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Going Beyond the I With CI: an Interview-based Design Space

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Abstract

Deaf and hard-of-hearing (DHH) individuals using cochlear implants (CIs) often have regular jobs or enroll in mainstream education where they face complex social challenges. While first HCI interventions targeted this group's communication skills, or compensated for limited sound perception, we instead focused on experiential aspects like fatigue and feeling different from others. We moved beyond individual-focused design by engaging interaction-partners to share responsibility for overcoming social barriers. This work identifies generative, intermediate-level design knowledge, addressing common interaction-level challenges. A design-oriented, thematic analysis of interviews with 14 CI users revealed four subsequent themes: invisible, shifting hearing demands; misunderstandings and social impact; strategies for managing interaction barriers; and emotional, relational costs. Mapping these themes to HCI concepts like seamfulness, social translucence, and proxemics highlights open-ended, concrete design opportunities that support socializing beyond functional access. Framing interaction success as shared responsibility broadens inclusive design discourse for DHH populations and wider disability design spaces.

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CCS Concepts

• **Human-centered computing**; • **Human computer interaction (HCI)**; • **Empirical studies in HCI**;

Keywords

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1 Introduction

As deaf and hard-of-hearing (DHH) individuals with cochlear implants (CIs) are increasingly integrated into mainstream education and work [36, 111], it becomes increasingly important to focus on ensuring fair access to social participation in these settings, which often still presents a complex challenge. Approximately 5% of the world's population is DHH, experiencing mild to profound hearing loss in their better ear [128]. CIs, surgically implanted neural prostheses, are commonly used to provide or restore speech perception in cases of severe to profound sensorineural deafness [126, 132]. CIs improve access to verbal communication and thus contribute to the integration of DHH individuals in predominantly

hearing environments [4, 36, 111], further driven by inclusive education policies [108]. For example, in the Netherlands¹, about 40% of school-age CI users attended mainstream secondary schools between 2007 and 2018, often with language and academic skills on par with those of hearing² peers [111]. Similarly, CI users can be employed across a range of work environments, showing employment characteristics comparable to hearing colleagues [36]. Yet, hearing difficulties and barriers to full communication and social participation across school and work settings remain well-documented challenges [21, 28, 36, 63, 70, 78, 97]. Addressing this is crucial, as access to the social world is fundamental for social-emotional development and well-being in school years and beyond [67, 99, 120]. Unresolved barriers pose an increased risk for mental health issues [65], experiencing peer problems [99], and feelings of stress, insecurity, loneliness, or isolation [21, 63, 97, 100, 130].

Socializing in daily school and work settings can be challenging due to multi-speaker interactions [97, 98], interfering background noise, and/or reverberant room acoustics [3, 112]. Environmental noise and reverberation greatly reduce speech understanding for CI users, even for those with near-typical language reception in quiet conditions [35, 57]. Additionally, reduced directional hearing limits spatial sound perception, including the ability to localize speech and monitor peripheral cues in social spaces [134]. Engaging socially in settings with difficult hearing conditions, in an attempt to maintain ‘normalcy’ and develop relationships with hearing peers [97, 98], is cognitively demanding [54] and socially straining. CI users’ social interactions thus often rely on continuously integrating fragmented auditory input with visual cues [5, 117] (e.g., speechreading, body language, peripheral vision), and using self-advocacy strategies (e.g., requesting clarification) when key information is missed and communication breaks down [63, 118, 130]. While hearing limitations are often invisible, failing to meet social expectations and conform to interaction norms can lead to stigma and exclusion [129], increase self-consciousness, emotional energy drain [63], and hesitation to ask for help [130]. Consequently, supporting CI users’ daily social interactions requires attention to cognitive, emotional and relational dimensions shaped by social and environmental factors. Recognizing this complexity is crucial for designing interventions that move beyond perceptual support to more holistic inclusion.

Most Human-Computer Interaction (HCI) research on CI user inclusion in mainstream social contexts focuses on overcoming practical challenges such as supporting speech understanding [39, 72, 80, 85, 93, 94, 104] and access to peripheral sound information [37, 44, 45, 55, 62]. The CI itself is a successful example of a clinically deployed interface between human (at the auditory nerve) and computer (speech processor) that restores or enables speech understanding [132]. Work on CIs and related HCI technologies (assistive devices, (interactive) training interventions, etc.) has made valuable contributions by designing technology to help improve the lives of CI users and expanding opportunities for participation in mainstream society. HCI has only begun to examine how technology can address aspects beyond functional accessibility, such

as stigma [96]. As Bennett et al. [6] and Shinohara & Wobbrock [106] argue in the broader context of HCI for social interaction, assistive technologies must consider the environment and context of use, including social and relational dimensions of technology, while maintaining a human-centered focus. For instance, while student-teacher microphones support listening in classrooms, they are often rejected because they put CI users in an unwanted spotlight, increasing self-consciousness and stigma [97, 130].

First-, second-, and third-person perspectives provide a framework for understanding how technologies intervene in situated contexts, addressing these concerns [24, 81, 113]. The first perspective emphasizes soma-aesthetics and the felt bodily experience of being in the world [53, 81, 86]. The second emphasizes interaction, empathy, and attunement with others. The third takes a detached, more objective stance. While current approaches often mediate sensory experience (first-person), they rarely address broader aspects of lived experience, such as feeling othered (second-person). Most interventions targeted changes at the level of CI users, whilst limited research has explored interventions in physical environments (e.g., via interactive floors [61]) or aimed at social change [83, 84, 102, 103, 116, 122]. Yet, this is rarely done with the aim to apply technologies in mainstream, dynamic, face-to-face scenarios, leaving significant room for exploration. To our knowledge, only since the last decade there have been calls for interventions that target environmental adaptation, reduce responsibility on DHH individuals, and promote broader awareness among peers [84, 99, 103, 114, 123]. Such approaches fit within community-based accommodation [64] and interdependence frameworks [6, 87], wherein all people (regardless of ability) are seen as inter-reliant and access is treated as relational. The scarcity of such approaches in work surrounding DHH individuals, and specifically CI users, reflects a persisting medicalized view, where design seeks to fix perceived deficits rather than remove systemic barriers, which is a perspective assistive technologies should move away from [82]. Some work with DHH and CI users has addressed these concerns by highlighting DHH people’s voices and agency in generating design direction, analyzing community-based ‘DIY hacking’ initiatives [91] or through speculative participatory design [2, 25]. These approaches integrate first- and second-person perspectives, are user-centric also in terms of values and needs and avoid perpetuating ableist assumptions; we extend them with a third-person perspective, adding the more contextual and objective view on them, where, and how barriers occur. This ableist concern aligns with central issues in disability studies concerning the questioning of power relations in research [15].

Our contribution. We examined CI users’ social experiences in mainstream school and early work life through a design focused lens. By focusing on mainstream-integrated CI users (a distinct and growing sub-group within the DHH population), we aimed to address a gap in accessibility design research. CI users are often framed through a medicalized lens as patients and recipients of hearing technology, while simultaneously appearing as “non-disabled” and thus overlooked in design work that targets more visible accessibility needs. Their experiences are also frequently conflated with those of broader DHH populations, making it hard to identify potentially unique design implications grounded in communication contexts and identity. We identified four themes of

¹The Netherlands are relevant for this study, as they are the primary research location.

²In the context of DHH research, non-DHH individuals can be referred to as ‘typically’ or ‘normally’ hearing, with diverging opinions on what is appropriate. In this paper, we use ‘hearing’ (vs. DHH) individuals for simplicity, acknowledging aural diversity as a spectrum [27].

interaction-level challenges that offer opportunities for intervention. These themes capture both functional and subtle emotional or relational challenges, expanding the scope of current HCI research. Using reflexive thematic analysis with abductive reasoning, we linked empirical insights to established HCI and HCI-adjacent concepts, extending intermediate-level³ design knowledge [51, 52] to inform HCI work in the current context. Our goal is to provide a structured lens that broadens the solution space and guides design thinking without prescribing specific interventions. Staying grounded in CI users' experiences, we aim to offer concrete and actionable guidance for technologies (e.g., ranging from interactive floor projections to nudging cues that guide non-CI users) by proposing a set of design principles that address both access and lived experience, situating existing HCI interventions within a broader design space, and enriching ongoing discourse on disability in HCI to support work towards more inclusive, context-sensitive, and non-medicalized design approaches.

2 Related work

Researchers and practitioners across HCI, assistive technology, audiology, and related fields have explored how technology can support CI users' participation in interactions with hearing individuals. Prior work can be grouped into three areas: (1) technologies that train DHH users' skills, (2) technologies used only by DHH users during interactions, and (3) technologies used collaboratively during interaction (including those targeting the environment). The first two address interaction challenges at first-person level, while the third intervenes at second- or third-person level. Table 1 summarizes this work.

One research direction focuses on extending CI users' skills to prevent or manage interaction challenges. For children, interventions have supported learning skills for social interaction and peer collaboration through interactive multi-sensory rooms [43], language literacy, and speech learning systems ranging from PC/mobile to robots and XR [133], including a playful environment-embedded solution to playfully teach children with CIs language skills by engaging their body [61]. For DHH children in general, sign language training has been a primary focus, although this is less helpful in mainstream settings, highlighting the need for technologies that help DHH children, including those with CI, to flexibly access hearing environments [133]. Training interventions have also been developed for speechreading acquisition in older adults [46, 47].

Beyond training, much work has aimed to enhance CI users' real-time interaction capabilities, particularly by providing missing important sensory information important in social contexts. The CI itself augments hearing and, like conventional hearing aids, is clinically developed. A well-established group of assistive technologies includes remote microphones that improve speech understanding in noise [85], although their design does not fully support dynamic, multi-speaker settings, which remains a challenge under development [22]. Other mature approaches draw on the visual

modality, such as automatic speech recognition for live transcription on mobile devices [80, 104]. Experimental approaches have extended this further through augmented reality, displaying subtitles on head-mounted displays [93, 94]. HCI has also explored more novel directions: affective captioning to represent speech prosody through a haptic wearable [75]; and sensory substitution systems that expand sound perception, situational awareness, and auditory localization through visual and haptic cues delivered via mobile or wearable devices [37, 44, 45, 55, 62]. These approaches highlight the importance not only of understanding speech content but also perceiving the broader social environment in which interaction is situated. At the individual level, psycho-social aspects have received less attention, though some research has explored reducing stigma and supporting self-expression by modifying the visibility and aesthetics of devices through decorative covers or personalized skins [96].

Moving beyond individual-focused designs, some work has examined how technology can mediate collaborative problem-solving between DHH and hearing interaction partners. These efforts include collaborative correction of captions [72] and design of communication application features [105]. In the context of live or online DHH captioning technology development, controlled experiment studies have explored how captioning affects hearing partners' speaking behavior [102] and which partner-side adaptations in speaking behavior benefit DHH individuals [103, 104]. Related work has explored how features of captioning-related technology can better support mixed-hearing group communication [83], and how communication norms are established in such scenarios [84]; outside of captioning, qualitative work has similarly explored the natural emergence of shared accessibility practices between DHH and hearing colleagues during partner exercises [123]. While several findings are relevant for social interactions in dynamic, real-life mainstream contexts, implications can only be made partially and speculatively. For example, inferring how virtual meeting facilitation might translate to face-to-face interactions without captioning, or how the emergence of shared practices in a formal collaboration scenario might relate to developing mutual supports in unstructured social settings. On the other hand, some studies have shifted away from real-time mediation, instead aiming to build awareness of DHH experiences through immersive or gamified experiences for hearing individuals [116, 122]. Such approaches are valuable, as CI users often receive self-advocacy training as part of rehabilitation, but evidence suggests self-advocacy alone has limited impact on social participation without active support from peers [30]. This raises the question of how technology could better facilitate this support, whether through awareness-building or real-time mediation of behaviors in dynamic social situations. While this remains underexplored for CI users, HCI research in other domains shows that human behaviors can be influenced through mechanisms of 'technology-mediated nudging' that can leverage cognitive biases [14]. For instance, designs may encourage sustainable practices by making otherwise invisible energy consumption visible [40, 41, 48, 66], or public-floor projections of walking trajectories can enhance social awareness [88].

Given this gap in HCI research "beyond individual-focused designs", particularly regarding CI users in mainstream contexts and

³Intermediate-level design knowledge is knowledge useful to designers, which is more abstract than design instances (artefacts), but less abstract than general theory [17, 51, 52], thus maintaining some specificity to be generative and inspire ideas when applied to a use context.

