Understanding tensions in music accessibility through song signing for and with d/Deaf and Non-d/Deaf persons

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ABSTRACT

Song signing is a method practiced by people who are d/Deaf and non-d/Deaf individuals to visually represent music and make music accessible through sign language and body movements. Although there is growing interest in song signing, there is a lack of understanding on what d/Deaf people value about song signing and how to make song signing productions that they would consider acceptable. We conducted semi-structured interviews with 12 d/Deaf participants to gain a deeper understanding of what they value in music and song signing. We then interviewed 14 song signers to understand their experiences and processes in creating song signing performances. From this study, we identify three complex, interrelated layers of the song signing creation process and discuss how they can be supported and completed to potentially bridge the cultural divide between the d/Deaf and non-d/Deaf audiences and guide more culturally responsive creation of music.

CCS CONCEPTS

• **Human-centered computing** → *Empirical studies in accessibility*.

KEYWORDS

Accessibility, Music, Song signing, People who are deaf or hard of hearing, Assistive technology

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1 INTRODUCTION

Music is an important part of people's lives and often contributes to one's cultural identity and well-being. Although music is usually understood as an auditory experience, music can be multimodal and thereby also appreciated through the visual and tactile senses [12]. People who are d/Deaf[1] may engage with multiple forms of music that are not purely auditory [14]. One example of visual representation of music is song signing,[2] a traditional performative art in the Deaf community to appreciate music. Song signers interpret lyrics into sign language and express musical elements with their bodies and faces to convey the meaning, story, and emotions of a song. They layer these visual interpretations onto the original music to create a synesthetic experience of seeing and hearing the music all at once, and perform song signing in live performances or online videos. While song signing originated from a religious context and focused on storytelling [60], song signing today takes place in many contexts, featuring musical renditions for recreational and educational purposes. The rising popularity of video-sharing and social media platforms has brought song signing beyond the Deaf culture. Now entire communities of d/Deaf (Deaf, hard of hearing), and non-d/Deaf individuals contribute to the production of song signing content and enjoy it [60].

Although song signing has gained broader attention, its value and key attributes for engaging the Deaf community remain largely unappreciated [62, 97]. For example, the Deaf Community has regularly responded to broadcasted song signing performances at the American Super Bowl with intense backlash, denouncing its visual inaccessibility to Deaf audiences [97]. The central grievance is that the artistic and creative dimensions of a signed song are largely misunderstood by those outside of the Deaf community, relegating the status of sign language to be only useful in interpretations of spoken messages [97]. In a similar vein, the literature has reported that the Deaf community has criticized song signing performed by non-d/Deaf persons on social media (e.g., YouTube, Facebook) for misrepresentation and appropriation of Deaf culture and language [18, 44, 61].

Song signing is an established practice that interaction researchers and designers can use to inform the development of interfaces to

[1] Lower case "d" refers to audiological deafness, while upper case "D" refers to people who are in the Deaf community (membership within Deaf culture). In this paper, we use "d/Deaf" to refer to both Deaf and hard of hearing people [80].
[2] Also often referred to as signed song and sign-singing

enable people who are d/Deaf to access any musical content without requiring specialized hardware. However, the grievances above indicate there is a need for research focused on issues such as what d/Deaf people value about song signing and how to make song signing productions that d/Deaf people would consider acceptable.

Thus, this paper embarks on the following research questions, bearing a lens from critical disability theory that advocates for a cultural understanding of disability that rejects "normality" as the ultimate goal [65].

- **RQ1:** What features of music do d/Deaf people value? How does song signing make these features accessible?
- **RQ2:** What are the practices used by song signers and challenges that they face in creating performances that d/Deaf audiences would find acceptable?
- **RQ3:** What are potential opportunities and design guidelines to promote Deaf culturally-responsive song signing content?

Through two sets of semi-structured interviews with d/Deaf audience participants and song signers (non-d/Deaf and d/Deaf), we provide design guidelines and potential opportunities for designers/researchers who aim to make music accessible for people who are d/Deaf through an understanding of the following:

- **d/Deaf people prioritize lyrics, emotion, timing over pitch, instruments, and volume.**
  Aspects of music valued by d/Deaf audience participants aligned with what d/Deaf song signer participants prioritized in their performances. We found that, while d/Deaf and non-d/Deaf song signer participants shared similar opinions on the importance of some music components (e.g., lyrics), they differed in their prioritization of certain elements over others (e.g., vibe and tempo over pitch, instruments, and volume). These preferences can inform the design of novel approaches to music accessibility for d/Deaf people.
- **Song signing productions involve multi-layers of work.**
  We uncovered that song signing is a multi-modal process which requires technical translation, artistic interpretation, and cultural representation. We explored these steps through the nuanced perspectives of persons within and outside the Deaf community.
- **Song signing artistry involves cultural sensitivity and collaboration.**
  We delineate how participant backgrounds influence how they perceive content as either empathetic and collaborative or misrepresentative and offensive. Participants suggest collaboration between d/Deaf and non-d/Deaf song signers may appeal to both communities.

2 BACKGROUND AND RELATED WORK

People who are d/Deaf appreciate music in multiple ways beyond its auditory qualities. Music can be considered by its multi-modal dispositions: not by relying only on the ear but also on the eye and the body to enrich the musical experience together [12]. Darrow *et al.* reported that over 50% of the deaf participants in their study enjoyed musical activities such as singing, signing, listening to music, and dancing to the music [23]. According to Stark *et al.*, two-thirds of their survey respondents listen to music regularly [107]. As such, prior research works have explored different "music representations" to support d/Deaf individuals experiencing music. These include (1) tactile technologies using vibration, (2) visual technologies such as captioning, visualization, and song signing, and (3) hybrid technologies utilizing both haptic and visual feedback.

2.1 Vibrotactile representation of music

Vibrotactile technology enables what is often described as "hearing through the skin" by converting musical sounds into musical vibrations that differ in parameters such as amplitude, duration, and location [92]. Listening to music involves feeling the mechanical vibrations in space, which concerns the ear, and simultaneously the body, especially the hands and the feet. For example, some deaf people can experience music by placing their hands on the speakers to feel the air vibration or by going barefoot to sense vibrations from the floor [12].

Many scholars have investigated the relationships between musical parameters such as pitch, rhythm, timbre, and dynamics with touch-based alternatives [29, 56, 68, 70, 93, 94]. Sharp *et al.* investigated the identification of musical emotion through tactile stimuli for deaf individuals, suggesting that deaf people may have elevated abilities in understanding complex tactile stimuli [100]. Also, Tranchant *et al.* [110] found that deaf participants were able to synchronize their body movements to the beat of the music while standing on a vibrating platform with the same accuracy as non-deaf individuals.

Researchers have previously explored how to communicate emotional expressiveness [51–53], rhythm, pitch [47], and other parameters of music such as melody, harmony, timbres [4], and instruments to d/Deaf people by augmenting chairs[4, 47, 51–53] and beds [101] with haptic actuators. Karam *et al.* showed that d/Deaf people who have been using their "Emoti-Chair" for a sequence of studies were even able to develop a preference for a specific music genre [51].

Furniture-based haptic devices are bulky, expensive, and mainly focused on conveying musical elements to the user. Therefore, recently, more portable and compact wearables have been explored for the same purpose. For example, Hashizume *et al.* explored a haptic suit that covers the torso [41]. Others have focused on parts of the body like the arms, hands, and fingers using sleeves [42], gloves [66], and hand grips [49, 50]. DeGuglielmo *et al.* developed a vibration band that can be worn on the head and demonstrated d/Deaf people can distinguish the genre of music through different vibration patterns [26].

Although these systems support a vibrotactile interpretation of music, users must have access to specialized hardware. In addition, haptic devices may not bring a homogeneous experience of music to users. Prior research has shown that participants who lack experience with vibration patterns from such hardware could not discern between the different musical elements of a song [4, 42]. Moreover, vibrations can cause unpleasantness in certain body parts, which can also differentiate comprehension of the relation between what was felt and what was experienced [113].

2.2 Visual representation of music

Deaf people culturally define themselves as 'visual beings' and specifics of their hearing impairment suggest that their perception rests especially on visual and dynamic elements [12]. Elements

in signing such as body posture, facial expression, hand location, and motion comprise the parameters of visual representation [116]. Moreover, visual perception is a founding principle for artistic practice development, a primary sense of all aesthetic experiences for d/Deaf people [12]. Researchers have shown that dissonance, pitch interval, and emotional context of a musical piece could be perceived by the viewer when presented with a video-only stimulus [12]. There have been numerous studies on representing music for d/Deaf people through: (1) captioning and (2) visualization.

2.2.1 Captioning. Closed-captioning systems have made many of the media contents accessible for d/Deaf individuals. However, conventional closed-captioning systems are also known to have limitations with conveying music, sound effects, and speech prosody [57, 88, 102]. To supplement such limitations, prior studies have suggested emotive captioning that conveys non-dialog sound information. For instance, Lee *et al.* augmented conventional captioning systems by adding border colors, emoticons, icons, and varied location placements [57]. Rashid *et al.* also investigated the effectiveness of animated text to express emotions in music [88]. Also, Vy *et al.* developed EnACT, a software tool that generates animated lyric captions to express the emotions and tone of a song in a video. [117]. Using EnACT to create the animated lyrics, a follow-up study examined the readability, user attitudes and preference, and showed the user can identify the emotional intention of songs [69].

Although these study results show that such emotive captioning systems can enhance the understanding and viewer experience of the d/Deaf participants, some participants found the animated captions difficult to comprehend and instead preferred animated symbols [57, 89]. Furthermore, Revuelta *et al.* [89] conducted an EEG study that highlights the limitations of conveying emotional interpretation via captioning systems. Results from Revuelta *et al.*'s work [89] show that captions transcribing musical information increase participants' attentional activity, rather than emotional processing. Similarly, Aleksandrowicz discovered the subtitles for film music did not affect any emotional information watching movies [3]. Their study reveals that captioning systems in music generate participants' increased attention to the caption itself, rather than emotional response and empathy.

