear. Although interactive step-by-step guidance ultimately resolved most of the problems, they were time-consuming and distracted from the meetings.

Recommendation: Meeting organizers should prepare simple step-by-step instructions (with pictures or videos) of the meeting features that participants will need for accessibility and share them ahead of the meeting. Be aware of the most common problems that participants experience with the chosen meeting software and be prepared to review them at the beginning of the meeting.

Recommendation: Meeting organizers should consider running a second instance of the meeting software as a regular participant through a DHH lens. Doing so lets the organizer/moderator follow closely what participants actually can see and hear, which

can be very different from the meeting view that a person with a host or moderator role sees. Frequently, this trick makes the problems that participants experience immediately clear, and the organizers can take appropriate action.

3.1.3 Hardware Capabilities of Participants are Diverse. Video conferencing requires significant hardware capabilities, and low-end computers – especially some types of Chromebooks and other entry-level laptops – may struggle to display video at the frame rates required for sign language [5.]. Participants also have varying screen sizes, with some screens too small to accommodate videos, screen shares, and captioning transcripts. Some participants may have a dual monitor setup that alleviates problems with small screen real estate. Other participants may opt to use a tablet as a second screen, logged into the teleconference twice, in order to view the sign language interpreter on video, or in order to view captions on an external web site, such as StreamText.

However, meeting organizers cannot rely on participants to have these capabilities, and even if they do, the setup may be too complex for some. For instance, the older adult mentioned in §3.1.1 ended up viewing the active sign language interpreter on a second screen on their iPad while keeping screen shares and the chat box on their main laptop, but it took a full day to figure out this setup.

Recommendation: Meeting organizers should prioritize what participants need to see. For instance, often the view of the speakers and the sign language interpreter (if used) are the most critical for access, while the other videos can be turned off. Reducing the number of active videos allows participants with low-end hardware to obtain better frame rates; and, participants with small screens can see videos at a size that works for them. Similarly, screen sharing and other activities that take up screen real estate should be considered carefully, and alternatives that do not require them should be prepared as a fallback option.

3.1.4 Background and Lighting. Busy backgrounds are distracting to DHH users who rely on visual information – they make it harder to follow both signing and lip movements. Cluttered backgrounds also result in poor contrast for the participants body movements. These problems are compounded when there is motion in the background, such as a TV running, children at play, or pet activities. Among DHH signers, it is common to use a backdrop specifically designed for the purpose of minimizing clutter and maximizing contrast; popular choices include black, chroma key blue, and neutral grays.

While some meeting services offer the popular option of virtual backgrounds to enhance privacy, they can result in ghosting and other artifacts that are distracting for DHH participants in the same way that cluttered backgrounds are. These problems are especially acute for sign language where the arms, face and hand all move rapidly and frequently. Animated virtual backgrounds present the worst of both worlds, with both ghosting and constant visual distractions. In one instance, a DHH user had to ask a hearing participant to turn off the moving background, as it was directing visual attention away from the sign language interpreter.

Lighting is important for both sign language and lip-reading. Poorly placed lights (or having a bright window in the background) darken the meeting participants' faces such that lip-reading becomes impossible.

Recommendation: Meeting organizers should ask everyone to minimize use of cluttered and virtual backgrounds ahead of the teleconference and remind participants to sit in well-lit areas if they are on video.

3.1.5 Audio Quality: Microphones and Wideband Audio. DHH users who listen while attending teleconferences are more susceptible to poor speech recognition under suboptimal audio conditions compared to their hearing peers [6.]. In addition, both ASR and human captioners struggle if audio quality is poor, with frequent missed words or even entire missed sentences [9.]. For instance, a user who uses hearing aids in an office setting has seen significant improvements in their ability to understand speech during teleconferences when every participant talks into microphones that are placed right next to their mouth, as opposed to using built-in laptop microphones that are set a foot and a half away on a desk. In another instance in mixed deaf, hard of hearing and hearing work meetings, the deaf person spoke for themselves with a “deaf accent” that made it challenging for the hard of hearing participant, as well as ASR captions, to follow. Using a headset with a microphone significantly improved matters, due to the better audio quality compensating for the accent.

A related topic is the use of phone audio versus computer audio in many teleconferences. Phone audio is limited to narrowband speech, while computer audio supports wideband speech. The added access to the wideband audio frequencies between 3300 and 8000 Hz has been shown to significantly increase speech recognition and decrease mental effort among both hearing aid and cochlear implant users [13.]. While ASR has not seen a similar performance improvement with wideband audio, the decrease in listening effort is still important, especially given that fatigue is a major concern (cf. §3.1.9).