Table 1: Overview of related work in HCI, highlighting areas of the current design space for CI-user social participation enhancement.

Intervention Type	Target of intervention (e.g. capability to enhance)
Training DHH person	Social interaction & peer collaboration skills [43] Speechreading skills [46, 47]
Technology used by DHH person	Sign language, literacy, language & speech skills [61, 133] Sound perception / situational awareness [37, 44, 45, 55] & auditory localization [44, 62] Speaker recognition (in captioning) [124] Speech understanding / recognition in general [80, 93, 104], in groups [94], in noise [39, 85] Speech prosody perception in real life [75] & in captioning [76] Modifying visibility (addressing stigma or self-expression) [96]
Beyond individual-focused designs	Collaborative captioning / collaborative design for captioning [72, 105] Technologically mediated (specifically online and in-person captioning) [83, 84, 102–105] and unmediated [123] adaptation of TH communication behaviors DHH awareness [116, 122]

the need for designs that support real-life, dynamic, face-to-face social interactions, our preliminary research questions were:

- **Understanding challenges.** What can the interaction-level challenges observed in this group’s daily social experiences reveal about design needs, friction points, and pressures that design could help address?
- **Connecting empirical evidence and theory:** Which concepts from HCI or adjacent fields can help bridge between lived experiences and the design solution space? Which concepts support moving beyond individual-focused designs towards perspectives of interdependence or shared responsibility?
- **Informing design practice:** What concrete design guidelines can HCI practitioners derive from these concepts, and how might these be applied to specific pain points identified for the target group?

3 Methodology

3.1 Study Aims and Approach

This study analyzed interviews with CI users through a design lens to identify interaction-level challenges in mainstream social contexts and generate design-relevant insights. Using reflexive thematic analysis [12] with abductive reasoning [115, 121], we connected participants’ experiences to concepts such as social translucence, seamfulness, and proxemics (definitions in Table 2) and identified open-ended HCI design directions. Finally, we translated these conceptual insights into actionable implications for HCI by proposing a set of concrete design guidelines to support CI users’ (and, by extension DHH individuals’) social interactions.

3.2 Participants

Fourteen CI users (seven female; age 17-34) participated⁴, four from Germany and 10 from the Netherlands. Participants were recruited

⁴This study is part of a larger interview project in which participants were interviewed on various topics. Based on this dataset, one manuscript is already in preparation besides the current one (see 3.4). One participant excluded in the original study due to age was included here, as the present analysis explicitly considers young adulthood and work life.

via the Otorhinolaryngology Department of Leiden University Medical Center, as well as through word-of-mouth, CI-related events, and associations. Inclusion criteria were having at least one CI, experience with mainstream education after primary school, and being over 16 years old (maximum age was flexible, if participants could still comfortably recall details of secondary or higher education). Participants’ school and early work experiences spanned mainstream secondary (n=5), vocational or higher education (n=7), and employment (n=2)⁵.

Hearing loss and CI timelines varied widely. Age at first implantation ranged from seven months to 24 years and eight months. Eight participants had bilateral implants (one of whom only used one CI), while the remainder were implanted unilaterally and four used a conventional hearing aid on the contralateral ear. Detailed participant information is described in the primary study report (see [79]).

3.3 Interview Materials & Study Design

We conducted 14 interviews, of which 12 were retrospective semi-structured, open-ended interviews and two in-situ go-along interviews, providing complementary insights into CI users’ lived experiences. The semi-structured protocol was co-designed with two CI users to ensure appropriateness and reduce researcher bias. Topics explored participants’ everyday social interactions at school or work, how these related to their built and social environment, which strategies they applied to adapt to challenges, how they used and related to their devices and identity, and what they wish designers, architects and “magical” solutions would solve for them in the future. Open-ended questions allowed interviewers to follow participant priorities and explore topics in depth.

Semi-structured interviews were conducted in person (n=8) or online (n=4) via video call, in participants’ native languages (Dutch or German); the interviewers were matched for language proficiency. Interviewers (first author and two psychology master’s students) received guidance from a DHH researcher, including

⁵Numbers indicate participants’ school or work context at data collection, though interviews often covered both current and past mainstream experiences (e.g. school, vocational training, and work).

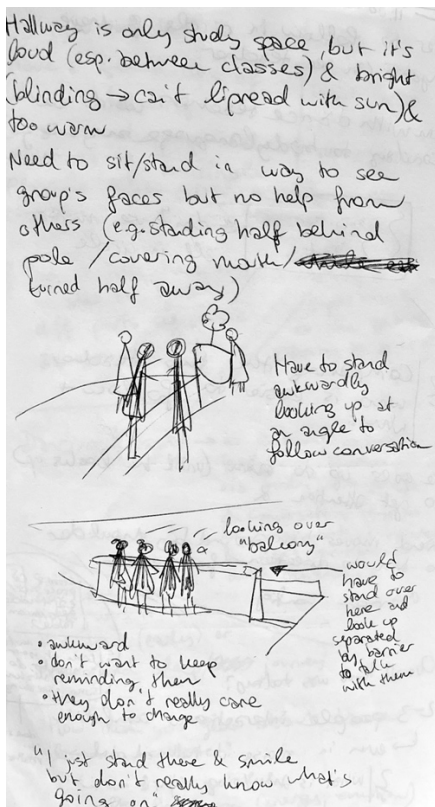


Figure 1: The left image shows fieldnotes taken during a go-along interview. The fieldnotes consist of written and sketched observations about the way participant and interaction-partners positioned themselves in relation to each other and the surrounding space, annotated with additional comments about things the participant said and the researcher's own thoughts. The right image is a photograph, taken during a go-along interview, showing the architectural space and people sitting and standing within it.

test-interviews and preparatory advice. Participants used spoken language; accommodations included previews and printouts of questions. In-person audio recordings were transcribed manually, and online interviews with automated transcripts were manually checked by the interviewer, who then translated all transcripts to English, which was then double-checked by a second translator for accuracy.

Go-along interviews [73, 74] (n=2) involved following participants through a university day, observing lessons, lunch breaks and transit between classes, and conducting brief on-site interviews initiated either by the participant to provide additional information or by the researcher, prompted by situational context and observations. This method captured contextual and subtle, sometimes subconscious, behaviors that are difficult to access through traditional memory-based interviews. The first author collected fieldnotes, audio recordings and environmental photos, see Figure 1. Participants reviewed the final reports for accuracy. Interviews were conducted in English. Go-alongs required pre-established trust, so within the research scope they could only be conducted with two participants where familiarity had been built over multiple prior meetings. Example situations included joining a participant's

lunch break at medical school, and observing dance lessons at a university, including interactions with teachers and peers.

3.4 Analysis

We conducted a design-focused secondary qualitative analysis, making use of pre-existing interview data [49] (see companion paper [79]) to investigate the questions as formulated in this study. Our goal was to identify interaction-level challenges for CI users in mainstream schools and early work environments that could inform HCI design, generating design-relevant insights rather than generalizable claims (cf. prior design-space analyses of qualitative data [90]). This analysis was built on our familiarity with the dataset from an earlier study (see [79]) with a different focus using thematic content analysis with multiple coders (first author and three master's students) and inductive coding [10, 11]. We did not reuse any original codes or themes, yet this prior work informed our understanding of the data and guided the identification of interaction-level challenges. This familiarity also helped determine that the scope of the content within the dataset provided a sufficient basis to fulfill the goals of the current study, as the present paper's focus aligned closely with the open-ended and

experience-centered interview protocol that produced the dataset. The protocol can be found in the primary study report (see [79]). Revisiting existing data was both practical and ethical: the dataset was rich enough to address new questions [49] while avoiding additional burden on CI users and circumventing issues around data sharing and privacy, since the data remained within the same research team [20]. We acknowledge that prior familiarity with the data inevitably shapes interpretation; consistent with our abductive and reflexive approach as described below, we treated this not as a source of bias to be eliminated but as a resource for generating new theoretical and design insights. Iterative discussion with co-authors supported awareness of these influences and helped ensure that interpretations remained grounded in data while open to alternative framings. Finally, through the review process, which included CI/DHH users with HCI expertise, we decided to highlight a previously only touched-upon aspect related to effort and fatigue, by adding two additional excerpts.

Our analytical approach combined thematic analysis (TA), as commonly used in HCI research [9], with abductive reasoning [115, 121]. In line with Braun and Clarke’s reflexive TA [12], we treated themes as interpretive accounts of meaning patterns (for designing) rather than descriptive categories, acknowledging the researcher’s active role in generating them. Abductive reasoning complemented this by moving iteratively between data and theory, enabling the development of new conceptual links rather than only applying existing frameworks or claiming a purely inductive stance. This was especially valuable in a secondary analysis, where previous work inevitably shapes familiarity with the dataset; abduction leverages that prior knowledge as a resource for seeing the data anew, rather than treating it as limitation [121]. In sociology, abduction has been described as a way to generate theory from surprising data excerpts [115]; in our case, it helped map CI users’ lived experiences to HCI and design concepts not previously applied in this context, while remaining grounded in the data.

Specifically, we followed Timmermans and Tavory’s [115] steps of (1) revisiting the phenomenon, (2) defamiliarization, and (3) alternative casing, revisiting each iteratively. The first two steps involved reviewing the dataset and prior codebooks to apply a design-oriented lens and see the data from a different angle. We then iteratively identified interaction-level challenges, each loosely linked to potential design directions (e.g., reframing “invisibility” as a challenge to “designing for visibility”). Step three involved considering alternative framings and linking the phenomenon to different literatures and concepts. Developing and updating a codebook supported transparency and helped clarify theme boundaries. In line with reflexive TA, our emphasis was not on treating coding as a neutral process or demonstrating inter-rater reliability, but on constructing clear, well-defined interpretations of participants’ experiences that could inform and inspire design [12]. The secondary analysis was conducted by the first author, whose prior role in the original study ensured an in-depth understanding of the dataset when conducting the secondary study. Additionally, following the suggestion from Elliot et al. [32], a colleague from another institute who was up to then unfamiliar with the data was asked to review the analysis and suggest some elaborations.

3.5 Ethical Considerations & Positionality

Ethical approval for the collection and use of interview data, including its use in follow up, design-related research (by the same researchers), was obtained through Ethics Committees from two institutes: Leiden University (PSY) Ethics Committee (no. 23-3036) for semi-structured interviews, and University of Twente (CIS) Ethics Committee (no. 230611) for go-along interviews. All participants provided informed consent, were debriefed and could stop participating at any point.

Our work is informed by social-environmental models of disability and practice-oriented CI care. While none of the authors are DHH, prior collaborations with DHH researchers (e.g. on the same dataset) and CI users have shaped our awareness of their diverse perspectives. We view challenges related to inclusion arise not because of deafness itself, but as a mismatch between CI users’ capabilities and mainstream environments designed around normative assumptions. We acknowledge the validity of CI users’ varied identities (d/Deaf, hearing, disabled, non-disabled), intersectionality (e.g., multiple disabilities, socio-economic factors, gender) and their implications for design. By adopting a non-deficit lens and framing challenges as a shared responsibility for DHH and hearing individuals, we aim to open dialogue on ‘truly inclusive’ design of technologies for CI users and the wider DHH population. As Western researchers, designers, and doctors, we recognize that our cultural context and privilege shape our perspectives [32].

Given our reflexive, abductive analytical approach, inferences were necessarily influenced by the coder’s disciplinary and social background [12, 115]. In this case, the first author’s background in interaction design and cognitive science (including human behavior and perception), as well as previous experiences researching CI users’ lived experiences influenced choices made during the analysis.

4 Results

We present four subsequent themes from our analysis. **Theme 1: Invisible, shifting hearing demands** (4.1) captures the situational complexity of CI hearing and the difficulty of conveying it to hearing partners, which complicates establishing common ground. **Theme 2: Misunderstandings and social impact** (4.2) describes consequences of this gap, including communication breakdowns and misinterpretations when others fail to recognize causes or show limited empathy. **Theme 3: Strategies for managing interaction barriers** (4.3) examines how CI users and partners prevent or repair barriers, highlighting which information supports behavioral change. **Theme 4: Emotional, relational costs** (4.4) outlines the challenges CI users face with current strategies, revealing design considerations and potential pitfalls. Each theme concludes with an open-ended design prompt. Subsection 4.5 links **empirical data to HCI design knowledge**, showing how insights were interpreted in connection with design-relevant concepts.