2.2.2 Visualization. Several conventional music players have attempted to extract musical elements and visualize music. Windows Media Player or iTunes provide music visualizing options using a computer graphic interface. Meanwhile, studies to convey pitch, tempo, and volume have been also introduced by many scholars. However, there are few assistive technologies for d/Deaf people to appreciate music using visualization.

Isaacson evaluated seven different music visualization techniques including time plot graphs, tonal landscapes, and spectrograms [46]. As well, real-time music visualization schemes using individual notes from a MIDI (Musical Instrument Digital Interface) keyboard [72] and Isochords to deliver a better classification method of musical structures have also been evaluated [9]. These studies showed that different visualization techniques can help the user perceive musical properties such as rhythmic patterns, pitch, dynamics, timing, and melodies [9, 46, 72].

Color plays an important role in the visualization of music. Music-color synaesthesia explorations have built on psychological findings that visual lightness can depict pitch and melodic interval [76]. Using color and 3D graphics of instruments, Szücs *et al.* visualized musical components such as rhythm and volume, underlining that 'spatiality' is significant since it coexists with ratio, dynamics, and instrument arrangement to develop the whole understanding of the song [109]. Outram has explored the geometries and color of the music in a virtual reality environment [79]. Using the 'orbital mode' interaction technique with control of observation and navigation, he showed frequency and volume of music can be mapped to several visual degrees of freedom.

These works described how music could be visually translated for non-d/Deaf audiences. Deja *et al.*, on the other hand, created a visualization tool for frequency, and lyrics involving members of the Deaf community throughout the major iterations of the study [27]. Researchers have found out that equivalent descriptions of musical elements can assist the experience of d/Deaf people. Also, Pouris *et al.* confirmed that their visualization system based on an audio-visual sensory substitution, called MusicViz, helped d/Deaf people convey musical information and emotion of the music [86].

2.2.3 Hybrid representation of music. Recent works have also explored the multi-modal representation of music which involves haptic, audio, and visual information. Haptic and visual information can be delivered by combining a visual display with a variety of vibrotactile form factors, such as a chair [71, 73], portable device [85] and arm sleeves [111], to augment the musical experience, and have been shown to be better than just haptic or visual representations alone [71, 73]. Typography composed based Graphics Interchange Format (GIF) was introduced to convey sound as a moving image with using a smartphone as a vibrator [31]. VR devices have also been explored as a way of providing visual and haptic information to make music more accessible to d/Deaf people. For example, a user study with children has shown that a hybrid representation of music delivered through VR glasses animation and a vibration glove is more entertaining and easy to learn than a single representation [30]. However, most of these hybrid technologies have yet to be evaluated with the target user, d/Deaf people.

2.3 Song signing

Existing methods for representing music reviewed above typically de-emphasize entertainment and focus on expressing musical information precisely, not conveying the emotional elements in the music [37, 89]. In contrast, song signing is a performative art in which the signer emotes through their body and face while translating the music. "Song signing" is one of the many storytelling traditions [6] in many Deaf cultures around the world since the early nineteenth-century [60]. Signed songs are usually either a translation or interpretation of a pre-existing song into a signed language, an original piece composed in sign language, and/or an arrangement of signs to certain beats called percussion signing (e.g., "Bison Song" by Dorothy Miles). Originated as primarily a live experience for the Deaf community, song signing performances have expanded beyond religious hymn interpretations and simple rhythmic signed songs [6] to artistic song signing [6, 60, 61].

According to Maler, artistic song signing falls into its own category of signed songs [60]. These performances are often an amalgamation of music, sign language, special effects, rhythmic signs,

Table 1: d/Deaf audience participant information and their music experience frequencies

	Age	Description	Experience music	Watch music video	Watch song signing	Primary communication method	Interview method
M1	25 - 34	deaf (profound/cochlear implants)	weekly	weekly	weekly	speak	Zoom audio & video call with live transcription
M2	25 - 34	deaf (profound/none)	weekly	weekly	monthly	sign and speak at the same time	Zoom audio & video call with text chat
M3	25 - 34	deaf (profound/hearing aids)	daily	weekly	monthly	sign	Zoom audio & video call with text chat
M4	18 - 24	deaf (profound/cochlear implants)	daily	never	never	speak	Zoom audio & video call with live transcription
M5	25 - 34	deaf (profound/cochlear implants)	daily	monthly	rarely	sign and speak at the same time	Zoom audio & video call with live transcription
M6	25 - 34	hard of hearing (severe/hearing aids)	daily	daily	daily	sign and speak at the same time	Zoom audio & video call with live transcription
M7	25 - 34	hard of hearing (moderate/hearing aids)	daily	daily	daily	sign and speak at the same time	Zoom audio & video call with live transcription
M8	25 - 34	hard of hearing (moderate/hearing aids)	daily	daily	daily	sign and speak at the same time	Zoom audio & video call with live transcription
M9	18 - 24	hard of hearing (moderate/hearing aids)	daily	monthly	rarely	sign or speak (not at the same time)	Zoom audio & video call with live transcription
M10	25 - 34	hard of hearing (severe/hearing aids)	daily	daily	daily	sign and speak at the same time	Zoom audio & video call with live transcription
M11	35 - 44	hard of hearing (severe/hearing aids)	daily	daily	daily	sign and speak at the same time	Zoom audio & video call with live transcription
M12	35 - 44	hard of hearing (severe/hearing aids)	daily	daily	daily	sign and speak at the same time	Zoom audio & video call with live transcription

and acting. In the guide, "Exploring the arts of sign and song", song signing is described to include not only lexical context but also signs for "volume, pitch, rhythm, and mood through the use of body language, facial expression, space, and manner of execution" [22]. Musical arousal could be distinguished through the expression of rhythm and signing space, while emotion could be expressed through dynamics and pitch. Body movements and facial expressions are used to figure emotional intentions [64]. Captions are often provided with both the lyrics and corresponding signed language interpretation [60]. Through the unique opportunity to assert 'musical otherness', Deaf culture is highlighted in song signing [12]. The experience of Deaf Otherness restores an element of music that is detached from the usual, ear-dependent performances [12]. Deaf cultural meanings captured in song signing performances enable non-deaf people to understand deaf-centered lifeways [90].

Some have suggested that signed songs have largely found popularity online within non-d/Deaf cultures is controversial which could indicate "appropriation by non-d/Deaf performers of a Deaf art form" [18, 33, 60, 61]. A majority of respondents to the question "Do you feel comfortable having heard people signing songs to a deaf audience?" in a Deaf community magazine replied that they did not like the idea [1, 24, 61]. However, minimal prior work has explained how and why the Deaf community feels offended and disrespected by non-d/Deaf song signers, and what could be done by way of culturally-sensitivity to address or resolve this tension.

3 STUDY ON d/DEAF PEOPLE'S EXPERIENCE WITH MUSIC & SONG SIGNING

3.1 Method

3.1.1 Participants. To understand how song signing and music are experienced and how various aspects of song signing are meaningful to d/Deaf people, we recruited 12 individuals from social platforms (e.g., Reddit, Discord) to participate in a semi-structured interview (See Table 1). To be eligible for the study, participants needed to be 18 years old or above and have a hearing impairment.

3.1.2 Study procedure. Prior to the study, participants were asked to complete a pre-interview survey on their demographic information and music experience, such as how often they experience music, watch music videos, and watch song signing videos. We then conducted semi-structured interviews with each participant individually. During the interview, we first asked participants to describe in more detail their general experience in interacting with music. Then, we covered the following topics: what musical components interested them; their experience with music produced by different languages, cultures, and communities (e.g., non-d/Deaf, d/Deaf); methods and tools they use to interact with music; how these methods enabled them to experience music beyond what they were already able to do and differently from each other; and challenges and limitations they perceived with the various tools and methods for interacting with music.

The interviews took approximately 45~60 minutes and each participant was compensated with $50 CAD. We conducted the interviews through Zoom.[3] Communication was done through Zoom text chat, speech with the live transcription (automatic speech recognition) feature in Zoom, or with an ASL interpreter when requested. Interview transcripts were created from Zoom text chat records, Zoom live transcriptions, or Zoom audio recordings transcribed using an otter.ai. The transcripts were between 4000~5000 words. Three researchers individually performed open coding [17] on the interview transcripts following the thematic analysis methods [11, 39]. Researchers held 3 rounds of discussion sessions to

[3]Using Zoom to interview the participants often meant a smaller number of topics were discussed in a longer amount of time than in-person interviews, because there was a need for more conversation repair to occur due to mishearing or not being able to hear the other party, errors in the live transcription results (when participants opted to use that feature), and a likelihood that some non-verbal cues were not observable. However, the use of Zoom allowed us to recruit and interview participants who were not available in our immediate locale.

resolve conflicts or confusion on any codes. The study protocol was approved by our university's research ethics board.

3.2 Findings

While d/Deaf participants reported engaging with music in relatively common contexts, they also distinguished their musical experiences as different from non-d/Deaf persons. Common interactions that participants had with music included: "listening to music while working," "playing music on the radio on the way to work," and "using music as a tool that gently relieves stress in the mind." M2 reminisced about their first memory of listening to music and described it to be "like discovering a substance you have never seen before in an unknown world." Even with some access to music as an auditory experience, however, participants stressed the uniqueness of their musical experiences: "hearing music through implants does not equal hearing people's experience." (M2) They described valuing different music elements, the augmented, multisensory experience created by song signing, and explained their preferences for music by Deaf artists.

