A Participatory Design Approach to Explore Design Directions for Enhancing Videoconferencing Experience for Non-signing Deaf and Hard of Hearing Users

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ABSTRACT

The breakout of the COVID-19 pandemic shifted people's daily activities from in-person to video-mediated ones. Many people with hearing loss encounter cognitive overload due to ineffective visuals of the videoconferencing interface and therefore find meeting contents difficult to comprehend. This research incorporates a participatory design methodology to investigate the Deaf and Hard of Hearing (DHH) users' tacit needs. DHH users demonstrated ways of mitigating their hardships in the workshop, such as emphasizing the visual hierarchy or assigning visual cues to fixed positions. These findings are used in developing design directions for creating a more inclusive online environment.

CCS CONCEPTS

• **Human-centered computing** → **Graphical user interfaces**.

KEYWORDS

Hard of hearing, Accessibility, Videoconferencing

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1 INTRODUCTION

The breakout of the COVID-19 pandemic pressured communities and businesses around the globe to physically isolate and familiarize themselves with the virtual world, enabling various professional work to be done without having to relocate. The current work-from-home nature of jobs seems to offer a potential solution for the work limitations in the DHH community, such as the barriers in daily commute, which can lead to job termination[4, 12]. However, the sound-dependent system of current videoconferencing services is not properly designed for people with hearing loss and does not support an inclusive nor compelling work environment the DHH workers need, leaving most DHH workers in distress [1, 13]. This work focuses on the Deaf and hard of hearing (DHH) people's use of the videoconferencing tools in a work environment to address these restraints.

There are ongoing efforts to make videoconferencing inclusive of the DHH community, and they have learned to adapt to it in a few ways, like reading captions, interpreting lip movements, or having sign-language interpreters [7, 24]. However, these approaches do not resolve the fundamental restraints. Advancement of auto-captioning technology[16] attempt to assist the DHH users in some ways but are often incomplete, incorrect, or delayed. Lip-readers find the digital screen size and quality not adequate for lip-reading [15]. DHH users are frequently left with fractional information inadequate for a complete assistance, and their efforts to gather these fragmental data for comprehension leave them with an excessive cognitive load [18]. These technical problems are not always solved by having signers available. Merely providing signers in an online meeting is counterproductive to making a videoconferencing environment accessible because only 1% of DHH people know sign language, and even those who know sign language may prefer to understand hearing people without a signer [11].

This research seeks to address an area that has not been discussed: DHH people's videoconferencing occasions without sign language. We aim to create an inclusive environment for the DHH community with varying preferences of communication strategies. Our research goals are: 1) Understand DHH user's pain points and needs for communicating with coworkers when sign language is not the main communication method, and 2) Explore design directions to enhance these user's video-mediated working experiences

For our study, we applied a participatory design method [3] with a close interview to present qualitative results showing pain points and the possible design directions to enhance videoconferencing experiences for DHH users in non-signing situations.

2 RELATED WORKS

There are prior researches conducted pursuing accessible communication services for DHH people. There are lists of common difficulties in DHH people's videoconferencing experiences and guidelines for mitigating those, such as providing live caption and transcripts[10] or providing visual and haptic feedback [19]. While these studies provide important findings for the DHH community and suggest some foundational guidelines in making videoconferencing accessible, these works consider sign language a primary communication method. On the other hand, our work aims to pinpoint DHH people's experiences in a non-signing context. Another research integrates ASR (automated speech recognition system) to

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Table 1: List of Participants

Participant	Gender	Hearing Loss Level (dB HL)	Affiliation	Communication Method (In-person)	Communication Method (Online)
P1	Female	Moderately severe (56-70)	Student	Lip-reading	ASL, Lip-reading, Reading captions
P2	Male	Moderately severe (56-70)	Store manager	Partial hearing, Lip-reading	Partial hearing, Lip-reading, Reading captions
P3	Other	Moderately severe (56-70)	Music producer	Lip-reading, Reading facial expressions and body language	Partial hearing, Lip-reading, Reading captions, Typing
P4	Male	Severe (56-70)	Engineer	ASL, Lip-reading, Writing	ASL, Lip-reading, Reading captions

aid conversation between Deaf and hearing pairs [20], primarily focusing on text-based conversation, which is one of many necessary communication strategies for DHH users. This study intents to look at multiple conversational techniques combined as a whole (e.g. lip-reading, reading facial expressions and body language, using text, etc.), for many DHH people use combination of communication method for fuller comprehension.There were also approaches using live captions for DHH people's comprehension in real-life situations by using digital aid [25] or using smart glasses [17]. These works illustrate valuable data on DHH people's cognitive interaction with live captions; however, they are confined to real-life situations and possibly not be the case in virtual settings.