4.1 Theme 1: Invisible, shifting hearing demands

Participants described their hearing as shifting with environmental conditions. Changes in group size, positioning, or background sounds could make the difference between feeling engaged and

becoming exhausted. Shifts often involved subtle factors like speech direction and clarity: “[When speech is] less loud and clear, from behind, from the side, not directed at me... it doesn’t have to be perpendicular, but straight in front of me or something. Then it’s easy. And if it’s not like that, so a bit from the side, from behind, soft, mumbling, then it’s difficult.” (P1) Visual cues also became critical under certain conditions: “In places where there’s a lot of noise. Then I think it’s about 60% lip reading. Maybe even more... I am really fully dependent on lip reading in busy places” (P2).

While these demands required constant adaptation, they were often invisible to hearing peers. One participant’s peers unknowingly obscured visual lines by turning their backs or moving behind a column. Some peers did not seem to realize that they were excluding the CI user by talking in the noisier part of the room. Others noted that interaction partners rarely recognized the effort behind maintaining conversation. Shifting demands were closely tied to fatigue, one participant noting “it makes you tired, very tired...I’m completely exhausted by the afternoon...I must constantly fill in what others are saying...That just takes up energy” (P3). Two years after implantation, one participant noted that, while with their CI provided more information than their previous hearing aid (resulting in “less effort to understand someone”), “training your brain and processing all those signals really costs me a lot of energy” (P13). Yet participants felt that their tiredness and effort was not typically visible to others: “No one directly asks how it feels or how I experience it...People don’t realize the emotional or social burden...At least not that it’s due to my CI” (P2). Beyond fatigue, other unique sensory and emotional experiences could be tied to CI use, invisibly impacting participants: a program version that sounds echoey (“it drove me crazy” (P3)), feeling a door opening without hearing it when the CI is off (“it’s kind of scary” (P12)), if the “CI starts making crackling sounds on its own” in quiet (P13), suddenly losing sound when the CI falls off or after forgetting to charge and bring spare batteries.

CI users emphasized that while others might assume hearing was stable and effortless based on their own experience, their experience was one of constant adaptation. “I’m seen as a normal hearing person...So they expect me to hear everything” (P3). Another reflected: “I’m in the hearing world as a deaf person thanks to my CI...that gives me many possibilities, but it’s also very limiting because hearing people don’t know what it’s like to be deaf” (P2).

Technology added another layer of shifting unpredictability and ‘unrelatability’ for hearing people. Device programs could work differently depending on the context. As one explained: “I have a program on my CI... it looks around me like, is it crowded? And if it’s very crowded, then it will only play sound from what I’m looking at [but sometimes] people don’t know how to talk to me so that I understand it...” (P4). Users adjusted programs, volume, or external microphones to match their needs, yet these changes would not automatically be known by others. One participant highlighted this variability: “I have four programs, I can set ForwardFocus⁶ anywhere, I can adjust mic sensitivity, volume, treble and bass, I can connect external devices...” (P5). Another described that when connected to a teacher’s microphone, they could not hear peers nearby. Others used additional classroom microphones, but the priority between

channels was invisible to peers, making it unclear when the CI user was available to listen.

CI users sharing their experience proved difficult because it could not be compared to that of hearing individuals. “What it’s like to hear through CIs...I can’t explain that. Because I don’t know any different. I don’t know how they hear, and they don’t know how I hear” (P1). One participant wished for “a kind of audio replica of my hearing. Or CI users” (P6), while acknowledging that even such a tool would need to reflect how variable CI hearing is.

Open-ended design prompt: How might we make hearing status or effort noticeable to interaction partners, and which aspects of it are relevant for smooth interaction?

4.2 Theme 2: Misunderstandings and social impact

Invisible and shifting demands often led to misunderstandings. In group conversations, participants described falling behind and quietly disengaging when speech overlapped or moved too fast. One participant explained: “People talk over each other. So, I often ... just thought, I’ll just do something on my phone for myself. That actually having a conversation wasn’t really worth it” (P1). Such withdrawal could be misread, creating worries about identity and self-presentation: “In groups of hearing people, if you can’t keep up acoustically, you start to pull back, and then you come off as weird. In a way that you actually don’t really want to appear. And ...that puts you into a difficult situation. You can’t fully express yourself, you can’t show who you are, because you fall short in communication” (P5). Another simply wished “to not come across as awkward, to avoid the fear of saying something wrong” (P3).

Mishearing or guessing wrong also created tension. One participant recalled: “They’d look at me like I was strange, especially if they said something sad and I laughed...I’d say something wrong because I couldn’t follow the conversation... they would often call me dumb” (P3). Another participant only realized later that they had misunderstood: “I gave a completely off-topic answer...I didn’t notice anything, he walked away with a completely confused look on his face, so that makes me think, what did I miss. So, at that time, I thought I was catching everything” (P7). This kind of error could lead to prejudice: “People then develop such harsh prejudices and mostly they don’t really tell you usually and then you just notice it over time” (P8).

Missing cues to respond was another common source of misattribution. “He kept trying to talk to me from the side...I didn’t respond at all. Because I didn’t hear him!... unfortunately, he thought I was arrogant and didn’t care about what he was saying” (P5). Similarly, another explained: “If I don’t respond, people quickly judge, what is she rude, what is she arrogant, she ignores me, why doesn’t she respond” (P2). Withdrawing, misunderstanding, not responding, but also talking too loudly when not hearing oneself could all be misread as flaws in character, intelligence or taken personally, rather than being recognized as consequences of hearing limitations.

Especially when fatigue amplified irritation, consequences could cause strain in relationships. “I had this issue with my friend where we would quickly get irritated with each other and have arguments...fatigue makes me more irritable and I show more irritation towards others, which isn’t always pleasant” (P3).

⁶ForwardFocus’ is a CI feature [19].

Frustration could also arise from mismatched expectations and lacking nuanced understanding of deafness and CIs. *“The others would just get annoyed, like ‘... he interrupted again, because he doesn’t understand anything. You’ve got hearing aids, right? So just listen”* (P9).

Open-ended design prompt: How could we help establish common ground or reveal hidden barriers to prevent misunderstandings or unbalanced interactions?

4.3 Theme 3: Strategies for managing interaction barriers

CI users employed a wide range of strategies to prevent or repair breakdowns, often centering on positioning and environmental control. They sought quiet spots, good lighting, or supportive seating arrangements. *“Facing each other is usually ...better than sitting next to each other, but if you’re sitting next to each other, you can also turn towards each other ... talking in my direction”* (P1).

One participant described how, in a group with mixed hearing abilities, everyone contributed to reducing barriers: *“Is it quiet? ...are we not sitting right in the sun, so that when the person looks at us, they can’t see the mouth because they’re blinded by the sun, but also that we ourselves aren’t blinded by the sun...Can everyone see everyone? Because sometimes...one person is blocked by another, and you can’t see that person’s mouth... which person has which better ear? Some people just have a specific ear where they can hear or understand much better”* (P9).

Managing large group conversations was harder, but some identified specific conditions that helped, such as turn-taking and spacing: *“You can have a very large group, but ... if everyone listens to the person speaking, and then there’s a turn-taking, so the next person is pointed out ... if there are people talking over each other, but... people are standing far enough apart”* (P7). Technology sometimes helped reinforce these behaviors, even leaving lasting habits: *“When they have the microphone, they themselves learn to listen to the others ... without talking over them...that has really become ingrained in the group”* (P8).

Hearing people could take an active role in supporting interaction; in some cases, peers noticed breakdowns quickly and adapted: *“They notice it faster if I haven’t heard something... they also know that they should look at me”* (P4). Others adjusted environments, paused conversations to fill gaps, or shifted to quieter spaces: *“They notice or explain it again. They always look for quieter spots and ask if it’s too busy here ...In class, if they notice that I need some rest, they give me that rest... they stop the conversation for a moment for me and say, ‘Oh, we’re talking about this’, and then they continue”* (P3). One CI users’ colleagues with DHH experience were also proactive, for example closing doors or moving to another room to reduce noise.

In many cases, a key strategy for CI users to prevent issues was to first explain their needs: *“Whether it’s for the hearing impaired or for the hearing people, to make it easier for them to find common ground”* (P9). Awareness of one’s own needs was not always immediate, as one noted: *“You first have to become aware of what your needs actually are. Because you can’t communicate them to others if you don’t even know what you need...Not everyone needs the same thing”* (P10).

Open-ended design prompt: How might we support or enhance existing coping strategies (building on CI users’ own adaptations, but including the interaction-partners) making them easier, more efficient, or more natural?

4.4 Theme 4: Emotional, relational costs

Although CI users employed many coping strategies, these often came at a significant cost. A central issue was the asymmetry in responsibility. CI users often carried the main burden of making communication work, while hearing partners contributed less. Many CI users accepted this imbalance as inevitable, with one participant saying they *“don’t want to be a burden either”*, while recognizing *“it’s also exhausting for the other person...when you’re not really understanding”* (P5). Still, others wished that interaction partners would share more of the effort.

This asymmetry was tied to the invisibility of challenges. Subtle strategies such as lipreading or orienting positions demanded constant cognitive and physical energy, yet those efforts were often unnoticed. *“I’m the one who always makes sure everything runs smoothly...I’m trying to figure out... how you can shape it so that you don’t always lose so much energy... so that you’re not always the one who has to adjust everything”* (P2). Another noted: *“It can sometimes be really exhausting, especially because you have to keep moving your head in all directions and can’t just say, ‘Yeah, I can hear you anyway’”* (P10).

When others were not aware of breakdowns, CI users had to step in explicitly, which came with costs of its own. Repeated reminders of their deafness were *“the tiring part, or the more effortful one”* (P9). Interrupting conversations to ask for repetitions could *“kill the flow of conversation”* (P9), prevent them from joining group moments (*“it’s too late to ‘join’ the group laugh”* (P11)), feel impolite, or even create irritation on both sides: *“They get irritated too, and then I get irritated ...I don’t want to ask again, and I feel guilty or stupid...I’d rather not, and then you get this awkward silence...”* (P3). At times, others dismissed requests altogether: *“The response from the other person is, ‘Oh, it’s not that important... in that moment, the other person is essentially deciding for you”* (P10). As another said: *“We want to decide for ourselves what’s important to us and what’s not. And when you’re just dismissed like that, it’s frustrating”* (P5).

Self-advocacy also involved disclosure, which brought a new tension. Speaking up meant drawing attention, risking negative judgements, and standing out as someone needing help. Some weighed whether the benefits justified the exposure: *“You don’t want to put too much emphasis on it...I’ll just let it go, because I won’t change anything anyway”* (P10). Others struggled with labels: saying ‘hard of hearing’ sometimes lead people to overestimate them, while ‘deaf’ triggered black-and-white responses, helpful where hearing partners *“look for ways to communicate via body language, via signs, to convey things differently”* (P7) or exaggerated where hearing partners *“act strange like talk very extremely etc., that’s not even necessary”* (P11). A few preferred to avoid disclosure entirely when possible: *“Usually, I just try to avoid it. I just like it when people see me as a normal person”* (P12). Across cases, the common thread was the desire for control over when and how to reveal their needs.

Participants agreed that these costs could be reduced if others were more proactive. One wished that their peers would occasionally check in: *“If, for example, I have a strange expression on my face because of a misunderstanding and then ask: ‘Hey, did you somehow not understand that just now and should I repeat it again for you?’ ...It happens far too rarely”* (P8). Another described how valuable it was when others showed patience and understanding: *“Not many people do that, you know...try to read me when I can’t hear. Try not to get irritated if I don’t understand something after three attempts...Explain it again [...] showing understanding, trying to see when I can’t hear and when I can. It’s very difficult, but it would be very nice if someone could say it again without me having to ask”* (P3).

However, as many participants emphasized, such proactive support was often lacking because the cues that would prompt it were invisible. Others would *“simply forget in that moment that you’re dealing with certain limitations”* (P10). Where people had learned through repeated reminders, behaviors could become automatic: *“Just like my friends now naturally sit to my left. I’ve had to tell them many times but now they do it automatically”* (P2). But reaching that point came at the CI user’s expense. Without more visible, shared cues, the asymmetry of responsibility remained.

Open-ended design prompt: (How) could we support or generate empathy and understanding among hearing interaction partners? How might we mediate interaction challenges, reduce disruption, encourage shared responsibility, and give CI users control over personal disclosure? What information should be shared, and what should remain private?

4.5 From empirical data to design knowledge

During the analysis we iteratively related empirical observations to theoretical concepts. These concepts do not map directly onto single themes but instead cut across them, capturing recurring mechanisms in CI users’ experiences. For example, proxemics illustrates how positioning in groups can invisibly alter hearing conditions (theme 1) while also serving as a strategy to sustain interaction (theme 2). Table 2 presents concept–data links, showing how each concept connects to aspects of CI user experiences found in interviews (as described across 4.1–4.4).