3.2.1 How d/Deaf people experience music and what they value. Participants mostly interacted with music on video-sharing websites (e.g., YouTube) and/or music streaming apps (e.g., Spotify, Apple Music) using their hearing aids. Sites like YouTube, for example, offer a variety of video formats, such as many songs' original music videos, lyric-only videos, cover videos, song signing videos, and original sign-only music videos. In addition to plentiful and diverse content, participants pointed to the recommendation features on music streaming platforms as their main source of music discovery.

Participants expressed varying interests in the different musical elements such as lyrics, mood, rhythm, pitch, and melody while interacting with music. Across participants, however, lyrics were emphasized as one of the most central elements that helped them engage with the music, understand the original artist's intentions, and interpret the song's meaning. Participants (M5, M6, M9, and M10) point to both YouTube's and Spotify's lyrical transcription functionality to explain their preference for these platforms.

Many participants (N=9) enjoyed watching music videos with captions. M5 noted that music videos provide additional opportunities to interpret the music and express what the artist is trying to convey through their lyrics. As such, participants indicated that they almost always look for captions when engaging with music. For example, M9 described how she explores music on YouTube: She (1) looks for an official music video with closed captioning, (2) if subtitles are not supported, she looks for a performance video with lyrics, and (3) if neither exists, she looks for lyric-only videos (e.g., karaoke videos). Only one participant (M3) prioritized the tempo/beat of the song, rarely watching music videos, explaining his preference for experiencing music through vibrotactile methods.

After lyrics, M2 and M9 prioritized other visual aesthetics (e.g., choreography). Participants often watched music videos for visual entertainment such as dancing rather than seeking to understand the meaning of music.

> "Growing up, I didn't like music videos because there was no captioning. But I'd only watch not for the music, but for the visual aesthetic. For example, whenever I talk about music videos with my deaf friend, it's mostly on the dance part. And then later, we check the subtitles to see what the song is even about." (M9)

Some participants valued being able to interpret lyrics themselves, and thus preferred lyrics-only videos or music streaming apps to the music video. M10 described that she likes Spotify which helps her understand music since it provides the content and makes it easy to repeat/rewind the song. M1 also mentioned that reading the lyrics is difficult while watching music videos since the combination of dance, sound, and visual effects distracts her a lot.

3.2.2 How song signing produces a multi-sensory and augmented music experience for d/Deaf people. Most participants had experience watching song signing videos (except for M4, M9) through YouTube, and only some had watched in-person performances, such as a staged sign language musical or play (M2, M10). Participants tended to search for song signing videos only after they had first watched and enjoyed the original music video.

> "Most of the time, I "watch" it (song signing video) to see the (song signer's) choreography more. This is because I need to pay attention to "listen" to a song. So I watch it after I get used to the song - when I'm familiar with the melody and the beat." (M2)

Many participants (M1, M2, M9, M11) described that watching music videos and song signing videos required multi-modal engagement: "There are visual elements to interpret, captions to read, audio to listen to and feel, and oftentimes a performer to connect to". This plethora of information enriched participants' understanding and enjoyment of the song.

Some participants found music videos to enhance their appreciation of a song.

> "So music videos for me would be about the visual art as well as seeing the artists' interpretation of their music, which I do like seeing and it's always nice to see what was pictured by other people versus what was pictured by me." (M5)

In a similar vein, participants believed that song signing augments their musical experience with an additional level of interpretation and expression.

> "I think the signing brings a vivid understanding of the song, bringing out emotions." (M7)

> "You have the captions, and also you have the facial expressions. So it's very much easier to understand that much." (M11)

M10 equates song signing as the combination of music videos and lyrical videos. To them, having features from both modalities (e.g., visual interpretations and lyrics on screen) makes song signing "quite far, much better than the other two." M5 noted a form of connection to the song signer, where the listener engages with not only the song, the lyrics, and the background visuals, but also the gloss,[4] the sign interpretations, and the performance of the signer.

> "I think primarily there is a human connection...One person might choose to sign it this way, another person might choose another way...There are regional

[4]Gloss is a written or typed approximation of ASL typically using English words as "labels" for each sign along with various grammatical notes.

> variations and very individual differences that we would get and that would be characterized as someone's individual style or flavor of signing." (M5)

As follows, participants felt that song signing augmented their experiences with music by providing additional layers of interactions through which to understand, relate to, and appreciate the music and music videos.

3.2.3 How music from d/Deaf community differs from music from non-d/Deaf community. Participants noted several differences between music made by d/Deaf artists [5] and non-d/Deaf artists. M2 described that music created by non-d/Deaf artists focuses more on being "pleasing to the ears" while music created by d/Deaf artists focuses more on being "pleasing to the eyes."

> "I absolutely prefer the deaf community's music. Through "facial expressions", I can feel the emotion of the artist, and through the intensity and speed of the "hand gestures", I can distinguish the dynamics of the song. My first language is sign language so I feel more comfortable with it." (M2)

M10 criticized music from non-d/Deaf community as "unfavorable to the people with hearing difficulties" because it often does not have subtitles for lyrics. Moreover, M11 described some challenges in interpreting music as the mood and atmosphere the non-d/Deaf musician is creating. M3 had the same issue and thus prefers to listen to music with non-d/Deaf people.

> "Unfortunately, I can't feel the atmosphere by myself. I want to know whether it is a sad song or a happy song, but it is difficult to interpret when I am alone. I think a deaf person truly tastes the music when listening to music with a hearing person." (M3)

While most participants' music repertoires consisted mostly of songs from non-d/Deaf (non-song signing) artists, they generally preferred d/Deaf content and wanted to support artists from the Deaf community. Participants attribute this dichotomy to the limited amount of content from d/Deaf artists and performers. Regardless, many participants enthusiastically sought out new content released by d/Deaf artists.

> "I'd love to learn more about music from the deaf community. But unfortunately, it's not there. You know about the Super Bowl incident and how disappointing it was for the media not to focus on the deaf people there signing. So that's how the media treats us." (M9)

All but one participant expressed a desire for more d/Deaf representation in music and song signing-related content. Notably, there were a few participants who held outlying opinions about song signing content or had yet to form an opinion. For example, M4, who did not know sign language, did not strongly oppose song signing content from non-d/Deaf artists, did not seek out d/Deaf content, and preferred non-d/Deaf community's songs. M5 also reflected that, although she strongly prefers d/Deaf content and song signing, she believes many people in the Deaf community may not have fully formed their opinions on song signing given that "nowadays (song signing on social media) is still relatively new."

3.2.4 How d/Deaf song signers and non-d/Deaf song signers are contrasting. Participants had varied opinions on song signing content and song signing by non-d/Deaf performers versus d/Deaf performers. Many participants (M2, M3, M5, M9) complained about inaccurate sign language and "clout chasing" shown in non-d/Deaf song signing performances.

> "You are going to run into a lot of deaf people who absolutely hate hearing students do ASL music videos because it tends to be taken out of context. A lot of hearing students are doing it for clout or students just trying to practice, and then put out material that isn't necessarily correct." (M5)

Participants were also concerned that non-d/Deaf song signers cannot reflect the Deaf culture:

> "A lot of song signers for ASL music videos, they were mostly hearing song signers getting views and subscribers. They were all hearing, and that was something that did not sit well with the community, and the culture. We're saying that they're not expressing well, they just want five minutes of fame." (M9)

On the other hand, participants preferred song signing content from d/Deaf artists that, not only had accurate sign language but also placed more focus on facial and body expressions, and had fluent use of non-manual markers (NMMs).

> "Facial expressions are the most important component in sign language. No matter how good you are at sign language if your expression is not clear, I can't enjoy it. I don't know what the situation is. Hearing community music lack that important part." (M2)

They also believed that d/Deaf song signers convey a deeper meaning of the song: "Deaf song signers think more about the meaning of the lyrics rather than the specific word-to-word translation." (M5)

Participants also noted that song signing cinematography is also often different between non-d/Deaf and d/Deaf content creators from filming angles to themes which made them more accessible. For example, M5 discussed how videos made by d/Deaf song signers usually had angles that made interpreting the sign and body language of the performer easier to read than those in non-d/Deaf performed song signing videos. In addition, d/Deaf song signers were more likely to convey additional lyrical meanings and interpretations into these angles and cinematography (e.g., filming the space around the performer to convey emotion), while non-d/Deaf song signers would spend more effort in focusing on the translation.

3.2.5 How collaboration can enhance d/Deaf people's music experience. d/Deaf participants ideally want to experience music created by Deaf artists. Many non-d/Deaf song-signers suffer from inaccurate signings and are perceived as 'imposters' within the d/Deaf community. Their performances sometimes turn into points of controversy and contention. However, there exist mixed opinions on non-d/Deaf song signers song signing.

> "I think the advantage is that sign language can be publicized. But there are many (hearing) people using

[5] Deaf community's music encompasses traditional percussion songs, translated songs, and purely signed music [10, 18, 60]. The 'song signing' referred in our study is one of the translated songs, videos featuring the performance of a preexisting song translated into ASL or live music interpretation services/performances [61].