Recommendation: Meeting organizers should encourage participants to wear headsets with a microphone, and state that dial-in numbers are used to be only as a method of last resort when computer audio options are not practical (such as taking a teleconference call in an area with poor internet connectivity).

3.1.6 Transcripts vs Captions. Some teleconferencing platforms offer built-in support for captioning and live transcripts. This means that captions can either be shown within the software application in a dedicated area (e.g., Adobe Connect, Cisco WebEx and Google Meet at the time of writing this paper) or overlaid on the speaker video in a manner similar to the way TV and internet video captions are shown (e.g., Microsoft Teams and Zoom). Although captions overlaid on video require less eye movement and less visual split attention for DHH users, they also cause problems with pacing and reading for some users. If a participant speaks quickly, the caption may pop on and disappear from the screen too quickly to be read, especially so if the captions are in a second language for the DHH user [11.]. Additionally, many DHH users have reported problems with not being able to look away for a moment to focus their attention on other matters (such as reading a message, looking at a screen share, or getting distracted by a child or pet), because doing so would cause them to miss content.

In contrast, live text transcripts (e.g. CART) allow looking away and catching up via reading back once attention has been focused

back on the speaker. This approach allows better functional equivalence with hearing participants who can look away, but still listen to the audio, and avoid missing important parts of the teleconference. These considerations also apply when a participant is watching a sign language interpreter – providing a live captioning transcript in addition to the interpreter allows them to look away and catch up via reading back. Note that live text transcripts can also be offered on separate web pages.

Recommendation: Meeting organizers should consider offering an option for a live text transcript irrespective of whether the chosen platform supports built-in captions on the speaker video.

3.1.7 Eye Contact. Users sometimes set up the camera far apart from their display, and viewers find it difficult to maintain eye contact and the other person may perceive it as lack of attention. This occurs due to the distance between the camera and screen. For example, when using a mobile phone where the camera is above the screen to chat with a remote user, looking at the user’s eyes is perceived as looking downward.

Recommendation: Cameras should be placed as close as possible to the teleconference visual display.

3.1.8 Two-Dimensional v. Three-Dimensional Space. Teleconference software is typically shown on two dimensional screens and does not convey the feeling of space. In face-to-face meetings, users have a sense of where others are standing, and in orienting and following audiovisual information and cues. Gestures including facial expressions (eye gaze, eyebrows, nose, cheek & mouth), movements (head, body & hands/arms), space & prosody are crucial for human communication. This have not been replicated in current teleconference software, for example, to ensure that viewing order remains the same for all participants. Currently, most teleconference services follow a first-come, first-served order. Furthermore, if the video is muted, the person is moved to the end of the list, and this shuffling can make it hard to find people among a long list of participants.

Recommendation: Minimize the number of people shown on screen, by asking hearing participants to hide their video, so that only the deaf participants’ video is displayed.

3.1.9 Fatigue. The mass use of teleconferencing has popularized the term, “Zoom fatigue,” due to imperfect audiovisual communication technology. Users concentrate more to process non-verbal cues like facial expressions, the tone and pitch of the voice, and body language, and force all to work harder in processing nonverbal cues, especially when the audio or video resolution is poor. The lower audiovisual fidelity of teleconference communication compared to face-to-face communication can consume a lot of mental effort. Background noise also requires users to concentrate more as opposed to face-to-face interaction where they can use binaural cues to tune out noise. Accurate captions provide a fallback if users have trouble following audio. Some auto-caption engines have been trained on poor mic/internet quality audio, and these accurate captions help not only DHH, but also hearing on teleconference sessions where the audio quality is poor. Other auto-caption engines have extensive dictionaries that include discipline-specific vocabulary, which can disambiguate unfamiliar words and spell out these words in the captions for the listener.

Recommendation: Meeting organizers and consumers should increase audio and video quality through better cameras and microphones and maintain audiovisual streaming consistency by increasing bandwidth. All users should have the option to turn on auto-captions so as to be able to follow the meeting with less fatigue and better comprehension. Post-meeting transcripts can also reduce anxiety over missing out on information. Finally, there also should be breaks every hour to allow for participants to recover.

3.2 Procedural Guidelines

Even the best accessibility features in a meeting platform by themselves may not be sufficient for DHH users. Having proper procedures in place for running a meeting can compensate for many problems that they encounter related to turn taking, cognitive demands, and getting the clearest audiovisuals of the speakers and interpreters. The following procedural guidelines have been developed through trial and error over a period of nine years in work-group meetings that have mixed DHH, blind and sighted/hearing participants.