5 Discussion

In this paper we addressed a current gap in the HCI design space to support CI users’ social interaction. We drew on interview data to highlight interaction-level challenges, which were interpreted through a design lens and connected with HCI concepts to develop intermediate-level design knowledge. Here we discuss the **usefulness of this approach to expand the design space and inform future HCI work** (5.1), how insights from this work **extend discourse on designing for CI users and beyond, providing concrete design guidelines** (5.2 and 5.3), and **limitations and future directions** (5.4).

5.1 The usefulness of intermediate-level design knowledge: How do these concepts extend the design space for CI social interaction?

We set out to connect empirical data with theoretical concepts to exploit their potential to inspire new design directions, aiming to

expand the design space rather than prescribe solutions. Following Höök and Löwgren [52] and Stolterman and Wiberg [110], we drew on ‘strong concepts’, intermediate-level knowledge abstract enough to be generative yet concrete enough to guide several design instances. We included two established strong concepts [16, 17, 51] – ‘grounding’ and ‘seamfulness’, and added ‘proxemics’, previously characterized as (umbrella for) sensitizing concepts in HCI, also proving useful as generative instruments in the design process [71]. We also included principles from human-centered disciplines, such as perception and social behavior, which offer valuable insights but limited direct design guidance. By examining prior use contexts in design, we provide parallels to translate insights from other domains.

To address disparities in **situational awareness** between CI users and hearing peers, one avenue is to enhance hearing partners’ sensitivity to factors relevant to the CI experience. Prior HCI work has visualized situational cues in augmented-reality headsets to support awareness while balancing cognitive load [127], and encoded spatial distances via haptic interfaces to improve team play and situational awareness in a 3D game [95]. Analogously, designers could scaffold CI users’ situational information and convey it visually or haptically to hearing partners, enabling them to perceive, interpret, and anticipate interaction challenges. For example, hearing partners could become aware of noise levels that impact the CI user or lighting conditions that affect speechreading in real time.

This links to **mutual awareness and social presence**, which emerged as a key factor in interaction breakdowns, misattribution by hearing individuals, and asymmetrical efforts by CI users to manage barriers. Social presence has long been a design goal in HCI for teleconferencing, speech interfaces, social robots, and embodied agents [8], as well as awareness systems for computer-mediated communication [56]. In these systems, social presence supports monitoring others’ activities, facilitating emotional and informal communication, and increasing a sense of connectedness [58]. Unlike most prior work, in face-to-face interactions both partners share physical space and are human yet may still fail to fully relate. Designing to establish mutual awareness can go beyond functional considerations, drawing from subtler cues that convey feelings of connectedness, mutual understanding, and relatability to help overcome functional barriers, but also foster empathy. Designers could explore translating insights from digital mediation to semi-real-time interfaces for in-person interactions. For example, instant messaging systems use online status indicators to increase social presence [56]; analogous features could signal when CI users are receptive, accounting for device status, speaker distance, or environmental noise.

Practical guidance on how to approach issues around mutual awareness come from the concept of **grounding**, which has informed human-robot interaction [17] and effective computer-supported cooperative work (CSCW) through visual interfaces [50]. Tools like Joint Action Storyboards [50] illustrate how interface design can reduce grounding costs. This could be highly relevant here, as many CI users’ strategies for managing barriers function as acts of grounding, often incurring high cognitive and social costs. Applying design insights to existing or new interfaces to reduce

Table 2: Concepts, their definitions, and connections to findings from interviews.

Concept	Definition	Connection to empirical data
Situational Awareness [127]	Part of perception; consists of (1) perceiving and detecting environmental elements, (2) comprehending and interpreting them, and (3) predicting the environment's future status based on this [127].	<ul style="list-style-type: none"> - CI users are sensitive to environmental elements that hearing partners may miss (e.g., background noise, sun glare, visual occlusion), and try to act on them to optimize the situation. - Hearing people are often unaware of how (much) environmental factors affect CI users' interaction experience.
Peripheral Awareness [1]	Part of perception; the ability to monitor surrounding information without directing full attention [1].	<ul style="list-style-type: none"> - CI users monitor multiple speakers and surroundings with partial attention, relying on vision or other cues to compensate for limited peripheral auditory input; some information may still be missed as attention is focused on managing interaction. - Some intentionally reduce the scope of peripheral monitoring (e.g., focus on only one person in a group). - Success depends on hearing partners' behavior (e.g., voice orientation, turn taking).
Mutual Awareness & Social Presence [7,8,56]	How people in a mediated or shared environment perceive each other, recognize each other's presence, and anticipate being perceived; cognitive states involving mental models of others [8]; "activated when a user feels perceived access to other intelligence and its reaction to the user in any social interaction" [56]. Mutual awareness, related to social presence in HCI [56], refers to reciprocal awareness of / attention to each other's' sensory properties [7].	<ul style="list-style-type: none"> - Hearing partners often do not perceive CI users' effort or fatigue. - Lack of awareness when CI users are missing information, needing repetition, or struggling – no awareness of sensory properties (on both sides). - Experienced partners show better mutual awareness.
Grounding / common ground (for joint action) [18,50,125]	Interactive and dynamic process of establishing and maintaining mutual knowledge, mutual beliefs and mutual assumptions – i.e. common ground [18, 50] to support coordination and alignment; interaction partners can e.g. "increase the predictability of timing and content" to support alignment to coordinate dialogue [125], anticipate each other's capacities, and clarify when understanding breaks down.	<ul style="list-style-type: none"> - CI users explicitly ask for repetitions, clarifications, or adjustments to re-establish understanding. - Breakdowns in communication highlight gaps in shared assumptions. - Maintaining common ground often requires one-sided effort.
Social Translucence [33]	How systems can make socially relevant information visible to users to support awareness, accountability and shared understanding; seen as fundamental requirement to support communication and collaboration. For instance, people could adjust their own actions if they could anticipate how constraints affected a group's interaction. Being aware that <i>others</i> are aware of constraints also played a role [33].	<ul style="list-style-type: none"> - CI users' effort and barriers are often invisible to hearing partners, so accountability falls mostly on CI users. - Invisibility of hearing limits or fatigue makes spontaneous support difficult. - If social cues were visible, hearing partners might have a better basis to be proactive. - Yet avoiding <i>transparency</i> matters to CI users; desire to manage which information should be visible to reduce vulnerability.
Seamfulness [16,59]	Deliberately revealing system constraints or boundaries to reveal complexity, ambiguity or inconsistency; empowers users to take advantage of limits, adapt more flexibly and effectively by appropriating and personalizing them for their own use [16, 59].	<ul style="list-style-type: none"> - CI users exploit their hearing limits to manage conversation, e.g., turning towards a better ear. Also, in their use of assistive devices, when they "expose" usage limitations and features they can be used strategically. - Making constraints visible could help hearing partners act more effectively; (mutual) awareness of "seams" supports flexible adaptation dynamically / spontaneously.
Proxemics [71]	Structuring of social interaction through spatial arrangement of people to each other and their environment. Sub-concepts include proxemic malleability (range of socio-spatial configurations: distance, orientation, facing), threshold (difficulty of changing configurations), and gravity (tendency to return to default configuration) [71].	<ul style="list-style-type: none"> - CI users adjust to optimize who they can hear. - Considerations include avoiding glare, ensuring line of sight for speechreading, and ear orientation. - Spatial adjustments can go unnoticed or require reminders for hearing partners but are critical for participation.

these real-life grounding costs for CI-hearing interactions represent a promising research direction.

We also highlighted the role of **peripheral awareness**. Prior HCI research has explored expanding DHH individuals' peripheral awareness to compensate for limited auditory input (e.g., [62]), as well as how peripheral monitoring of sound helps identify events, things, places, status notifications, and maintain social awareness in factory settings [1]. In group settings with CI users, designers could explore augmenting peripheral awareness for one or both interaction partners to better manage complex cues, such as those needed for turn-taking, extending beyond directional sound to highlight key signals that guide multi-person dynamics.

Proxemics can inform design for CI users by highlighting how spatial relationships shape interactions, including proxemic malleability, thresholds, and gravity [71], which may differ for hearing individuals. CI users receive direct feedback about whether a spatial configuration works to include them, but others may not notice, instead adjusting based on attention, comfort, habits, environmental dynamics (such as other people moving and shifting positions to maintain space or distance) and so on. Technology could mediate hearing participants' spatial behavior to support CI users, for example with approaches like interactive floor projections like Snibbe's boundary functions [60, 107], which model subtle, shared spatial signaling to enable proactive positioning without explicit cues.

Seamfulness offers a design lens for addressing breakdowns caused by hearing interaction partners being unable to adapt dynamically to CI users and appropriate barriers by seeing where the 'seams' are and what they look like [52]. Here, these seams are system or situational constraints (e.g., factors that are inhibiting communication) invisible to hearing partners. While seamfulness has more notably been applied to digital systems, it also informs designs that reveal partners' current possibilities where people collaborate in real-time, but in separate virtual spaces – exploiting "seamful revealing of sensing, communication and structure" [16]. Translating this to face-to-face interactions, designers could use seamful approaches to make CI users' effort or engagement visible, for example via cues inspired by affective clothing [89] or other dynamic interfaces, helping hearing partners better understand and respond to interaction constraints.

Social translucence highlights subtle design concerns that go beyond functionality, helping designers remain sensitive to relational dynamics. Originally applied in CSCW to remedy social blindness in digital systems and support communicative symmetry [33], social translucence can also inform mediating real-world interactions for CI users, where social blindness still occurs. A key principle is the tension between translucence and transparency: making social information visible while preserving privacy. CI users already navigate this tension through strategies balancing disclosure and vulnerability. Prior work may sensitize designers to consider which information (e.g. about CI users' inner states) to share, how it may affect CI users, and how to give users agency, aligning with Shinohara and Wobbrock's [106] call for socially acceptable design.

Our analysis scoped a design space for technologies that support real-time, face-to-face collaboration between CI users and hearing interaction partners. Lived experiences revealed barriers

and opportunities for supporting mutual engagement, suggesting designs that enhance others' awareness of CI users' sensory and situational states, reduce the need for constant explanations and interrupted conversations, and distribute responsibility for successful interaction. At the same time, they expose key design constraints: preserving CI users' control over what is shared and minimizing potential vulnerability or overexposure. By linking to concepts used in HCI, we created bridges across domains that support creative, 'out of the box' thinking by mapping solutions from other contexts to this one. Because many design ideas relate to bodily cues, spatial awareness, and sensory experience, future work may consider using embodied interaction [26] as a lens for designing intuitive, context-sensitive solutions. Framed through first-, second-, and third-person interventions, our design directions extend the underexplored second-person level (here referring to design at the intersection between two or more people) and highlight the 'felt' qualities of first-person experience [86, 113]. By focusing design on mutual attunement in dyadic or group interactions, we move away from seeing CI users as clinical subjects who need to be supported to match established norms in mainstream environments.

5.2 Reflections on future design for CI users in mainstream settings and beyond

This work emphasizes shifting responsibility from DHH individuals to include interaction partners, strongly relating to Wang et al.'s notion that communication "requires both parties to take responsibility" [122], extending the scope of prior work in this direction in the context of mixed hearing-ability interaction [83, 84, 102–104] to include real-life, unstructured social interaction scenarios with a focus on CI users in mainstream settings. This contributes to broader discourse on fairness and removing pressure from, for example, disabled individuals in the context of inclusion, aligning with frameworks like interdependence theory [6, 64, 82, 87]. Beyond fairness, focusing only on technology 'reducing' disability risks leaving users vulnerable, for example when a CI fails with no fallback, but also accounting for technology being most (or only) effective when their context of use enables it. As McDonnell et al. note: "captions cannot work unless people are willing to work with them" [83], and we make a similar case for CI-use in social contexts.

This section translates empirical insights and intermediate-level design knowledge into actionable design implications for HCI. Table 3 summarizes six design principles (DP1-6) that define opportunities for technology to scaffold mutual awareness, adaptive behavior and balanced disclosure in face-to-face socializing between CI users and hearing interaction partners. We then illustrate how these principles can be operationalized through three types of nudging strategies [14] that encourage partner-side accessibility behavior while preserving CI users' agency, linked to themes and concrete examples in this study.