Table 2: Song signer participant information
(NOTE: S refers to non-d/Deaf song signer participants and SD refers to d/Deaf song signer participants)

	Age	Years of Experience	Role involving song signing & Motive	Description	Primary communication method	Interview method
S1	25 - 34	3-5	Online content creator (Learn & practice sign language)	Hearing	Speak	Zoom audio & video call
S2	18 - 24	5-10	Student (Learn & practice sign language)	Hearing	Speak	Zoom audio & video call
S3	25 - 34	3-5	Online content creator (Learn & practice sign language)	Hearing	Speak	Zoom audio & video call
SD4	25 - 34	5-10	Sign lanugage artist (Promote Deaf music)	Hard of hearing (profound/cochlear implants)	Sign and speak at the same time	Zoom audio & video call with live transcription
S5	35 - 44	5-10	Deaf school teacher (Promote Deaf music)	Hearing	Speak	Zoom audio & video call
S6	18 - 24	1-3	Professional song signer & Official translator (Promote sign language)	Hearing	Speak	Zoom audio & video call
S7	18 - 24	1-3	Online content creator (Learn & practice sign language)	Hearing	Speak	Zoom audio & video call
S8	25 - 34	1-3	Student (Learn & practice sign language)	Hearing	Speak	Zoom audio & video call
S9	25 - 34	5-10	Official translator (Accessibility service)	Hearing	Speak	Zoom audio & video call
SD10	25 - 34	More than 10	Professional song signer (Promote Deaf music)	Hard of hearing (profound/hearing aids)	Sign and speak at the same time	Zoom audio & video call with live transcription and text chat
S11	25 - 34	5-10	Deaf school teacher (Promote sign language)	Hearing	Speak	Zoom audio & video call
S12	25 - 34	5-10	Pastor (Accessibility service)	Hearing	Speak	Zoom audio & video call
SD13	25 - 34	5-10	Deaf band member (Promote Deaf music)	Hard of hearing (profound/cochlear implants)	Sign and speak at the same time	Zoom audio & video call with ASL interpreter
SD14	25 - 34	More than 10	Professional song signer (Promote Deaf music)	**deaf (severe/hearing aids)**	Sign or speak (not at the same time)	Zoom audio & video call with ASL interpreter

> sign language to gain recognition and make money, which leads to a negative view. But it'd be fine if it was with a deaf performer. Song signing without deaf performers feels awkward. There's a video[6] where a hearing celebrity and deaf translators perform together. It's great when it works like this!" (M2)

> "(There is fear of) misrepresentation of the deaf community and culture and drawing attention away from deaf artists and their financial opportunities. On the other hand, song signing may be a way of promoting the deaf community and culture. As the culture of the deaf flows into the hearing world, it is possible to prepare a foothold for coexistence. With the influx of the hearing community's music, it might be easy to activate music for the Deaf and foster artists." (M3)

Some participants (M1, M2, M3, M9) are eager to see a middle ground with original artists and song signing performers working side-by-side. To them, visualizing the original artists and song signing performers next to each other might create a sense of "appreciation and acknowledgment that sign language is equal to the language that hearing people use." (M2) In addition, participants thought that performances by non-d/Deaf and d/Deaf artists together have the potential to showcase their unique nuances such as exposure, accurate sign, and mood.

> "First of all, I think the deaf song signers are good at expressions and sign language - their expressions are good. The hearing ones will do better on timing. Signing at the right time. I hope deaf and hearing people can co-create the song signing video." (M1)

[6]https://www.youtube.com/watch?v=pGWdglgD0ww

4 STUDY ON SONG SIGNERS' PROCESS AND EXPERIENCES

Drawing from our insights that d/Deaf people may uniquely value song signing for accessibility and cultural-responsiveness, we conducted a subsequent interview study with d/Deaf and non-d/Deaf song signers to understand and compare their practices and experiences in attempts to create acceptable song signing content.

4.1 Method

4.1.1 Participants. We recruited 4 d/Deaf song signers (3 Hard of hearing, 1 completely deaf) and 10 non-d/Deaf song signers. We recruited participants ages 18 and older who have song signing experience, from social media platforms (e.g., Facebook, YouTube), and personal websites, and then used the snowball sampling method. A broad range of song signers (N = 14) participated in our interview study (See Table 2). Most of the participants were recruited from YouTube (N = 10) and others were recruited by snowball sampling method. Participants were involved with many types of translated songs as Maler defined [63]: (1) Live music interpretation by ASL interpreters (S9), (2) live performances by song signing artists (S1, SD10, SD14), (3) videos featuring an interpretation of a pre-existing song - who upload their video to social media platforms (e.g., Facebook, YouTube) (All participants except S9, S12, SD13).

The reason participants started song signing differed between d/Deaf song signers and non-d/Deaf song signers. Non-d/Deaf participants usually started the song signing as a way to help them learn and practice sign language. Eight of the participants learned sign language in college or institutions and started song signing as a class project. S2 and S8 are students who are preparing for their interpreter tests and engaged in song signing for practice. d/Deaf

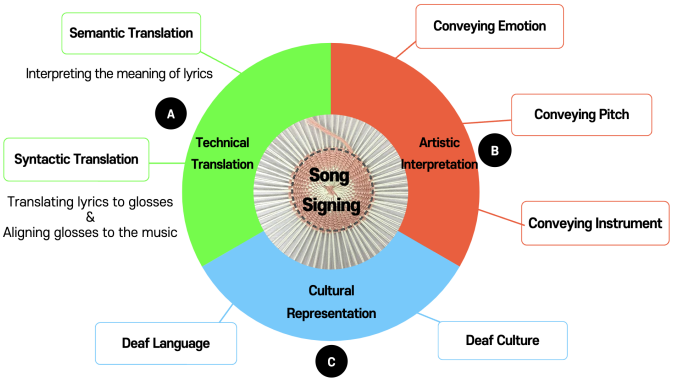

Figure 1: Three intertwined layers of work in a song signing performance. (A) Technical translation layer: translating lyrics to glosses, with semantic and syntactic translation. (B) Artistic interpretation layer: creatively conveying musical elements, such as emotion, pitch, and instruments. (C) Cultural representation layer: reflecting Deaf language and culture

participants, on the other hand, started song signing "naturally" because they liked music and wanted to perform music. Song signing was a method to express one's identity.

Participants had various reasons for continuing song signing as well. Some of them were continuing song signing as part of their job: (1) professional song signers, and (2) official sign language interpreters. Seven participants were professional song signers (N = 5 d/Deaf, N = 2 non-d/Deaf). Two participants were official ASL interpreters, both with live concert translation experience (S6, S9). Meanwhile, other participants' purposes for song signing were communicating in religious and educational settings. Two of the participants are involved in their churches and perform song signing for religious reasons, such as part of ministry service (S12, SD13). S5 and S11 are special education school teachers for children with communication impairments. Song signing was used as a teaching tool to encourage students to learn sign language.

4.1.2 Study Procedure. Participants were asked to complete a pre-interview survey on their demographic information such as age, gender, and song signing experience such as how frequently they sign and how long they have been song signing. We then employed the same data collection method described in Section 3.1.2, but focused on following topics: how they select a song to perform, their song signing process, how they convey and interpret musical components, challenges and areas of improvement in their song signing work, and audience reactions. Interview transcripts were 6000~7000 words. Three researchers individually performed open coding [17] on the interview transcripts following the thematic analysis methods [11, 39]. Researchers held 4 rounds of discussion sessions to resolve conflicts or confusion on any codes.

4.2 Findings

Participants had various motivations for song signing, such as educational purposes to teach sign language and social-political purposes to bolster awareness of Deaf music.

> "The purpose is more on promoting sign language rather than being professional. Actually, from the point of view of a sign language interpreter, there are two purposes. One is for dialogue between the Deaf and the hearing person, and the other is to teach sign language to the hearing person." (S6)

Regardless of their motivation, song signers tend to use the same work processes. Analyzing the song signing process, we synthesized three distinct and related layers of work involved in song signing (See Figure 1): (1) a technical translation layer: Among the song signer participants, everyone agreed that analyzing lyrics is the first step, followed by creating glosses and aligning them with the music; (2) an artistic representation layer: Additionally, they described song signing as an art form that conveys musical elements through the artistic interpretation of the signer; and (3) a cultural representation layer: Participants elucidated a tension between the non-d/Deaf and d/Deaf song signers over concerns about cultural representation and appropriation of song signing.

4.2.1 Technical translation layer. The technical translation layer is the basic layer of work in the song signing process. It involves (1) the semantic translation of interpreting lyrics and (2) the syntactic translation of aligning glosses to the music, which can be done in parallel and iteratively. As song signers interpret the lyrics, they define the appropriate glosses. This process, however, is constrained by the need to perform the translated signs/glosses in sync with the music. It is repeated until the lyrics can be translated in a way that is compatible with the tempo of the song. Both non-d/Deaf and d/Deaf participants experienced difficulties interpreting lyrics. Where non-d/Deaf participants spend more time creating glosses, however, d/Deaf participants spend more time matching the tempo/beat of the song. Participants also highlighted the importance of captioning both lyrics and glosses that show the decision process with translations.

Semantic interpretation: Interpreting the meaning of the lyrics. Both non-d/Deaf and d/Deaf participants described the semantic translation as the first step and interpreting the meaning of the lyrics as the most important but most difficult and time-consuming process in song signing.

Participants used various methods to help interpret the lyrics, including (1) researching the original songwriter's intention and the song's background; (2) looking for other sign language covers; and/or (3) consulting with others, such as online forum users, d/Deaf family/friends, and sign language interpreters.

Across these approaches, participants described challenges with interpreting the meaning of the lyrics. All participants mentioned the ambiguity of lyrics in poetic expressions, such as symbolism and metaphors, with multiple interpretations (See Figure 2 (A)).