3.2.1 Turn-Taking. DHH users who rely on visual accommodations such as captioning or sign language interpreting, are not easily able to interrupt or participate in turn-taking due to delay in the captions or interpreting. In addition, hearing users have to account for those delays, further altering the conversation while they wait for turn-taking. They often have to reconstruct the utterance to regain the context of what has been said because they are trying to process two parallel and incongruent streams, which is like listening to two people speaking at the same time, or like reading a book and listening to someone talk on the radio at the same time.

Recommendation: Have moderated turn taking (e.g., raising hand on video, asking for turn in the chat box, using built-in hand raising features), as a way to take the guesswork out of who is to speak next and to give the DHH user a fair shot at getting a turn.

3.2.2 Speaker Identification (Diarization). DHH users are better able to follow teleconference sessions if they know who said what and when during the meeting, and automatic speaker-labeling or identification has been shown to reduce mental workload [8, 10]. Currently, Google Meet offers automatic speaker identification in its ASR captioning feature. Some sign language interpreters and human captioners, are also able to identify speakers correctly, but not reliably.

Recommendation: Meeting organizers should set a rule that whenever a participant gets a turn, they first identify themselves by name. Doing so greatly reduces cognitive load not only for DHH participants, but also for sign language interpreters and human captioners.

3.2.3 Chat Box Monitoring. DHH users frequently have to rely on the chat box to alert the meeting participants to communication breakdowns and to provide clarifications; especially if they are relying on a VRS interpreter to voice for them, who likely is unfamiliar with the subject matter of the teleconference. Nothing is more frustrating to DHH participants than situations where the chat box is ignored, which frequently can happen in the heat of the moment. By the time a chat message is finally noticed, the meeting may have moved on to new topics.

Recommendation: Meeting organizers should designate a participant to monitor the chat box and read every message out loud at regular time intervals, especially if the number of participants is large. Doing so also benefits participants who are blind and participants connected via phone audio.

3.2.4 Gallery View, Speaker Focus, Pinning, and Video Off. Gallery views showing every participant's video at the same are a popular way for maintaining a semblance of the human connections that underpin face-to-face meetings. However, for DHH users, they can cause problems if the number of meeting participants is too large. What exactly constitutes "too large" depends on DHH users' hardware capabilities and screen sizes (cf. §3.1.3) – can video frame rates be maintained, and are the videos big enough for sign language or lip-reading? Some platforms (e.g. Zoom, Google Meet) slow down frame rates and reduce resolution beyond a specific number of videos, which also makes it harder for DHH users to follow.

Hearing participants often use a video-follows-speaker mode, where the video of the currently active speaker is automatically highlighted. Unfortunately, analog automated mechanisms to highlight the video do not yet exist for sign language users (with the exception of FaceTime in iOS 14 [2.]). Additionally, if a DHH user needs to watch an interpreter, automatically following the speaker video is not an option, as it would take focus away from the interpreter. One possible option is to get the video of interest pinned; however, this increases cognitive load on either the DHH user pinning the video or on the meeting organizers pinning the video (also called "spotlighting" in Zoom). While spotlighting has been effective in a number of meetings involving DHH users, experience has shown that it requires a dedicated person's full attention just on handling this feature; and participants need to wait for the spotlight before commencing their turn.

Another option is inspired by hearing participants muting their audio when it is not their turn: everyone except for the active speaker and sign language interpreters, if any, turn off their video until it is their turn. This has the advantage that the DHH user can stay in gallery view and receive better video frame rates, while at the same time lessening both cognitive and hardware load (cf. §3.1.3 and 3.1.8).

Recommendation: Meeting participants should use video on sparingly, mostly to check in on one another, to ask for a turn or to provide feedback to one another. Aside from these situations, they should turn video off except for sign language interpreters and active speakers. Participants should also consider using a side channel separate from the conferencing platform for communication with selected key individuals, such as the interpreter or captioner. For example, this could happen through a private chat in the application, or a simultaneous call on another service.

4 CONCLUSIONS

In this experience report, we have described the challenges that deaf and hard of hearing participants face in teleconference meetings. Through personal experience and information from personal interactions with other DHH users, we describe the types of accommodations and challenges in participating in teleconference meetings with these accommodations. Based on these experiences

and interviews, we discuss best practices that facilitate participation by deaf and hard of hearing participants in teleconference meetings.

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