Facilitator nudges: supporting peers who want to help but lack awareness [14]. Our analysis highlighted that CI users' peers were often willing to adapt their behavior, yet a lack of DHH experience meant this rarely happened proactively or effectively. Other studies similarly reported that creating accessibility in mixed hearing-ability interactions can require an "onboarding" process

Table 3: Design principles for HCI-mediated, face-to-face socializing between CI users and hearing interaction partners in mainstream settings.

Design Principle	Description (<i>linked concepts from 5.1.</i>)
(1) Raising awareness for the global (environmental) situational context	Make environmental factors that affect CI users' effort/energy/sensory experience visible to hearing peers (e.g., lighting, noise, distance cues that impact speechreading or audibility). Help peers anticipate challenges and adjust behavior, e.g., proactively changing locations (<i>situational awareness, mutual awareness</i>).
(2) Minimally disruptive, dynamic mutual-awareness signals	Provide moment-to-moment cues that indicate attention or conversation breakdowns without interrupting conversation flow and reducing grounding effort, e.g., subtle indicators that CI users didn't hear a word or need clarification. Enable smoother repair and avoid misunderstandings (<i>mutual awareness & social presence, grounding</i>).
(3) Making invisible effort (and other states) visible	Make slower-changing cues like (increasing) fatigue, felt listening effort, or device status perceptible to others. Enable others to adapt interaction onset, pacing, adjust expectations and support empathy (<i>seamfulness, social translucence</i>).
(4) Proxemic defaults with low social cost	Mediate physical positioning and orientation of interaction partners through (ambient/personal). Help hearing peers naturally adopt supportive behaviors without explicit negotiation, explanation or reminders, e.g., guiding distance, relative positioning or orientation (<i>proxemics, peripheral awareness</i>).
(5) Support smooth interaction flow and turn-taking coordination	Guide (group) conversation dynamics to reduce interruptions or misunderstandings, e.g., augmenting cues to follow turn-taking, signal need for pauses, monitoring conversation speed or complexity. Support maintaining optimal conditions without relying on verbal intervention to adjust (<i>grounding, mutual awareness, peripheral awareness</i>).
(6) Translucent not transparent & disclosure control	Balance visibility and privacy/agency by letting CI users decide when and what to reveal about inner states, engagement, or environmental needs; carefully design nature, target and trigger of signals / nudges. Maintain shared responsibility without increasing vulnerability or creating overexposure (<i>social translucence, seamfulness</i>).

with a significant learning curve for hearing people, demanding time and effort from both sides, though shared practices can eventually emerge [84, 123]. As in the present study, hearing individuals sometimes adjusted speaking behaviors unproductively, e.g., overrenunciating, slowing too much, or yelling unnecessarily [6, 84, 103, 123]. Difficulty relating to each other's needs could lead to helplessness, strain and frustration. As these needs are often situation-dependent, varying with environmental conditions or the CI users' energy level, effective adaptation becomes a complex task.

This example presents a concrete design opportunity (DP1-3). Previous work suggests that technologies providing continuous or punctual feedback on speech behaviors can enable automatic speaker self-regulation and behavioral change [13, 68, 83, 102]. HCI designs could scaffold dynamic calibration of interaction partners' speech rate, intensity, enunciation, gesturing, pause timing, maintaining dynamic intonation and eye contact, as well as subtly notify others when communication breaks down [84, 103, 104, 123]. Possible mechanisms for real-time face-to-face scenarios could transmit nudges via haptic signals or visual feedback triggered by the DHH person or automated monitoring. Incorporating sensors for environmental conditions like sound or lighting (DP1) or status indicators for the DHH users' energy level (DP3) could further guide system thresholds to deliver nudges or be conveyed to increase partners' empathy. Notably, nudges may be designed intentionally to achieve a learning effect (even after removal of the intervention) when they prompt active reflection rather than subconsciously influencing behavior, and timing nudges more frequently at the beginning may

speed up initial adoption of new behaviors, though this should be calibrated carefully to avoid overload [14].

Beyond targeting hearing peers, such systems could support DHH users in adjusting their own behavior [84] and developing a more conscious understanding and vocabulary for expressing needs, requesting accommodations, and identifying issues to thematize with healthcare providers to optimize use of assistive technologies like CIs.

Signal nudges: maintaining consistency when intention and awareness already exist [14]. Even peers who know which behaviors support CI users often fail to maintain them consistently: turning away mid-sentence, forgetting to stay on the better-hearing side, or talking over others as group conversation intensifies. This might be approached similarly as facilitator nudges but shifting the focus from teaching new behaviors to sustaining known ones without tiring or disruptive reminders. There is a HCI opportunity in gently reinforcing proxemic alignment (DP4) through subtle or implicit cues that avoid interrupting conversation flow [84]. Laboratory research considering the spatial reception ranges of CI users [77, 101] could inform visualizations that make these ideal communication zones visible and thus actionable to interaction partners. For instance, through floor projections around speakers that help others orient naturally.

More "private" approaches (considering DP6), such as personal AR glasses, could provide peripheral feedback to maintain visual alignment. For example, partially obscuring the user's view when turning away from a listener, rewarding continued face-to-face alignment with restored visibility (building on the idea of adding

and removing friction [14]). Similarly, systems supporting group conversation dynamics (DP5) could use implicit cues to maintain orderly turn-taking, such DHH conversation norms may need to be adopted by mixed-hearing groups to achieve accessibility [84, 123], inspired by one participant's note that passing a microphone naturally encouraged speakers to wait their turn, even after the device was removed in later interactions. To sustain habits, designers should avoid overly frequent nudges that might cause saturation and reactance [14]; continuous, automatic feedback may be more effective than disruptive manual alerts. Further, developing systems that offer guidance rather than simply drawing attention might avoid accidentally generating ambiguity and confusion [84].

Spark nudges: motivating adaptation when initiative is low or friction for behavior change is high [14]. When hearing peers strongly resist supportive behaviors, nudge-based mechanisms may not be effective [14]. Yet, in many cases, resistance seems to reflect low awareness or perceived inconvenience rather than unwillingness due to ill will. Here, HCI design may support increasing empathy, reducing friction, and leveraging social motivation. Social influence nudges that leverage the tendency to keep commitments previously made, or raise visibility of positive or negatively valued actions to exploit social desirability or herd instincts could encourage adaptation [14] (e.g., gamifying certain behaviors without singling out CI users as “recipients” of the intervention). However, designers should avoid punitive or competitive mechanisms that risk reinforcing inequalities, e.g., by accidentally suppressing already shy individuals [84].

Given that deafness can still evoke stigma or negative judgement, privacy and agency are critical (DP6). Thus, designers should carefully decide when and how information is shared: privately with target individuals, to a group via a shared ambient interface, or across participants individually [83]. Approaches should remain flexible to user preference, recognizing that making disability visible is not always desirable and may differ across individuals and situational contexts [6].

Additional consideration across nudge types. Designers must also consider the practicality and cognitive impact of nudge mechanisms, avoiding distraction, overload, or habituation [14]. A hybrid strategy may balance impact and feasibility: for example, using more elaborate systems (AR glasses or haptic feedback for multiple participants, virtual reality, interactive floors...) for short-term training or awareness exercises (e.g., [116]), complemented by lightweight, scalable tools (smartphone or wearable apps) for long-term use in daily life.

Taken together, the proposed design principles conceptualize accessibility as an ongoing, co-created competence achieved through mutual adaptation and technological mediation. The goal is to enable all participants in social interaction to be effectively inter-reliant and ease natural processes of developing attunement and “access intimacy” [6, 87]. Importantly, all interaction partners may have gaps or strengths, meaning that DHH individuals are not only recipients of support but also active contributors where their capabilities complement others' [6].

5.3 Implications for wider DHH populations, accessibility, and inclusion in HCI

By examining CI users' experiences, this work extends discourse on embodied interaction and assistive technology by highlighting design at the boundary between body and device. CI users' auditory experience is inherently technologically mediated, raising implications for design both at the level of the implant [96] and for external systems that interface with it [23].

While our focus was not to draw strict comparison between CI users and other DHH populations, this study contributes to the limited HCI work addressing the lived experiences of CI users without collapsing them into the broader DHH population. This does not imply an absence of overlap: rather, understanding distinct sub-groups can inform how general accessibility approaches and experiences may translate across user profiles [103]. The discussion below outlines CI-specific implications alongside broader, transferable considerations for HCI design.

CI-specific considerations and unique HCI opportunities. CIs bypass the auditory pathway entirely, transmitting electrical signals directly to the cochlea. This can lead to fragmented signal quality, limited spatial hearing [134], and high susceptibility to reverberation [3, 69, 77]. Listening fatigue may arise not only from increased processing demands associated with auditory device use in complex listening situations [54] but, for CI users, electrical stimulation itself may affect their hearing experience (e.g., uncomfortable electrode behavior or nerve co-stimulation), especially as stimulation levels are not always stable over time [119]. Participants described sensory, cognitive, and emotional strain associated with CI use; some struggle with an intense cognitive load to process auditory input even years after implantation. Several participants removed CI processors to rest, especially in the morning or after prolonged use, highlighting the potential for design interventions that help monitor and manage stimulation levels or reduce awkwardness and vulnerability of integrating listening breaks in daily life.

CI users also face sudden, sometimes complete, auditory loss when processors fail, run out of battery or are displaced, occasionally accompanied by internally generated sounds or phantom auditory sensations. Such moments of vulnerability highlight the importance of shared responsibility approaches, where hearing peers collaborate to sustain communicative access without fully relying on technology. In contrast, hearing aid users often retain residual hearing, likely making temporary interruptions less disruptive. These differences remain speculative in design terms and point to the need for future work that carefully reports hearing profiles sufficient detail.

CI users may also deal with distinct nuances of social challenges: hearing partners often overestimate their hearing ability and underestimate when support is needed [38]. Whether other hearing technology users experience this to the same extent remains unclear, but in both cases, designs that visualize listening states or environmental accessibility could help correct misperceptions and more fairly distribute communicative effort.

The hybrid architecture of CIs (where external processors are upgraded more frequently than the internal part) further opens

space for user-facing interface design. Providing transparent information about device state, program settings, or coupling status (e.g., with phones or accessories) could assist both users and peers in coordinating communication. Similar design logistics could benefit other established hearing technologies.

Finally, form factors raise additional design challenges. The size of external processors and magnetic coupling mechanisms can interfere with other wearables or XR/VR headsets, complicating cross-device compatibility. Concerns about CI weight or size, magnet stability, or dislodgement also shape everyday usability differently than, e.g., hearing aids. These embodied frictions suggest further opportunities for inclusive hardware and interface design that accommodate the use of multiple, complementary technologies at the same time.

Overlap and wider implications: broadening the audience. Despite such device-specific factors, most social participation challenges observed, such as conversation breakdowns, fatigue, stigma, or discomfort in expressing and advocating for needs, are widely shared across DHH individuals with and without implants, as evident from several mixed-DHH studies [31, 32, 92, 100, 114, 131]. Hearing exists on a continuum, and the design principles proposed here (e.g., fostering shared responsibility, mutual awareness, and adaptive feedback) can extend to other DHH individuals who rely primarily on spoken language and whose deafness is often “invisible” in mainstream environments. Evidence from related, non-CI specific HCI work [83, 84, 102–105, 123] shows that such mechanisms are a promising direction to reduce communication asymmetries, support attunement, and make access feel natural rather than compensatory.

Furthermore, modern hearing aids often share functionality with CIs (e.g., noise suppression algorithms and beamforming, Bluetooth connectivity, directional microphones), reducing the salience of technical distinctions for many HCI purposes. The more meaningful divide may instead be sociocultural: between DHH individuals who depend on spoken language and seek to blend into mainstream contexts, in comparison to those who primarily communicate through non-verbal modalities or strongly align with Deaf culture. For the former, subtle awareness cues, proxemic feedback, and adaptive environmental systems may help sustain social inclusion without exacerbating stigma. Still, ideas related to proxemics also keep relevance in culturally Deaf contexts, as exemplified by their relevance in DeafSpace architectural principles [29, 42].

Overall, this work contributes to HCI discourse on design beyond functional access, emphasizing how technology shapes both social perception and self-perception, linking to design for acceptability [106]. Unlike groups with minimal access to mainstream settings, CI users in this study often navigated hearing contexts with few functional barriers, highlighting the need for HCI to move beyond enabling basic participation toward making access feel natural and affirming. Their experiences of an “invisible” disability highlight questions of when to make limitations visible and how technology mediates belonging, identity, and appearance, which are considerations that extend well beyond CI users to many DHH individuals navigating similar social and communicative dynamics.