> "Interpretation? I think it's probably the most difficult aspect. Let's say there is a song that says, count. So,

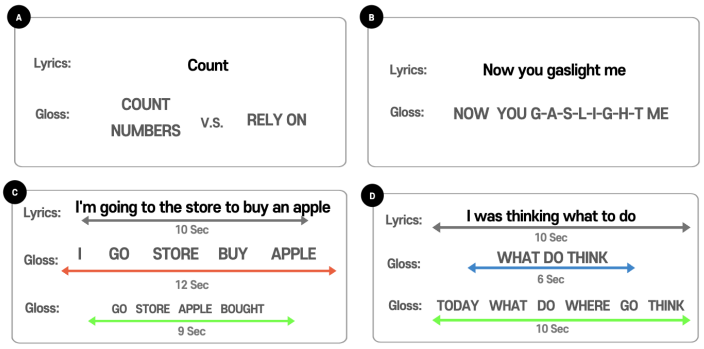

Figure 2: Examples of challenges in work performed at the technical translation layer. (A) Example of a semantic translation challenge when a word ('count') has multiple possible meanings. (B) Example of a semantic translation challenge when a word ('gaslight') does not exist in ASL and thus finger-spelling the word (C) Example of a syntactic translation challenge in which a gloss is too long and it is necessary to remove words or edit the gloss to match the time frame. (D) Example of a syntactic translation challenge when a gloss is too short and adding words to match the time frame is necessary.

> they might be talking literally about counting numbers. But using the metaphor, the meaning can be you can rely on someone." (S11)

S2 mentioned that when she cannot understand the word or when there is no corresponding sign of the word, she would just finger-spell the word (See Figure 2 (B)).

> "I actually just filmed a video yesterday that was probably one of the hardest songs I've signed. Because of the word the artist talked about, I didn't really understand exactly what he was trying to say. For instance, he says "now you gaslight me" and it was pretty fast. So I didn't really have time to explain the meaning behind gaslight and there isn't really a sign for it. So I had to spell it." (S2)

Syntactic translation: Translating lyrics to glosses. After interpreting the meaning of the lyrics, song signers perform syntactic translation, creating ASL glosses [7] that match the lyrics.

> "So there are two signs for wish and hope, even though there could be sort of the same concept. Because you can wish and you can hope for something. But choosing which one works in a song is like a decision to be made. Because they are sort of interchangeable. And it depends on what is meant by certain things." (S11)

Participants explained that the grammatical and linguistic aspects of sign language require a lot of decision-making to choose the best sign to express. One reason is that sign language grammar is different from spoken language grammar. In addition, there are "commonly used signs" that deaf people use every day that is different from the "dictionary-based signs" (S2, S3, SD4). Participants also noted that accents and dialects, which have regional variations, are tricky to convey. S11 expressed that interpreting lyrics is always difficult due to this lack of standardization and the tendency of sign languages to change over time.

Non-d/Deaf song signers typically perform direct translations focusing on the lyrics themselves (S2, S7).

> "And sometimes it is not easy (to choose the sign). As I said, I do not sign ASL technically. So the grammar I use is more like English. So I think that's another reason why it probably doesn't take me as long (in glossing) because I'm pretty much translating it close to what the lyrics are saying." (S2)

S1, S2, and S3 agreed that one-to-one translation is very difficult and time-consuming in order to personalize the meanings.

On the other hand, d/Deaf song signers consider signs that communicate the meaning of the lyrics and the mood. For instance, SD14 described how she frequently plays with the signs to convey clever or witty meanings.

> "I try and throw in tricks where instead of saying exactly what they intended, just saying, you know, what the underlying meaning is, that will make sense and visually support what they're trying to say in their creative lyrics" (SD14)

Iterative syntactic translation: Aligning glosses to the music. Aligning glosses to the music is another challenging step related to the syntactic translation of a song. Both non-d/Deaf and d/Deaf participants found fast songs, such as rap music, to be especially challenging. Song signers had difficulty matching the speed of the song while selecting the right sign to fit the lyrics (S2, SD14). Also, signing quickly can distort the meaning, which makes it difficult for audiences to follow and understand the gloss (SD4).

> "I have to put in a certain amount of signs, you know, to get the meaning across. So it can make it really, really hard when I'm trying to interpret a song that's either fast or doesn't have a lot of time frame, and I have to try to sign very quickly. And I feel like I'm not showing the sign as clearly as I would like." (S2)

Technical fluency in sign language can also limit the breadth of songs that a signer performs. For example, fast-paced songs were not preferred by participants who were new to song signing. Hence, rap music was considered difficult to match signs with tempo.

d/Deaf participants, with limited or unavailable hearing ability, required extra time and effort to match signs with the tempo of the song. They carefully review music videos or performance videos to identify the beat, which demands focused attention. SD14 shared how she determines the beat of the song: she reads captions with a music video and follows the lip-syncing of the performer. If a music video is not available, she reads the lyrics while listening to the song to learn when the timing pauses, and the tempo of the song.

> "I'll then get the speed of how fast they're saying and find different timing cues, where do they pause, is one word longer or shorter, faster, or they don't say the word completely, where they cut it off. So I'm looking to capture all of those little parts of the overall song to find the beat, find the tempo." (SD14)

[7] Gloss is a written or typed approximation of ASL typically using English words as "labels" for each sign along with various grammatical notes.

Furthermore, song signers revised glosses multiple times to make the signs fit into the song's timeline. SD14 believed that matching signs with beats (e.g., hitting the marks of the start and end of each phrase) is more important than how you sign and showed an example of dropping some words in lyrics (See Figure 2 (C)).

> "I've got to make sure my signs fit that timeline to have the transition to the next line of the song. If I'm saying, "I'm going to the store to buy an Apple", then I'm going to sign: "GO STORE APPLE BOUGHT". So that's how you're gonna fit in the signs within that line and still stay with the pace of the song." (SD14)

In contrast, S3 described the example where she adds more signs to make glosses fit in the time frame and convey a more concrete interpretation (See Figure 2 (D)).

> "The lyrics, "Thinking what to do". If I translate this sentence as it is, the gloss would be: "WHAT DO THINK". But it's too short for the time frame. The song is about someone thinking about a dating plan. So I added some words: "TODAY WHAT DO WHERE GO THINK". " (S3)

Considering the decision-making process in the technical translation layer, all participants unanimously highlighted that captions (of both lyrics and glosses) are necessary to make the song signing videos inclusive for both non-d/Deaf and d/Deaf audiences. They mentioned that subtitles will not only prevent the audience from mishearing the lyrics but also provide the reasoning behind the gloss selection that they made. Participants found it useful to compare lyrics and glosses to help their audience understand how metaphors (semantic translations) and timing (syntactic translations) are incorporated into the selection of signs. Additionally, they hoped that through this comparison, the viewer would gain a greater understanding of the message and storyline of the song.

> "Captions, the lyrics and glosses at the bottom will help the viewer understand the choices I've made because there is an element of making choices in interpreting a song into signing because of metaphors and timing stuff." (S11)

4.2.2 Artistic interpretation layer. The syntactic translation which involves choosing signs and matching the sign to the rhythm is also an artistic thought process. This is because it requires song signers to decide how much should they modify the original lyrics to artistically express meaning in their performances. In this way, the processes of creating glosses (technical translation layer) and artistic expression (artistic interpretation layer) are related. Participants creatively conveyed not only the lyrics/gloss but also other musical elements, such as emotion, pitch, and instruments They expressed these musical elements with intensities and nuances through bodily gesture, facial expression, and hand movement.

Conveying mood and vibe. All participants try to incorporate the emotional component of the song, which they referred to as 'mood or vibe', to express the intensity and nuances of the song. Song signers highlighted that conveying the emotion of a song is one of the important musical components to consider.

> "Song signing is an art form. I only sign a song that I'm emotionally connected to. So it is really important to capture the vibe, then just do a literal interpretation of the song." (SD14)

All participants tried to convey the mood and vibe of the song by incorporating emotions into their facial expressions and hand and body movements. Both d/Deaf and non-d/Deaf participants stressed the importance of "facial expression" and tried to convey the original singer's emotions while singing the song. S1 stated he feels a personal connection to the character in the song, and method acting is needed to channel the character and feel the emotions.

All participants described first listening to the song multiple times and analyzing the lyrics to understand the vibe of a song, based on its concepts and messages being conveyed. d/Deaf participants additionally used the live performance video to understand the vibe. For example, SD14 would watch the performance video to understand the emotion of the singer and do the "lip-reading" and sing along. SD13 prefers watching cover videos to the original music videos, finding it easier to understand the mood of the song by analyzing the facial expression of the singer.

However, some non-d/Deaf participants said, "facial expression" is difficult since it involves a degree of acting. This makes them hesitant to work with overwhelmingly emotional songs such as ballad songs and prefer songs that were easier to interpret succinctly and express clearly. S3 preferred bright songs and tried to avoid songs with poetic and implicit expressions.

> "I choose the song that I can express well since the facial expression is important in sign language. I usually don't try break-up songs because I'm bad at making a sad face." (S3)

In contrast, d/Deaf participants are more flexible with the genre of the song. They were open to trying more emotional expressions, thanks to their sign language fluency and proficiency which made this feel more natural. SD4 mentioned that he mostly signs ballads even though he received some feedback from the audience that they want him to perform more bright and upbeat songs. In addition, Deaf song signers were more open to trying challenging songs.

> "I like rap songs that are clever in their lyrics. Because those songs are challenging, and often everybody fails to get the translation. That's kind of how I select songs: ones which either have emotionally charged a story behind it or some kind of a lyrical challenge." (SD14)

Conveying pitch and instruments. Participants varied in opinion on whether they incorporated pitch and instrumentals into their song signing. For some d/Deaf song signers, they used sheet music (SD13) or audio spectrum applications (SD4) to determine the pitch in the song. SD4 describes his strategy:

> "If you look at the music video, if you sing softly, your expression does not change. When you sing in a high-pitched tone, you frown or widen your mouth. This way I can infer the pitch as well." (SD13)

Participants expressed pitch and instruments through their facial and body expressions (See Figure 3). They mimicked the air instruments (hand gesture playing). For example, S1 discussed how he would express a low bass of guitar notes.