Moreover, current studies of DHH users' videoconferencing experience largely depend on verbal interviews, and an approach to discovering their tacit needs is uncommon. It is difficult for the researchers to relate to the experiences of users with impairments because their experiences widely vary [21] and the experiences relating to their disabilities may be hard to articulate [5]. Understanding end-user experiences are crucial to align with the actual needs of the user [9] when the issues are driven by their limitations [8]. Although some studies incorporate co-design workshops with DHH users to do so[17, 19], common ability bias during co-design workshops can bias end-users' real feedback and alter their authentic insights [2]. Therefore, conducting a participatory design activity with DHH users is central when we lack knowledge about their interaction with digital technologies [14].

3 METHOD

The user study is divided into two consecutive sessions. First, interview session explores the real-life difficulties users face, discovers the essential areas for improvement, and triggers users' memories from past videoconferencing experiences. Participants are asked to point out the aspects of current video-mediated services that need improvement in their perspectives. Second, a participatory design workshop is conducted over Google Slides [22] to have users directly involved in rearranging the main UI components of Zoom. In this session, the users discover their ways of optimizing their comprehension in an online environment and seek solutions to make it accessible for themselves. We anticipate these design decisions in the workshop to uncover users' tacit needs that may be difficult to verbalize.

The study is conducted one-on-one in a private setting for each participant to enhance freer discussion on disability. The user study takes place on Zoom[26], the most commonly used and preferred videoconferencing tool for all recruited participants. The users participated in the remote user study in their usual settings, which also acted to provoke their past memories of video-meeting experiences for the user study.

3.1 Participants

We recruited four participants with moderately severe to severe hearing loss who were frequently involved (more than three times a week) in a videoconference. The participants were often involved in work related video meetings without using sign language (refer to Table 1 for detailed information on recruited participants).

3.2 Procedure

For effective discussion, we first show a short video of a real corporate Zoom meeting with six workers to provoke users' past experiences. We then proceed with our interview session and ask the users questions regarding the general use of online meetings, their change in communication techniques between in-person and online conversation, and their approaches to understanding others better online. Our questions are solely used to guide the discussion, and participants are encouraged to express anything they like.

For participatory design workshops, users design iterations based on their personal experiences to create the desired interpretation of Zoom. The participants are provided Zoom components on Google Slides for modification (Fig. 1a). The components include a GIF image of the speaker, GIFs of five non-speakers, text for captions, and a shared screen. The meeting scene used for the workshop comprises six total members; according to statistics, most work-related meetings include 4-6 people[23]. Possible modifications of these components are resizing, relocating, cropping, changing brightness or contrast, or recoloring them (Fig. 1b, 1c). There are three tasks for designing: 1) to optimize understanding with captions, 2) to optimize understanding with lip-reading, and 3) to optimize understanding with additional shared material.

4 FINDINGS AND DISCUSSION

All data were collected and analyzed by coding and affinity technique to extrude current problems and the corresponding solutions found from the users. The users' approaches for mitigating barriers and optimizing their comprehension were discovered by looking at their design decisions: the components they decided to change and how they changed them. We grouped the users' solutions and our

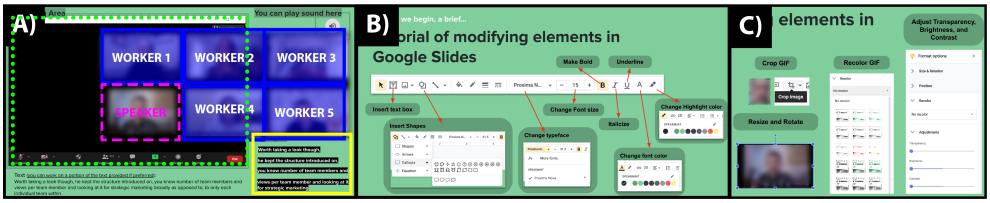

Figure 1: a) Google slides set-up for the workshop include GIF of the speaker (pink dashed outline), GIFs of other meeting members (blue fill) and subtitles (yellow solid outline). Participants are given common Zoom interface image as their workplace (green dotted outline), b) Tutorial slide for creating and decorating text and inserting shapes, and c) Tutorial slide for adjusting the GIF.

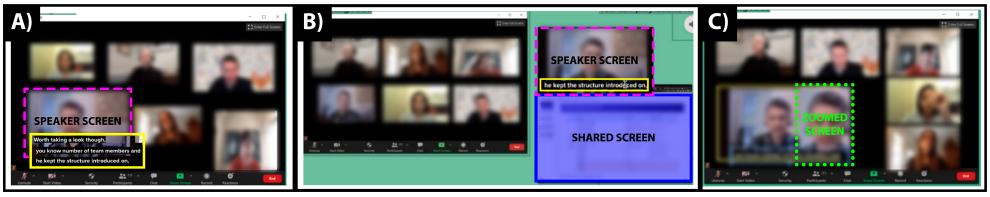

Figure 2: a) P2's placement of the presenter (pink dashed outline) and the live captions (yellow solid outline), b) P4's placement of the presenter and live captions with a shared screen (blue fill), and c) P2's design of zoomed in screen next to the speaker (green dotted outline).

design directions under the corresponding problems: 1) Limitations of lip-reading leaves users highly dependent on captions, and 2) Unclear identification of speaker makes users neglected from the meeting.