5.4 Limitations

Our study has four primary limitations that should be taken into consideration. **(1) Researcher positionality and users’ experiences.** Methodologically, our results were derived from a third-person perspective [24] on CI users’ experiences. This approach is inherently shaped by researcher biases (here, hearing) and well-documented limitations of thematic analysis [12]. Future work should incorporate methods that more directly foreground CI users’ experiences and values in order to guide design directions, reducing the risk of misinterpretations or external assumptions about users’ wants and needs [2]. This would also help avoid systematic frustrations that can arise from ‘hearing assistive technology’ not designed in a situated, user-centric way [91]. For instance, participatory speculative design workshops have been used with deaf participants to explore desirable qualities of technologies beyond assistance or accessibility [2], and with older DHH adults to envision possible futures that frame divergent hearing as a possibility rather than deficit [25]. While the former relates primarily to sign-language contexts, the latter produced ideas that align with our directions, such as making visible who a DHH person is listening to. Since the user populations in these studies differ from those in the present work, follow-up research should examine how our findings correspond to the preferences, needs, and values of CI users more representative of the current population.

(2) Sampling boundaries, CI-specificity, and transferability. Besides validating findings for the current population, future work should also expand the participant pool to diversify lived experiences and refine or extend design implications. Our study included 14 participants, all with at least one CI, Dutch or German, aged from adolescence to early adulthood. This relatively narrow sample limits the range of experiences captured in terms of culture, CI care and procedures, audiological functioning, and life stage. Shared national, educational, and healthcare contexts may also shape attitudes toward technology use and rehabilitation options, such as access to speech-language-therapy, psychological coaching, self-help groups and parent information. While participants’ study and work experiences covered a broad spectrum of settings from desk jobs, university and high school to performative arts, adolescence and young adulthood are life stages where concerns around stigma and fitting in may be more pronounced [34, 99, 109], potentially affecting experiences with CI use and negotiating peer interaction in ways that likely differ from older adults or small children. These factors should be considered as potential constraints for the transferability of findings to other countries, age groups, and educational or work contexts, which provides an interesting direction for future work investigating such potential differences.

In addition, while many experiences reported by participants (such as conversation breakdowns, listening fatigue and social concerns) overlap with experiences of other DHH individuals, our study did not include non-CI DHH participants. This was an intentional design choice to focus on CI-specific experiences, but it nonetheless limits the ability to directly compare or generalize findings across the broader DHH population. Subsection 5.3 outlines CI-specific versus more widely shared considerations, and future work could

include non-CI DHH participants to clarify whether proposed design guidelines are equally relevant for non-CI DHH individuals in similar settings and beyond.

(3) Limited perspectives of hearing interaction partners. Hearing interaction partners were not directly included in data collection. Consequently, their perspectives on awareness, willingness to support, and challenges in maintaining common ground are inferred from participants' accounts rather than captured firsthand, with the exception of two interviews where a CI users' mother and partner joined to provide limited comments, as well as two go-along interviews providing direct observations of hearing interaction partners' behaviors during interactions with CI users (yet interpreted via CI users and researchers). While this focus aligns with prior work that similarly uses DHH perspectives as a starting point to shape design directions that also affect hearing partners [83], it limits insights into the dynamics of shared responsibility within mixed-hearing interactions. Future work should incorporate both DHH and hearing participants to more fully address the interactional dimension of accessibility, following methods such as McDonnell et al.'s mixed-group co-design workshops [84] or more structured experimental research set-ups by Seita et al. [105]. Such approaches could help refine, extend and evaluate the design principles and nudging strategies proposed here, ensuring they support collaborative negotiation of accessibility in real-world contexts.

(4) Analytical scope and interpretive boundaries. Finally, our analytical approach relied heavily on creative connection-making, informed by the researcher's background knowledge. While transparency mitigates some potential issues, the analysis was conducted by a single researcher, not taking advantage of the benefits of multiple perspectives and backgrounds in coding and interpretation, especially to support the alternative casing stage in abductive reasoning [121]. Consequently, the set of interpretations and concepts presented is not exhaustive. Future work could build on this intermediate-level knowledge by revisiting and extending interpretations from new perspectives. The primary contribution of this paper is to fill a gap in design knowledge for the context of CI users and to encourage further exploration. This incompleteness should not be seen as a limitation of the findings themselves, but as a motivation to continue the discourse and investigation.

6 Conclusion

This work contributes to expanding the design space of technologies for CI users' social interactions in mainstream contexts, highlighting directions of how HCI can support shared responsibility between CI users and their interaction partners. By connecting empirical insights from interviews with HCI concepts such as seamfulness and proxemics, we identify opportunities for context-sensitive interventions that address cognitive, psychological, and relational aspects of interaction barriers. Our analysis offers intermediate-level, generative design knowledge and concrete design principles that can guide future research and design for inclusive social interaction, emphasizing nuanced dynamics of awareness, grounding, and empathy. These insights extend current discourse on accessible and inclusive design, suggesting directions for both CI-specific interventions and broader applications in disability-focused HCI.

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References

- [1] Petter Alexanderson. 2004. Peripheral awareness and smooth notification: the use of natural sounds in process control work. In *Proceedings of the third Nordic conference on Human-computer interaction* (NordiCHI '04), 281–284. <https://doi.org/10.1145/1028014.1028057>
- [2] Robin Angelini, Katta Spiel, and Maartje De Meulder. 2025. Speculating Deaf Tech: Reimagining Technologies Centering Deaf People. In *Proceedings of the 2025 CHI Conference on Human Factors in Computing Systems* (CHI '25), 1–18. <https://doi.org/10.1145/3706598.3713238>
- [3] Javier Badajoz-Davila, Jörg M. Buchholz, and Richard Van-Hoesel. 2020. Effect of noise and reverberation on speech intelligibility for cochlear implant recipients in realistic sound environments. *The Journal of the Acoustical Society of America* 147, 5: 3538–3549. <https://doi.org/10.1121/10.0001259>
- [4] Seong Hoon Bae, Sang Hyun Kwak, Gi-Sung Nam, and Jae Young Choi. 2019. Educational Status in Bilateral Prelingual Deaf Children with Cochlear Implantation. *Journal of Audiology & Otology* 23, 3: 135–139. <https://doi.org/10.7874/jao.2018.00521>
- [5] Clémence Bayard, Laura Machart, Antje Strauß, Silvain Gerber, Vincent Aubanel, and Jean-Luc Schwartz. 2019. Cued Speech Enhances Speech-in-Noise Perception. *The Journal of Deaf Studies and Deaf Education* 24, 3: 223–233. <https://doi.org/10.1093/deafed/enz003>
- [6] Cynthia L. Bennett, Erin Brady, and Stacy M. Branham. 2018. Interdependence as a Frame for Assistive Technology Research and Design. In *Proceedings of the 20th International ACM SIGACCESS Conference on Computers and Accessibility*, 161–173. <https://doi.org/10.1145/3234695.3236348>
- [7] F. Biocca and K. Nowak. 2001. Plugging your body into the telecommunication system: Mediated embodiment, media interfaces, and social virtual environments. In *Communication technology and society*. Hampton Press, 407–447
- [8] Frank Biocca, Chad Harms, and Judee K. Burgoon. 2003. Toward a more robust theory and measure of social presence: review and suggested criteria. *Presence: Teleoper. Virtual Environ.* 12, 5: 456–480. <https://doi.org/10.1162/105474603322761270>
- [9] Robert Bowman, Camille Nadal, Kellie Morrissey, Anja Thieme, and Gavin Doherty. 2023. Using Thematic Analysis in Healthcare HCI at CHI: A Scoping Review. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems* (CHI '23), 1–18. <https://doi.org/10.1145/3544548.3581203>
- [10] Virginia Braun and Victoria Clarke. 2006. Using thematic analysis in psychology. *Qualitative Research in Psychology* 3, 2: 77–101. <https://doi.org/10.1191/1478088706qp063oa>
- [11] Virginia Braun and Victoria Clarke. 2021. One size fits all? What counts as quality practice in (reflexive) thematic analysis? *Qualitative Research in Psychology* 18, 3: 328–352. <https://doi.org/10.1080/14780887.2020.1769238>
- [12] Virginia Braun and Victoria Clarke. 2023. Toward good practice in thematic analysis: Avoiding common problems and be(com)ing a knowing researcher. *International Journal of Transgender Health* 24, 1: 1–6. <https://doi.org/10.1080/26895269.2022.2129597>
- [13] Esteban Buz, Michael K. Tanenhaus, and T. Florian Jaeger. 2016. Dynamically adapted context-specific hyper-articulation: Feedback from interlocutors affects speakers' subsequent pronunciations. *Journal of Memory and Language* 89: 68–86. <https://doi.org/10.1016/j.jml.2015.12.009>
- [14] Ana Caraban, Evangelos Karapanos, Daniel Gonçalves, and Pedro Campos. 2019. 23 Ways to Nudge: A Review of Technology-Mediated Nudging in Human-Computer Interaction. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems* (CHI '19), 1–15. <https://doi.org/10.1145/3290605.3300733>
- [15] Mark Anthony Castrodale. 2018. Mobilizing Dis/Ability Research: A Critical Discussion of Qualitative Go-Along Interviews in Practice. *Qualitative Inquiry* 24, 1: 45–55. <https://doi.org/10.1177/1077800417727765>
- [16] Matthew Chalmers and Areti Galani. 2004. Seamless interweaving: heterogeneity in the theory and design of interactive systems. In *Proceedings of the 5th conference on Designing interactive systems: processes, practices, methods, and techniques*, 243–252. <https://doi.org/10.1145/1013115.1013149>
- [17] Nazli Cila, Cristina Zaga, and Maria Luce Lupetti. 2021. Learning from robotic artefacts: A quest for strong concepts in Human-Robot Interaction. In *Designing Interactive Systems Conference 2021*, 1356–1365. <https://doi.org/10.1145/3461778>