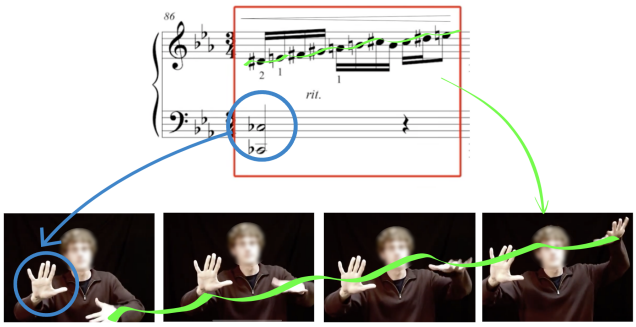

Figure 3: Example taken from a song signing video on YouTube showing work performed at the artistic layer: conveying pitch and instruments. The blue circle indicates the start of the guitar strum matching with the non-d/Deaf song signer's right hand and the green line indicates the flow of pitch matching with the song signer's left-hand movement

> "In Bohemian Rhapsody guitar solo, the sound is looping around. So I'll represent that in space with a circle. In an intense strum record, I'd let my body show the echo of the chord and let my hands visualize the change in pitch. But it was just like dancing with sign language on top, making it sound more refined." (S1)

In contrast, the deaf participant intentionally omitted these elements from their choreography. SD14 expressed her reasoning as a preference not to incorporate instruments:

> "So I have a rule, do not sign the sound of the instrument. Oh, so you will probably see those that they will do like the piano or the guitar. I am not interested in that. That is not the song. That is not what the singers are doing with their mouths." (SD14)

The deaf participant (SD14) omitted pitch due to not being able to perceive it and therefore did not conceptually understand it.

> "You're going to use different parts of the song that are available and accessible to you. So pitch, I usually can't hear so don't know about the pitch. Regardless, if it was accessible, I would not know how to apply the concept of how to use pitch. Because I still do not understand what pitch means." (SD14)

4.2.3 Cultural representation layer. We identified a third layer of the song signing process as a cultural representation layer —that is, the way in which song signing productions may represent or inadvertently misrepresent Deaf language, Deaf culture, and the Deaf community. For example, sign language is a core asset that represents Deaf language and culture; thus, using the wrong signs can cause people to learn the wrong signs. As a result, some Deaf people think only a Deaf person can authentically represent their community, and Deaf people thereby often scrutinize the limited signing proficiency and facial expression of non-d/Deaf song signers, and charge non-d/Deaf song signers' artistic productions as misrepresenting Deaf language and culture.

We found the below cases where non-d/Deaf song signers' creative attempts and use of artistic license can be scrutinized by Deaf people. For example, some non-d/Deaf participants tried to avoid direct translation in the technical translation layer and modified lyrics. Additionally, some participants did not sign the lyrics and used body language, gestures, and movements. S3 described she would do gestures rather than signing the exact lyrics: "To express "in the falling rain", rather than signing it, I did the gesture like this, putting my hands above my head to avoid the rain."

Perhaps unsurprisingly, the Deaf community grants license to their members that were not (easily) granted to non-d/Deaf song signers. Whereas Deaf song signers may be able to intuitively choose and perform signs that align with the Deaf culture, non-d/Deaf song signers may not always know the correct signs to use or the important nuances of sign language and grammatical tendencies of people from the Deaf community. Misinterpretations, according to S12, were met with negative feedback from the audience when the non-d/Deaf song signer tried to avoid direct translations:

> "If I interpret ambiguous expressions in line with the commonly used signs (ASL slang) or body language, it seems very easy and clear to understand. But the problem is, if I paraphrase that way, some people will say *"The signs are different from the lyrics. That person is bad at sign language."* It's very hard to find the middle ground." (S12)

Overall, although non-d/Deaf song signers receive positive feedback with support and encouragement from the audience (S5, S11), they tend to receive negative feedback from the d/Deaf audience. Participants noted that the non-d/Deaf audience is often less concerned with what is signed and, rather, is more concerned with how it is signed (e.g., visually matching signs to the beat) (SD14). This is because the non-d/Deaf audience can listen to the song and are watching to learn or enjoy the use of sign language. In contrast, the d/Deaf audience focuses conceptually on the logic behind what is signed and why it is signed a particular way (SD14). SD10 noted that she got negative feedback from people within the Deaf community about her different thought processes on signing.

> "The backlash I get a lot: Deaf people would automatically criticize my signing. For example, I use ASL and SEE (Sign Exact English) word by word at the same time. That is why I said that I am deaf, but I identified myself as hard of hearing because my thought processes are completely different." (SD10)

Thus, song signing performances by those who are not from the Deaf community are often criticized for using the wrong signs or showing signs performed incorrectly or awkwardly. As such, some participants worried about misinterpreting or misrepresenting the meaning of a song (S7, S11).

> "Interpretation is probably the most stressful for me. Because I know that if I get it wrong, I'm teaching people the wrong info. That's why I get it checked by my friends and work on it as best I can." (S11)

Furthermore, we interpreted the cultural representation layer as a continuum. On one end, Deaf persons may criticize non-d/Deaf song signers' technical proficiency, or lack of artistic mood and vibe. On the other end, non-d/Deaf song signers may be charged with exploiting them for personal profit or attention. For example, S1, a popular song signer who has the most view counts on YouTube, was charged with cultural appropriation and exploiting Deaf persons for profit. S1 explains his eventual decision to discontinue song signing out of respect for this sociopolitical issue at play:

> "I pursued song signing until the deaf community pushed back against my asking for support as an artist to do more of these videos. Because at the time, it seemed more important to show a good face toward accusations of cultural appropriation and to acknowledge that. I really had no interest in being a legitimate sign language interpreter. I was just doing this because it was fun, expressive, and artistic." (S1)

Adding to this, S2 described the backlash that she received from Deaf persons, which she interpreted as drawing the line that non-d/Deaf persons should not be given 'license' to widely disseminate their song signing productions.

> "So the deaf community is basically saying *"Hearing people should not sign to music and post online. They can sign to music if they're trained and if they're an interpreter, but they should only do it if it's at a concert, or a church service, etc."*. Because they've said it's clout chasing. We're doing it for fame or attention." (S2)

4.2.4 Collaboration weaving layers and bridging the cultural divide. Some participants described opportunities to bridge the cultural divide between non-d/Deaf and d/Deaf song signers - specifically through collaboration.

d/Deaf participants aptly identified complementary strengths between non-d/Deaf and Deaf song signers. For example, SD13 and SD14 described that profoundly Deaf song signers have beautiful ASL, but they might struggle with timing and, thus, need to improve their rhythmic sense.

> "Profoundly deaf, they're going to have the beautiful ASL, but they might break the timing. So you need somebody that guides them on the timing part." (SD14)

On the other hand, SD13 and SD14 described non-d/Deaf song signers as missing the vibe and intensity. Non-d/Deaf song signers may also use seemingly awkward signs, due to limited opportunity to communicate with persons in the Deaf community, and miss little nuances and grammatical tendencies.

> "Hearing song signers do the analysis of the song but I see a lot of awkward parts since they lack the ability to express in sign language. From a deaf person's view, there are many expressions directly translated. Thus, their signs are difficult to understand." (SD13)

SD10 described herself as a hard of hearing song signer who has "the best of both worlds" in the non-d/Deaf and Deaf community. SD14 also mentioned that hard of hearing song signers can follow the beat well and have ASL proficiency as well.

> "I try to incorporate both the sound and a strong ASL sign choice, which is the formula that I am still trying to develop. They (hard of hearing) can incorporate more of the nuances of the grammar while still understanding the sound and how to mix that in." (SD14)

By specifying complementary and augmentative aspects of song signing, some non-d/Deaf participants specified opportunities for collaboration between d/Deaf community and non-d/Deaf song signers (S1, S7, S12). S7 desired more interaction with the Deaf community to make his video more accessible. S1 and S12 commented on the complementary strengths of d/Deaf and non-d/Deaf song signers, suggesting that non-d/Deaf song signers and d/Deaf song signers could work together to provide nuances and accessibility from both sides.

> "Hearing song signers can interpret the lyrics well and then deaf song signers can take the lyrics in sign language and express them in completely different meanings. If we discuss how to interpret the lyrics together and use deaf people as role models, I think a better song signing performance will come out." (S12)

S1 suggested that getting feedback from more Deaf people from one's network could be valuable for helping non-d/Deaf song signers improve their work:

> "Probably more deaf, hard of hearing, or interpreter friends. Getting feedback that my interpretations were wrong or inaccurate. Something in me valued expression and passion over accuracy. So I think having more feedback would've made it a lot better. I would've been both accurate and beautiful. And would've continued to offer it with useful and elegant expressions." (S1)

5 DISCUSSION AND FUTURE WORK

Music-oriented technologies have investigated various approaches to making music more accessible to d/Deaf individuals, with a focus on enabling them to appreciate (e.g., [28]), create (e.g., [78, 105]), and perform (e.g.,[45, 84]) music. Recent work that has explored various music accessibility tools for d/Deaf individuals include visual representation, such as captioning [69, 89, 117] and computer graphics visualizer [27, 36], to convey lyrics, pitch, and emotion, and vibrotactile representation, such as wearables [4, 98] and furniture [47, 51], to convey rhythm, volume, melody, and emotion. Multimodal representation tools, such as music streaming apps [67] or specialized hardware with visual displays [71, 83], have also been studied. Our study extends the above research by examining the experiences of music and song signing to d/Deaf audiences (RQ1), challenges and practices involved in song signing creation (RQ2), and potential design and research opportunities to promote Deaf culturally responsive song signing productions (RQ3). Our findings suggest that song signing should be explored in future work as an alternative method of visual representation of music and focus on ways to convey lyrics, emotion, and timing elements of music.