4.1 Limitations of Lip-reading Leaves Users Highly Dependent on Captions

The difference in lip-reading experience between online and in-person communication was considered the biggest challenge of video-mediated communication. For the face-to-face conversations, all participants preferred to lip-read, and *"there is no need to use text to communicate in-person"*(P2). On the other hand, in a videoconference, the captions are a necessity (P2, P3), forcefully shifting the users' attention from looking at the speaker to focusing on the captions, confining the DHH users to a text-oriented communication method. However, these participants emphasized the importance of keeping eye contact, looking at the speaker's gestures, facial expressions, and precise lip movements to follow the conversation as a whole, and many did not prefer to rely on captions as an only communicative method.

Users' Approach: Emphasized Visual Hierarchy for Diverse Communication Techniques. We observed the users setting visual hierarchy and emphasizing information based on its significance. For example, the speaker's screen is usually considered the most important and is enlarged to be the largest component on the screen (Fig. 2a). However, in lip-reading scenarios, the zoomed-in portion of the speaker becomes the largest (Fig. 2c). The captions come next in the hierarchy, occupying ample space and located next to the speaker. Non-speaking participants are placed smaller than the speaker but are big enough for users to see their facial expressions (Fig. 2) because users consider them important for suggesting the overall ambiance of the meeting (P1). In the case of meetings with an additional screen being shared, the shared screen and the speaker takes up the majority of the screen (Fig. 2b), and *"those who don't talk can be eliminated on occasion to reduce visual distraction"* (P4). The amount of captions is reduced in this case because having more text causes confusion when another material is being shared (P2). Our users' comprehension method seemed far more complicated than those of signers; we observed non-signing DHH individuals to switch communication method within the meeting according to meeting context, speech-rate, or their momentary capability of taking in cognitive load.

Design Directions: An accessible design should not confine the user to a certain type of communication method and offer all possible ones. Additional screens of speaker's face or lips should be available to support a clearer view, and the visual information must be prioritized accordingly. The size of the videoconferencing screen is often limited, and securing the right amount of space is vital when designing for DHH users. Videoconferencing interface should offer different communication modes: for lip-reading, for reading body language or facial expressions, for just caption reading, etc. This feature is especially vital for non-signers because signing DHH people have tendency to focus on the signer and the speaker throughout the whole meeting, whereas non-signers need more freedom in choosing the right source of information to meet their dynamic needs.

4.2 Unclear Identification of Speaker Make Users Neglected From the Meeting

Video meeting participants often come across occasions when multiple people are speaking at the time or when the speaker change is abrupt. It is difficult for our DHH users to see other participants

when their eyes are focused on the current speaker. The inability of speaker identification is problematic because being unsure of the current speaker leads to difficulty finding the right time to speak up and, most of the time, they decide not to speak at all(P3, P4). The participants claimed the assistance from the host as unhelpful because *"it's very hard for the presenter to realize, understand, or get to know how many people ... have been left out."*(P4) in an online setting.

Users' Approach: Dedicated Locations for Each Information for Instant Identification. Our DHH users naturally found two solutions to mitigate their cognitive load and keep up with meeting contents: 1) having essential components closer together and 2) consistently placing the essential components. Our participants assigned the crucial components close to each other and in a place where they could easily focus. Moreover, all participants asked to keep speaker and captions and other components to be *"always fixed in their position"* (P1, P2, P3, P4) with captions always close to the speaker screen (P1, P2, P3, P4) (Fig 2a). Although the participants have different preferences of visual arrangement (e.g. left-bottom for P2, top-center for P3), they expressed the common need to have a specified location for these elements, preventing them from chasing around the speaker like they currently have to.

Design Directions: Decreasing split visual attention [6] to reduce cognitive overload is commonly discussed; however, we recommend a novel implication, which is to provide a designated location for informative elements. The current "speaker mode" in Zoom attempts to fix the speaker in one place. However, this feature makes other non-speakers' screens very small and thus considered unsuitable; it does not consider that these users often want to clearly see other participants during the meeting. Also, speaker screen is not the only important element during videoconferences, and all elements must be carefully and coherently placed. By doing so, users can effortlessly access visual information all in one picture and not lose optic focus by having to hunt for wanted elements on a given screen.

5 CONCLUSION

Through our user study, we aimed to understand the videoconferencing experiences from DHH people's perspectives and pinpointed critical insights that need to be considered to resolve the current issues. The study tackles an unexplored perspective of not sign language oriented online communication of the DHH community. We propose how their techniques for better comprehension can be utilized to provide a design direction that needs to be considered to make videoconferencing interface more accessible.

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