- 3462095
- [18] Herbert H. Clark and Susan E. Brennan. 1991. Grounding in communication. In *Perspectives on socially shared cognition*. American Psychological Association, Washington, DC, US, 127–149. <https://doi.org/10.1037/10096-006>
- [19] Janet Clarke. 2018. What is Cochlear ForwardFocus? -Ask the Experts 23792. *AudiologyOnline*. Retrieved September 11, 2025 from <https://www.audiologyonline.com/ask-the-experts/what-is-cochlear-forwardfocus-23792>
- [20] Carrie Coltart, Karen Henwood, and Fiona Shirani. 2013. Qualitative Secondary Analysis in Austere Times: Ethical, Professional and Methodological Considerations. *Historical Social Research* 38: 271–292
- [21] Jesper Dammeyer, Madeleine Chapman, and Marc Marschark. 2018. Experience of Hearing Loss, Communication, Social Participation, and Psychological Well-Being Among Adolescents With Cochlear Implants. *AMERICAN ANNALS OF THE DEAF* 163, 4: 424–439. <https://doi.org/10.1353/aad.2018.0027>
- [22] Geert De Ceulaer, Julie Bestel, Hans E. Mülder, Felix Goldbeck, Sebastien Pierre Janssens de Varebeke, and Paul J. Govaerts. 2016. Speech understanding in noise with the Roger Pen, Naida CI Q70 processor, and integrated Roger 17 receiver in a multi-talker network. *European Archives of Oto-Rhino-Laryngology* 273, 5: 1107–1114. <https://doi.org/10.1007/s00405-015-3643-4>
- [23] Geert De Ceulaer, Julie Bestel, Hans E. Mülder, Felix Goldbeck, Sebastien Pierre Janssens de Varebeke, and Paul J. Govaerts. 2016. Speech understanding in noise with the Roger Pen, Naida CI Q70 processor, and integrated Roger 17 receiver in a multi-talker network. *European Archives of Oto-Rhino-Laryngology* 273, 5: 1107–1114. <https://doi.org/10.1007/s00405-015-3643-4>
- [24] Audrey Desjardins, Oscar Tomico, Andrés Lucero, Marta E. Cecchinato, and Carman Neustaedter. 2021. Introduction to the Special Issue on First-Person Methods in HCI. *ACM Trans. Comput.-Hum. Interact.* 28, 6: 37:1-37:12. <https://doi.org/10.1145/3492342>
- [25] Judith Dörrenbächer and Marc Hassenzahl. 2019. Changing Perspective: A Co-Design Approach to Explore Future Possibilities of Divergent Hearing. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems* (CHI '19), 1–12. <https://doi.org/10.1145/3290605.3300259>
- [26] Paul Dourish. 1999. Embodied interaction: Exploring the foundations of a new approach to HCI
- [27] John Levaack Drever and Andrew Hugill. 2022. *Aural Diversity*. Routledge
- [28] Louise Duchesne, Marie-Pier Gingras, and Maude Gagnon. 2025. Communicative participation of school-aged children with cochlear implants: parental perceptions. *The Journal of Deaf Studies and Deaf Education: enaf021*. <https://doi.org/10.1093/jdsade/enaf021>
- [29] Claire Edwards and Gill Harold. 2014. DeafSpace and the principles of universal design. *Disability and Rehabilitation* 36, 16: 1350–1359. <https://doi.org/10.3109/09638288.2014.913710>
- [30] Adva Eichengreen, Anne Spigt, and Anat Zaidman-Zait. 2025. Social inclusion of mainstreamed deaf or hard-of-hearing preadolescents and their perspectives on coping with communication barriers. *European Journal of Special Needs Education* 0, 0: 1–19. <https://doi.org/10.1080/08856257.2025.2537508>
- [31] Adva Eichengreen, Anat Zaidman-Zait, Tova Most, and Gelema Golik. 2021. Resilience from childhood to young adulthood: retrospective perspectives of deaf and hard of hearing people who studied in regular schools. *Psychology & Health* 0, 0: 1–19. <https://doi.org/10.1080/08870446.2021.1905161>
- [32] Robert Elliott, Constance T. Fischer, and David L. Rennie. 1999. Evolving guidelines for publication of qualitative research studies in psychology and related fields. *British Journal of Clinical Psychology* 38, 3: 215–229. <https://doi.org/10.1348/014466599162782>
- [33] Thomas Erickson and Wendy A. Kellogg. 2000. Social translucence: an approach to designing systems that support social processes. *ACM Transactions on Computer-Human Interaction* 7, 1: 59–83. <https://doi.org/10.1145/344949.345004>
- [34] Erik H. Erikson. 1968. Identity Youth and Crisis. *W. W. Norton & Company*. Retrieved August 5, 2025 from https://www.academia.edu/37327712/Erik_H_Erikson_Identity_Youth_and_Crisis_1_1968_W_W_Norton_and_Company_1
- [35] Rosa Mora Espino, Franz Zenker Castro, María del Carmen Rodríguez Jiménez, José Luis Mesa Suárez, and Ana Coello Marrero. 2006. Los sistemas de frecuencia modulada en alumnos con implante coclear. *Auditio* 3, 2: 32–36. <https://doi.org/10.51445/sja.auditio.vol3.2006.0036>
- [36] V. E. E. Feenstra, A. A. Zekveld, M. W. Kaandorp, J. H. J. de Ruijter, H. C. Stronks, J. J. Briaire, B. M. Mol, J. H. M. Frijns, and S. E. Kramer. 2025. Occupational performance of cochlear implant users: a comparative study with other hearing-impaired and normal-hearing individuals. *International Journal of Audiology* 0, 0: 1–9. <https://doi.org/10.1080/14992027.2025.2486853>
- [37] Leah Findlater, Bonnie Chinh, Dhruv Jain, Jon Froehlich, Raja Kushalnagar, and Angela Carey Lin. 2019. Deaf and Hard-of-hearing Individuals' Preferences for Wearable and Mobile Sound Awareness Technologies. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems* (CHI '19), 1–13. <https://doi.org/10.1145/3290605.3300276>
- [38] Elizabeth M Fitzpatrick and Janet Olds. 2015. Practitioners' perspectives on the functioning of school-age children with cochlear implants. *Cochlear implants international* 16, 1: 9–23. <https://doi.org/10.1179/1754762814Y.0000000080>
- [39] Mark D. Fletcher, Amatullah Hadeedi, Tobias Goehring, and Sean R. Mills. 2019. Electro-haptic enhancement of speech-in-noise performance in cochlear implant users. *Scientific Reports* 9, 1: 11428. <https://doi.org/10.1038/s41598-019-47718-z>
- [40] Jon Froehlich, Leah Findlater, and James Landay. 2010. The design of eco-feedback technology. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '10), 1999–2008. <https://doi.org/10.1145/1753326.1753629>
- [41] Jon Froehlich, Leah Findlater, Marilyn Ostergren, Solai Ramanathan, Josh Peterson, Inness Wragg, Eric Larson, Fabia Fu, Mazhengmin Bai, Shwetak Patel, and James A. Landay. 2012. The design and evaluation of prototype eco-feedback displays for fixture-level water usage data. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '12), 2367–2376. <https://doi.org/10.1145/2207676.2208397>
- [42] Gallaudet University. DeafSpace - Campus Design and Planning. *Gallaudet University*. Retrieved July 21, 2025 from <https://gallaudet.edu/campus-design-facilities/campus-design-and-planning/deafspace/>
- [43] Mattia Gianotti, Maria Chiara Marini, Eleonora Aida Beccaluva, Matilde Maria Marulli, Italo De Meis, Donatella Tomaiuolo, and Franca Garzotto. 2024. Multisensory Training Intervention for Hearing Impaired Children: Preliminary Results of a Pilot Study. In *Extended Abstracts of the CHI Conference on Human Factors in Computing Systems* (CHI EA '24), 1–7. <https://doi.org/10.1145/3613905.3650734>
- [44] Steven Goodman, Susanne Kirchner, Rose Guttman, Dhruv Jain, Jon Froehlich, and Leah Findlater. 2020. Evaluating Smartwatch-based Sound Feedback for Deaf and Hard-of-hearing Users Across Contexts. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems* (CHI '20), 1–13. <https://doi.org/10.1145/3313831.3376406>
- [45] Steven M. Goodman, Emma J McDonnell, Jon E. Froehlich, and Leah Findlater. 2025. SPECTRA: Personalizable Sound Recognition for Deaf and Hard of Hearing Users through Interactive Machine Learning. In *Proceedings of the 2025 CHI Conference on Human Factors in Computing Systems* (CHI '25), 1–16. <https://doi.org/10.1145/3706598.3713294>
- [46] Benjamin M. Gorman and David R. Flatla. 2017. A Framework for Speechreading Acquisition Tools. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems* (CHI '17), 519–530. <https://doi.org/10.1145/3025453.3025560>
- [47] Benjamin M. Gorman and David R. Flatla. 2018. MirrorMirror: A Mobile Application to Improve Speechreading Acquisition. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems* (CHI '18), 1–12. <https://doi.org/10.1145/3173574.3173600>
- [48] Anton Gustafsson and Magnus Gyllenswärd. 2005. The power-aware cord: energy awareness through ambient information display. In *CHI '05 Extended Abstracts on Human Factors in Computing Systems* (CHI EA '05), 1423–1426. <https://doi.org/10.1145/1056808.1056932>
- [49] Janet Heaton. 2004. *Reworking Qualitative Data*. SAGE Publications Ltd. <https://doi.org/10.4135/9781849209878>
- [50] Leila Homaieian, James R. Wallace, and Stacey D. Scott. 2021. Joint Action Storyboards: A Framework for Visualizing Communication Grounding Costs. *Proc. ACM Hum.-Comput. Interact.* 5, CSCW1: 28:1-28:27. <https://doi.org/10.1145/3449102>
- [51] Kristina Höök, Peter Dalsgaard, Stuart Reeves, Jeffrey Bardzell, Jonas Löwgren, Erik Stolterman, and Yvonne Rogers. 2015. Knowledge Production in Interaction Design. In *Proceedings of the 33rd Annual ACM Conference Extended Abstracts on Human Factors in Computing Systems* (CHI EA '15), 2429–2432. <https://doi.org/10.1145/2702613.2702653>
- [52] Kristina Höök and Jonas Löwgren. 2012. Strong concepts: Intermediate-level knowledge in interaction design research. *ACM Trans. Comput.-Hum. Interact.* 19, 3: 23:1-23:18. <https://doi.org/10.1145/2362364.2362371>
- [53] Kristina Höök, Anna Ståhl, Martin Jonsson, Johanna Mercurio, Anna Karlsson, and Eva-Carin Banka Johnson. 2015. COVER STORY: Somaesthetic design. *Interactions* 22, 4: 26–33. <https://doi.org/10.1145/2770888>
- [54] Benjamin W. Y. Hornsby, Erin M. Picou, Todd A. Ricketts, and René Gifford. 2024. Listening-Related Fatigue in New and Experienced Adult Cochlear Implant Users. *Ear and Hearing* 45, 4: 929–944. <https://doi.org/10.1097/AUD.0000000000001488>
- [55] Jeremy Zhengqi Huang, Hriday Chhabria, and Dhruv Jain. 2023. “Not There Yet”: Feasibility and Challenges of Mobile Sound Recognition to Support Deaf and Hard-of-Hearing People. In *Proceedings of the 25th International ACM SIGACCESS Conference on Computers and Accessibility* (ASSETS '23), 1–14. <https://doi.org/10.1145/3597638.3608431>
- [56] Ha Sung Hwang and SungBok Park. 2007. Being together: user's subjective experience of social presence in CMC environments. In *Proceedings of the 12th international conference on Human-computer interaction: interaction design and usability* (HCI'07), 844–853.
- [57] Frank Iglehart. 2004. Speech Perception by Students With Cochlear Implants Using Sound-Field Systems in Classrooms. *American Journal of Audiology* 13, 1: 62–72. [https://doi.org/10.1044/1059-0889\(2004\)009](https://doi.org/10.1044/1059-0889(2004)009)
- [58] Wijnand Ijsselstein, Joy Baren, and Froukje Lanen. 2003. Staying in touch: Social presence and connectedness through synchronous and asynchronous communication media. *Smppte Motion Imaging Journal*