In the sections below, we discuss how to mitigate the challenges in conveying and interpreting musical elements in 3 intertwined layers. First, we extend a nuanced understanding of d/Deaf people's music experiences and the need to reconsider different elements of these experiences when designing tools to make music accessible for d/Deaf people. Second, we discuss the controversy in the Deaf community on non-d/Deaf song signers and how platforms and

contents should be designed so that Deaf culture does not get misrepresented. Finally, we discuss the potential value of diverse forms of collaboration between non-d/Deaf and d/Deaf communities.

5.1 Re-prioritizing musical elements from d/Deaf people's perspective

Our research reinforced the importance of the critical disability perspective when engaging with d/Deaf people. Critical disability theory invites us to question whether deafness is even considered a disability to d/Deaf persons based on their social and structural context [65]. Through this lens, we broadened our frame to examine the diverse values and cultural nuances at play, and reconsidered the notion of "accessibility" of music by d/Deaf people.

Maler accordingly critiqued the epistemic view of d/Deaf music through an "oralist framing", where music is an exclusively auditory or heard experience [62]. From an oralist perspective, technical interventions that aim to help d/Deaf people hear music are viewed as remarkable assimilation into normative hearing culture [62]. In this vein, tools that focus exclusively on devising ways for d/Deaf people to access the heard elements of music (e.g., melody, instruments, intensity) may inadvertently overlook or undermine d/Deaf people's preferences, values, and assets with respect to experiencing music. In our work, we learned that d/Deaf people may prioritize lyrics/gloss, tempo, and emotion over access to pitch, instrument, and volume. To date, however, these preferences are not well reflected in work studying music accessibility for d/Deaf people.

Musical elements such as pitch and instruments have been studied at length. For example, music visualizations create graphic imagery based on musical elements such as loudness or frequency spectrum or instrument arrangement [27, 72, 79, 109]. In addition, existing vibrotactile tools focused on converting audible musical sounds to vibration patterns, varying amplitude, duration, and location as parameters [4, 51, 71, 92]. Although lyrics have received some attention to promote increased accessibility such as captioning technology [57, 69, 88, 117], design work that improves timing (tempo) and emotive expression have yet to be explored.

For d/Deaf people, improving access to the musical elements that non-d/Deaf people can perceive may not always be desired. We encourage exploring opportunities to augment these musical elements that reflect the values and preferences of d/Deaf audiences, and the processes and challenges of both d/Deaf and non-d/Deaf song signers. Specifically, we encourage future design work to focus on the following elements:

- **Lyrics/Glosses:** Both song signers and d/Deaf audiences stressed that lyrics and gloss were the most important elements in music and song signing appreciation. The lyrics/gloss help them understand the message of the song, which in turn assists in song signing interpretation.
  Design Implications: One of the biggest challenges with the semantic translation of lyrics is the availability of resources to help song signers. A central medium where users can obtain summaries and explanations of the lyrics as well as discuss and reason about possible interpretations can aid streamline the semantic translation if/when those resources are available online. Additionally, future work might consider how existing research in NLP-based lyrics interpretation [32, 121], music emotion recognition (MER) [7, 87, 120], and recent advances in human-like text generator (e.g., GPT-3) [21, 35] can be applied to produce smart agents who can assist users on such a medium when there is a lack of existing resources.

  Sign language dictionaries may be used by both d/Deaf and non-d/Deaf song signers as a part of the syntactic translation process. However, Glasser *et al.* have found looking up signs using sign language dictionaries is not efficient [40]. Thus, it may be useful to automatically segment the lyrics, and show users different ways that lyric segments can be signed, how long it would take to sign, and how it might look when signed within a fixed amount of time. This would allow users to select the glosses that they are most comfortable with.
- **Timing:** Rhythm and tempo were commonly referenced as crucial to all participants, helping them "feel" the music and want to move (dance). Coordinating the gloss with the music is important for all song signers, but perceiving and matching to these timing cues of the song may be especially challenging for d/Deaf song signers.
  Design Implications: Existing AI lyrics syncing technologies [38, 58, 81] can be leveraged to provide users with the exact start and end time of different parts the lyrics (such as a line in the song) and the duration of individual words (such as when it is stretched for emphasis). One way to help d/Deaf song signers stay in sync with the music is to develop tools that can assist them in gaining a sense of rhythm (e.g., [83, 110]). Tools could also offer feedback on whether users' movements are synced with the music [5, 48, 122], using techniques such as pose similarity estimation and temporal alignment predictions [122].
- **Emotion:** We found emotion to be a key element of song signing that challenged both d/Deaf audiences and song signers to empathize with the original artist and convey a certain "vibe" through facial expressions and body gestures. Emotion is an important component not only in artistic interpretation but also in communication that can change the meaning of sign language. Conveying emotions precisely in these ways may be more natural and intuitive for d/Deaf persons who primarily use sign language in their communication. For non-d/Deaf people, however, this may involve skill development in acting and performing. Accordingly, some d/Deaf audiences may struggle to decipher the emotive mood and vibe being conveyed by non-d/Deaf song signers.
  Design Implications: Non-d/Deaf song signers may benefit from seeing examples of how to sign with facial expression and how to use signing space [64] to emote. Research on signing avatars to display synthesized ASL with emotion and non-manual signs [55, 99, 104] can be incorporated into tools to help non-d/Deaf song signers observe and practice expressing nuanced moods. Sign language dictionaries can also be extended to include examples of how to perform different signs with different emotions for the same purpose.

  Both d/Deaf and non-d/Deaf song signers may also benefit from tools which can provide feedback about whether the emotion conveyed while signing aligns with the changing mood within a song. This would require an analysis of both lyrics and music from the song [87] and letting users know

how much valance and arousal there is at different points of the song. Existing video and image-based emotion recognition research using facial expressions and bodily gestures [54, 96, 106] can be extended to create computer vision models of how different words and phrases can be signed with different emotions so users can be provided feedback about whether their performance aligns with the song.

- **Other musical elements:** Pitch, instruments, volume, and melody were considered peripheral to d/Deaf audiences' experiences. These elements were occasionally incorporated into song signing only by non-d/Deaf and hard of hearing song signers to enrich the music experience. d/Deaf participants tended to have difficulty discerning and processing these musical elements.
  Design Implications: To help d/Deaf people follow the melody, the pitch, volume, and instruments used at any point within a song should be identified and visually represented. For example, these tools might leverage an Optical Music Recognition (OMR) system [95, 112] to visualize the pitch of a song and provide a video of the original artist's performance as a reference for the signer. Additionally, an instrument extraction model [91, 114] can be used to inform users which instrument is being played in specific parts of the song.

5.2 Acknowledging cultural divide and tension in song signing

Participants articulated how song signing stokes the cultural divide between Deaf and non-Deaf persons (i.e., people who do not identify themselves as belonging to the Deaf community). Representation in arts and media influences social engagement by the Deaf community, and sign language shown in the media not only reflects how Deaf people are treated in society, but also how society's perception or values are implemented and enacted in society [97]. Thus, the precise use of sign language vocabulary and facial expressions to convey emotion matters significantly, as they represent the cultural values of the Deaf community [77].

Through this study, we have come to understand why Deaf people may feel misrepresented and further marginalized in society as song signing that emerges into the mass media (e.g., Superbowl, YouTube) misrepresents their language and cultural community. As others have pointed out [20, 82], our findings reinforce that song signing performances should reflect the cultural and social experiences of Deaf people, and promote and support the Deaf community. Participants confirmed the controversy in the Deaf community regarding non-d/Deaf song signers and the cultural ownership of song signing. Here, we highlight an interesting tension, where non-d/Deaf song signers seeking to learn sign language are rejected by Deaf people (as outsiders or imposters) due to inadequate language proficiency or personal profits from their artistry.

Consistent with findings from Maler and Cripps [19, 60], many of the non-d/Deaf song signers in our study also started creating song signing videos to learn sign language, usually as a part of the course. When ASL students, with limited command of the language, disseminate their productions to non-d/Deaf audiences who largely do not understand sign language, it may offend d/Deaf people whose language is paramount to the representation of their community and culture [33]. For those who know sign language and are part of the Deaf community, videos from non-d/Deaf song signers may be alienating, fetishizing, and in the worst-case scenario, offensive [33], spreading misinformation and misrepresentation to the mainstream. Furthermore, as Pereira argued, driven by financial benefit, non-d/Deaf song signers may get contracted for opportunities instead of Deaf people, which cherry-picks Deaf people's language and culture [82]. Non-d/Deaf song signers who gain online popularity and/or financial profit may therefore be charged with "cultural appropriation" and "clout chasing", and viewed as oppressors. For these compounding reasons, Deaf persons may hesitate to consume, or outright reject, content by non-d/Deaf song signers.

This intense cultural divide may also explain why the right to artistically adapt and create a song signing production - what we refer to as, artistic license - may not be easily granted to song signers outside of the Deaf community. Moreover, this context may leave non-d/Deaf song signers more susceptible to scrutiny and backlash by Deaf audiences over technical interpretations (e.g., adding or omitting words for gloss timing, using poetic glosses or body gestures instead of signing the exact lyrics) that are alleged to misrepresent Deaf language and culture.

Design Implications: To prevent misrepresentation, contents and platforms could provide features that allow song signers to label or tag their videos with information about their (1) motivation and (2) positionality. The availability of such information may enable audiences to make informed decisions about which content to engage with. Also, it can potentially provide context for interpreting the signs used in the videos and help to promote inclusivity and respect for diversity within the Deaf community.

Understanding signers' motivation to learn or adopt sign language is important for successful language maintenance and revitalization [25]. For example, non-d/Deaf song signers might mention that they are trying to learn sign language and use song signing as a way to practice. d/Deaf song signers might indicate their motive to promote Deaf music. This can help audiences understand which videos are likely to contain correct signings and prevents the spreading of incorrect ASL usage.

In addition to providing details about their motivations, it can also be helpful for song signers to include a positionality statement that explains their outsider/insider status in the Deaf community. Understanding the division between 'Hearing new signers' vs. 'Deaf new signers' vs. 'Deaf traditional signers' is instrumental for developing evidence-based sign language policies [25].

5.3 Bridging the divide and weaving the layers through cross-cultural collaboration

Although d/Deaf song signing video tends to garner less viewership [2], Pereira and Aaron discussed that d/Deaf-led song signing can benefit from collaboration with members of the hearing music community to appeal to both d/Deaf and non-d/Deaf audience [2, 82]. Similarly, in our study, we learned about the value of such collaboration, as well as the opportunity for hearing song signers to benefit from collaboration with members from the d/Deaf community. We consider moving beyond traditional notions of "accessibility" for d/Deaf people toward promoting *augmented* musical experiences that synergize the complementary assets of non-d/Deaf and d/Deaf

song signers in ways that promote Deaf culture and representation. Following the expression among disability activists, "Nothing about us without us" [16], our findings indicate there is potential for collaboration that may benefit all audiences.

We found that d/Deaf and non-d/Deaf song signers have complementary strengths and limitations. d/Deaf song signing may be seen as more expressive, natural, clever, and grammatically correct, but may struggle with sign timing. On the other hand, non-d/Deaf song signing may have clearer rhythm and timing, but may lack emotive expression With these contrasts in mind, participants from both interview studies indicated potential value for collaboration between non-d/Deaf and d/Deaf communities, ranging from song signers seeking consultation from the other community to co-creating content with other song signers. We note that collaboration should not be encouraged without taking into consideration concerns about how individuals might get exploited. Researchers may also consider ethical and communication principles, to have culturally sensitive attitudes toward, and adequate experience with, Deaf people and community [8, 118, 119].

5.3.1 Collaboration between community and song signers. Some non-d/Deaf song signer participants showed enthusiasm in consulting with Deaf people as mentors and role models in song signing artistry. They wanted more opportunities for "interaction with the Deaf community" and "getting feedback on interpretations".

Seeking feedback may help song signing artists weave together the technical, artistic, and cultural aspects of song signing. By iteratively seeking feedback and incorporating input from both communities, song signers can improve their work and create performances that are more inclusive and appealing to diverse audiences.

One way, non-d/Deaf persons may guide d/Deaf song signers on matching signs to the timing, rhythm, and intensity of the melody, while also helping d/Deaf song signers decipher the mood and vibe of the original (non-d/Deaf) artist. There are previous examples of such creative partnerships, where non-d/Deaf persons provide support and guidance to d/Deaf song signers. Fisher *et al.* reported '(d/Deaf) Performer and (non-d/Deaf) Feeder [8] relationship' in song signing production enhanced rich and informative interpretation [34]. A similar strategy was suggested to employ a professional hearing team and feature a d/Deaf signer at the center of the production to promote reach to a wider audience [2].

Reciprocally, non-d/Deaf song signers may benefit from consulting with d/Deaf people on the creation of glosses to ensure their signing is linguistically accurate and culturally appropriate. They may learn from Deaf persons how to convey emotive facial expressions and body movements. The contribution of d/Deaf individuals to the production of non-d/Deaf song signing performances may help avoid misrepresenting Deaf culture and encourage non-d/Deaf individuals to learn sign language and explore Deaf culture [2, 90].

Motivating intercultural contact and shared discourse, as encouraged by Schmitt et. al. [97], between d/Deaf and non-d/Deaf communities may lead to more dynamic and engaging song signing performances that appeal to a wider range of audiences. Collaboration between non-d/Deaf song signers and d/Deaf community, as well as between d/Deaf song signers and non-d/Deaf community, may benefit both d/Deaf and non-d/Deaf song signers, as well as audiences who gain opportunities to experience a wider range of performances and deeper appreciations of Deaf culture.

Research and design implications: While some non-d/Deaf participants reported seeking feedback from d/Deaf friends and family members on technical and artistic aspects of song signing, there is limited research and examples of d/Deaf individuals actively contributing to the work of non-d/Deaf song signers. Further research is needed to understand d/Deaf individuals' reservations and motivations to collaborate with non-d/Deaf song signers. This may promote greater understanding and appreciation of Deaf culture among non-d/Deaf individuals and foster more inclusive and dynamic performances.

To facilitate dialogue between d/Deaf and non-d/Deaf communities, one potential approach could be utilizing online platforms and social media to promote collaboration and dialogue between d/Deaf and non-d/Deaf individuals. Mack et. al. have demonstrated the desire of Deaf individuals to share their culture with non-d/Deaf people and the potential of social media as a tool, as many platforms already have a diverse user base [59].

5.3.2 Collaboration between song signers. Toward full collaboration, some d/Deaf audience and non-d/Deaf song signer participants expressed a desire for song signing performances that are co-created by both d/Deaf and non-d/Deaf song signers. An ideal collaboration between d/Deaf and non-d/Deaf song signers would involve both parties working together to create a performance from start to finish, from technical translation to artistic interpretation. This collaboration would be symbiotic, with each party bringing unique and shared expertise to the collaboration. This new form of song signing, as aptly expressed by M3, may lead to "a foothold for coexistence" between Deaf and non-Deaf song signers, creating more technically accurate, emotive, and culturally-acceptable productions, while promoting Deaf artists and Deaf representation that resonate with all audiences. These performances may help render Deaf culture and social participation more visible [62], projecting a sense of 'Deaf-hearing' equality [82].

Design and Research Implications: While the idea of full collaboration, the co-creation between d/Deaf and non-d/Deaf song signers, is appealing, it may not be realistic to expect that all song signers from these communities will be willing and able to collaborate. More modest forms of collaboration, such as inviting members of one community to provide feedback and suggestions to song signers from the other community, may be more feasible and effective in the short term and may even pave the way for full collaborations. Therefore, there is a need for further exploration into ways to motivate and enable collaboration between d/Deaf and non-d/Deaf song signers. This could include examining the feasibility of two-sided collaboration, where both d/Deaf and non-d/Deaf song signers receive feedback on their work, and exploring strategies for encouraging and enabling culturally responsive collaboration.

Future research on collaboration between d/Deaf and non-d/Deaf song signers can leverage insights from studies on other forms of

[8] 'Feeder' is a non-d/Deaf person who works closely with a d/Deaf performer in creating song signing products. A feeder provides cues for ensuring that d/Deaf performers interpret songs within time. This can range from basic timing cues, mouthing of lyrics, and conductor-like indications of dynamic patterns, to a full, behind-the-camera, mutually created embodied interpretation.

artistic collaboration between these communities, such as music-making [105], dancing [15, 43], and theatre acting [13, 103]. Additionally, there is potential for tools that facilitate collaboration between d/Deaf and non-d/Deaf song signers in a socio-technical environment. Extending prior work on using deep generative AI in music co-creation [108] could help speed up the process by offering recommendations for lyrics interpretation or video editing. To fully realize this potential, it will be necessary to gain a better understanding of how d/Deaf and non-d/Deaf song signers communicate and coordinate during the collaboration process, including their use of digital resources and social networks.

6 LIMITATIONS

Aligning with prior research [78], almost all of the d/Deaf audience participants (N=11) use hearing aids or have cochlear implants that enabled them to hear up to a certain range. [9] Although similar studies (e.g.,[64]) often include participants who use hearing aids or cochlear implants to assist their ability to hear music, we acknowledge this may limit the transferability of our study to d/Deaf persons who have no access to the auditory features of music. We note there exist different levels of hearing impairment, including profoundly deaf, and differing usages of devices, including no devices, that may encompass very unique and contrasting musical interactions that future work may explore.

As shown in Table 2, we enrolled more non-d/Deaf song signer participants (N=10) than d/Deaf song signer participants (N=4). We acknowledge that our study may have limited discourse from d/Deaf song signers; however, the demographics of the participants align with the larger existing song signing performer population. It is common for song signers to be non-d/Deaf, especially on YouTube [2, 19, 20, 60]. Finally, some of non-d/Deaf song signer participants also work with the Deaf community (e.g., Deaf school teachers, and official sign language translators) and thus can provide insights pertinent to the d/Deaf and hearing communities.

7 CONCLUSION

In this paper, we discuss semi-structured interview results from 12 d/Deaf audiences and 14 song signers. We learned from d/Deaf audience participants that lyrics were one of the most central elements in a song which helped them engage with the music, understand the original artist's intentions, and interpret the song's meaning; participants also valued being able to understand the tempo and emotion in a song. Participants felt that song signing augments musical experiences with an additional level of accessibility. However, there were perceived differences between performances by d/Deaf vs. non-d/Deaf song signers which made content by d/Deaf performers more culturally-responsive and acceptable. From interviews with d/Deaf and non-d/Deaf song signers about their process and experiences with creating song signing content, we identified 3 intertwined layers of work in the song signing process – technical translation, artistic interpretation, and cultural representation. Participants discussed how their proficiency in sign language, ability to hear the music, prioritization of different musical elements, and membership in the Deaf community impacted their process, the content they created, and their acceptance by the d/Deaf audience. Our findings suggest important considerations for future work exploring how to make music more accessible: re-prioritizing musical values from the d/Deaf perspective, acknowledging cultural division and tension, and facilitating collaboration between d/Deaf and non-d/Deaf communities to create culturally responsive content.

[9] It is estimated in 2018 that about one-third of people with hearing loss wear hearing aids, a number that increases every year [74, 115]. National Institute of Health (NIH) estimated, as of 2019, approximately 736,900 cochlear implants have been implanted worldwide. In the United States, roughly 118,100 devices have been implanted in adults and 65,000 in children [75].

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