- [59] Sarah Inman and David Ribes. 2019. “Beautiful Seams”: Strategic Revelations and Concealments. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems* (CHI '19), 1–14. <https://doi.org/10.1145/3290605.3300508>
- [60] Intercommunication Center. 1999. Adding Media, Subtracting Signs: Boundary Functions. Retrieved September 10, 2025 from https://www.ntticc.or.jp/en/feature/1999/+/-/Works/boundary_e.html
- [61] Ole Sejer Iversen, Karen Johanne Kortbek, Kaspar Rosengreen Nielsen, and Louise Aagaard. 2007. Stepstone: an interactive floor application for hearing impaired children with a cochlear implant. In *Proceedings of the 6th international conference on Interaction design and children - IDC '07*, 117. <https://doi.org/10.1145/1297277.1297301>
- [62] Dhruv Jain, Leah Findlater, Jamie Gilkeson, Benjamin Holland, Ramani Duraiswami, Dmitry Zotkin, Christian Vogler, and Jon E. Froehlich. 2015. Head-Mounted Display Visualizations to Support Sound Awareness for the Deaf and Hard of Hearing. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems* (CHI '15), 241–250. <https://doi.org/10.1145/2702123.2702393>
- [63] Kim Sune Karrasch Jepsen and Inge Kryger Pedersen. 2025. Impaired face-to-face interaction and emotional energy in cochlear implant usage: Strategies for social inclusion in everyday life among young people with hearing loss. *SSM - Qualitative Research in Health* 7: 100512. <https://doi.org/10.1016/j.ssmqr.2024.100512>
- [64] Devva Kasnitz. 2020. The Politics of Disability Performativity: An Autoethnography. *Current Anthropology* 61, S21: S16–S25. <https://doi.org/10.1086/705782>
- [65] Uzair Khalid, Nida Majeed, Cathy J. Chovaz, Fahad Riaz Choudhary, and Khadeja Munawa. 2025. Psychological well-being and mental health risks in deaf and hard of hearing youth: a systematic review. *European Child & Adolescent Psychiatry*: 1–15. <https://doi.org/10.1007/s00787-025-02795-6>
- [66] Ju-Whan Kim, Yun-Kyung Kim, and Tek-Jin Nam. 2009. The ténére: design for supporting energy conservation behaviors. In *CHI '09 Extended Abstracts on Human Factors in Computing Systems* (CHI EA '09), 2643–2646. <https://doi.org/10.1145/1520340.1520372>
- [67] Riikka Korkiamäki. 2016. Friendship as Potential? The Recognition of Teenagers' Peer Relationships at School. *Open Journal of Social Sciences* 4, 9: 34–43. <https://doi.org/10.4236/jss.2016.49005>
- [68] S. Koster. 2001. Acoustic-phonetic characteristics of hyperarticulated speech for different speaking styles. In *2001 IEEE International Conference on Acoustics, Speech, and Signal Processing, Proceedings (Cat. No.01CH37221)*, 873–876 vol.2. <https://doi.org/10.1109/ICASSP.2001.941054>
- [69] Abigail Anne Kressner, Adam Westermann, and Jörg M. Buchholz. 2018. The impact of reverberation on speech intelligibility in cochlear implant recipients. *The Journal of the Acoustical Society of America* 144, 2: 1113–1122. <https://doi.org/10.1121/1.5051640>
- [70] Stefanie Krijger, Martine Coene, Paul J. Govaerts, and Ingeborg Dhooge. 2020. Listening Difficulties of Children With Cochlear Implants in Mainstream Secondary Education. *Ear and Hearing* 41, 5: 1172–1186. <https://doi.org/10.1097/AUD.0000000000000835>
- [71] Peter Gall Krogh, Marianne Graves Petersen, Kenton O'Hara, and Jens Emil Groenbaek. 2017. Sensitizing Concepts for Socio-spatial Literacy in HCI. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems* (CHI '17), 6449–6460. <https://doi.org/10.1145/3025453.3025756>
- [72] Korbinian Kuhn, Verena Kersken, and Gottfried Zimmermann. 2025. Communication Access Real-Time Translation Through Collaborative Correction of Automatic Speech Recognition. In *Proceedings of the Extended Abstracts of the CHI Conference on Human Factors in Computing Systems* (CHI EA '25), 1–8. <https://doi.org/10.1145/3706599.3719984>
- [73] Margarethe Kusenbach. 2003. Street phenomenology: The go-along as ethnographic research tool. *Ethnography* 4, 3: 455–485.
- [74] Margarethe Kusenbach. 2016. The Go-Along Method. In *Sensing the City*, Anja Schwanhäuser (ed.), De Gruyter, 154–158. <https://doi.org/10.1515/9783035607352-015>
- [75] Caluá de Lacerda Pataca, Saad Hassan, Lloyd May, Michelle M Olson, Toni D'aurio, Roshan L Peiris, and Matt Huenerfauth. 2025. Tactile Emotions: Multimodal Affective Captioning with Haptics Improves Narrative Engagement for d/Deaf and Hard-of-Hearing Viewers. In *Proceedings of the 2025 CHI Conference on Human Factors in Computing Systems* (CHI '25), 1–17. <https://doi.org/10.1145/3706598.3713304>
- [76] Caluá de Lacerda Pataca, Matthew Watkins, Roshan Peiris, Sooyeon Lee, and Matt Huenerfauth. 2023. Visualization of Speech Prosody and Emotion in Captions: Accessibility for Deaf and Hard-of-Hearing Users. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems* (CHI '23), 1–15. <https://doi.org/10.1145/3544548.3581511>
- [77] Nienke Cornelia Langerak, Hendrik Christiaan Stronks, Jeroen Johannes Briaire, and Johan Hubertus Maria Frijns. 2024. The Benefit of Bimodal Hearing and Beamforming for Cochlear Implant Users. *Audiology and Neurotology* 29, 4: 297–305. <https://doi.org/10.1159/000536431>
- [78] Youngmee Lee, Sung-Wook Jeong, and Seung-Hwa Jeong. 2022. School adjustment of adolescents with sequential bilateral cochlear implants in mainstream school. *International Journal of Pediatric Otorhinolaryngology* 163: 111338. <https://doi.org/10.1016/j.ijporl.2022.111338>
- [79] Claudia A Libbi, Adva Eichengreen, Josine Buiscool, Andre Götze, Karolin Schäfer, H. C Stronks, Johan Frijns, and Carolien Rieffe. 2026. Cochlear Implant Users' Experiences of Built, Sound and Social School Environments. Retrieved January 23, 2026 from https://osf.io/preprints/psyarxiv/jdz4w_v1/
- [80] Fernando Loizides, Sara Basson, Dimitri Kanevsky, Olga Prilepova, Sagar Savla, and Susanna Zaraysky. 2020. Breaking Boundaries with Live Transcribe: Expanding Use Cases Beyond Standard Captioning Scenarios. In *Proceedings of the 22nd International ACM SIGACCESS Conference on Computers and Accessibility* (ASSETS '20), 1–6. <https://doi.org/10.1145/3373625.3417300>
- [81] Lian Loke and Toni Robertson. 2013. Moving and making strange: An embodied approach to movement-based interaction design. *ACM Transactions on Computer-Human Interaction* (TOCHI) 20. <https://doi.org/10.1145/2442106.2442113>
- [82] Jennifer Mankoff, Gillian R. Hayes, and Devva Kasnitz. 2010. Disability studies as a source of critical inquiry for the field of assistive technology. In *Proceedings of the 12th international ACM SIGACCESS conference on Computers and accessibility* (ASSETS '10), 3–10. <https://doi.org/10.1145/1878803.1878807>
- [83] Emma J. McDonnell, Ping Liu, Steven M. Goodman, Raja Kushalnagar, Jon E. Froehlich, and Leah Findlater. 2021. Social, Environmental, and Technical: Factors at Play in the Current Use and Future Design of Small-Group Captioning. *Proceedings of the ACM on Human-Computer Interaction* 5, CSCW2: 1–25. <https://doi.org/10.1145/3479578>
- [84] Emma J McDonnell, Soo Hyun Moon, Lucy Jiang, Steven M. Goodman, Raja Kushalnagar, Jon E. Froehlich, and Leah Findlater. 2023. “Easier or Harder, Depending on Who the Hearing Person Is”: Codesigning Videoconferencing Tools for Small Groups with Mixed Hearing Status. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems*, 1–15. <https://doi.org/10.1145/3544548.3580809>
- [85] Saeideh Mehrkian, Zeinab Bayat, Mohanna Javanbakht, Hesamaldin Emamdjomeh, and Enayatollah Bakhshi. 2019. Effect of wireless remote microphone application on speech discrimination in noise in children with cochlear implants. *International Journal of Pediatric Otorhinolaryngology* 125: 192–195. <https://doi.org/10.1016/j.ijporl.2019.07.007>
- [86] Maurice Merleau-Ponty. 2025. Phenomenology of Perception. *HannahArendtMarginalia-All*: 445
- [87] Mia Mingus. 2017. Access Intimacy, Interdependence and Disability Justice. *Leaving Evidence*. Retrieved November 9, 2025 from <https://leavingevidence.wordpress.com/2017/04/12/access-intimacy-interdependence-and-disability-justice/>
- [88] Beatrice Monastero and David K. McGookin. 2018. Traces: Studying a Public Reactive Floor-Projection of Walking Trajectories to Support Social Awareness. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems* (CHI '18), 1–13. <https://doi.org/10.1145/3173574.3174061>
- [89] Kristin Neidlinger, Lianne Toussaint, Edwin Dertien, Khiet P. Truong, Hermie Hermens, and Vanessa Evers. 2019. Emotional prosthesis for animating awe through performative biofeedback. In *Proceedings of the 23rd International Symposium on Wearable Computers*, 312–317. <https://doi.org/10.1145/3341163.3346939>
- [90] Céline Offerman, Jacky Bourgeois, Jules van Beurden, and Alessandro Bozzon. 2025. (Re)discovering Sexual Pleasure after Cancer: Understanding the Design Space. In *Proceedings of the 2025 CHI Conference on Human Factors in Computing Systems* (CHI '25), 1–17. <https://doi.org/10.1145/3706598.3713535>
- [91] Aisling Ann O'Kane, Abdinasir Aliomar, Rebecca Zheng, Britta Schulte, and Gianluca Trombetta. 2019. Social, Cultural and Systematic Frustrations Motivating the Formation of a DIY Hearing Loss Hacking Community. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems* (CHI '19), 1–14. <https://doi.org/10.1145/3290605.3300531>
- [92] Sylvia Olsson and Christine Gustafsson. 2022. Longing to Belong: Hard of Hearing Young Adults' Experiences of Social Identity and Group Membership. *American Annals of the Deaf* 166, 5: 638–662
- [93] Alex Olwal, Kevin Balke, Dmitrii Votintcev, Thad Starner, Paula Conn, Bonnie Chinh, and Benoit Corda. 2020. Wearable Subtitles: Augmenting Spoken Communication with Lightweight Eyewear for All-day Captioning. In *Proceedings of the 33rd Annual ACM Symposium on User Interface Software and Interaction* (UIST '20), 1108–1120. <https://doi.org/10.1145/3379337.3415817>
- [94] Yi-Hao Peng, Ming-Wei Hsi, Paul Taele, Ting-Yu Lin, Po-En Lai, Leon Hsu, Tzu-chuan Chen, Te-Yen Wu, Yu-An Chen, Hsien-Hui Tang, and Mike Y. Chen. 2018. SpeechBubbles: Enhancing Captioning Experiences for Deaf and Hard-of-Hearing People in Group Conversations. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems* (CHI '18), 1–10. <https://doi.org/10.1145/3173574.3173867>
- [95] Martin Pielot, View Profile, Oliver Krull, View Profile, Susanne Boll, and View Profile. 2010. Where is my team. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. 1705–1714. <https://doi.org/10.1145/1753326.1753581>
- [96] Halley P. Profita, Abigale Stangl, Laura Matuszewska, Sigrunn Sky, and Shaun K. Kane. 2016. Nothing to Hide: Aesthetic Customization of Hearing Aids and

- Cochlear Implants in an Online Community. In *Proceedings of the 18th International ACM SIGACCESS Conference on Computers and Accessibility (ASSETS '16)*, 219–227. <https://doi.org/10.1145/2982142.2982159>
- [97] R. Punch and M. Hyde. 2011. Social Participation of Children and Adolescents With Cochlear Implants: A Qualitative Analysis of Parent, Teacher, and Child Interviews. *Journal of Deaf Studies and Deaf Education* 16, 4: 474–493. <https://doi.org/10.1093/deafed/enr001>
- [98] Shanit Rich, Miriam Levinger, Shirli Werner, and Cahtia Adelman. 2013. Being an adolescent with a cochlear implant in the world of hearing people: Coping in school, in society and with self identity. *International Journal of Pediatric Otorhinolaryngology* 77, 8: 1337–1344. <https://doi.org/10.1016/j.ijporl.2013.05.029>
- [99] Carolien Rieffe, Evelien Broekhof, Adva Eichengreen, Maartje Kouwenberg, Guida Veiga, Brenda M S da Silva, Anneke van der Laan, and Johan H M Frijns. 2018. Friendship and Emotion Control in Pre-Adolescents With or Without Hearing Loss. *The Journal of Deaf Studies and Deaf Education* 23, 3: 209–218. <https://doi.org/10.1093/deafed/eny012>
- [100] Wouter J. Rijke, Anneke M. Vermeulen, Christina Willeboer, Harry E. T. Knoors, Margreet C. Langereis, and Gert Jan van der Wilt. 2022. Wellbeing as Capability: Findings in Hearing-Impaired Adolescents and Young Adults With a Hearing Aid or Cochlear Implant. *Frontiers in Psychology* 13: 895868. <https://doi.org/10.3389/fpsyg.2022.895868>
- [101] Stephen D. Sechler, Alejandro Lopez Valdes, Saskia M. Waechter, Cristina Simoes-Franklin, Laura Viani, and Richard B. Reilly. 2017. Virtual reality sound localization testing in cochlear implant users. In *International IEEE/EMBS Conference on Neural Engineering, NER*. <https://doi.org/10.1109/NER.2017.8008369>
- [102] Matthew Seita, Khaled Albusays, Sushant Kafle, Michael Stinson, and Matt Huenerfauth. 2018. Behavioral Changes in Speakers who are Automatically Captioned in Meetings with Deaf or Hard-of-Hearing Peers. In *Proceedings of the 20th International ACM SIGACCESS Conference on Computers and Accessibility (ASSETS '18)*, 68–80. <https://doi.org/10.1145/3234695.3236355>
- [103] Matthew Seita, Sarah Andrew, and Matt Huenerfauth. 2021. Deaf and hard-of-hearing users' preferences for hearing speakers' behavior during technology-mediated in-person and remote conversations. In *Proceedings of the 18th International Web for All Conference (W4A '21)*, 1–12. <https://doi.org/10.1145/3430263.3452430>
- [104] Matthew Seita and Matt Huenerfauth. 2020. Deaf Individuals' Views on Speaking Behaviors of Hearing Peers when Using an Automatic Captioning App. In *Extended Abstracts of the 2020 CHI Conference on Human Factors in Computing Systems (CHI EA '20)*, 1–8. <https://doi.org/10.1145/3334480.3383083>
- [105] Matthew Seita, Sooyeon Lee, Sarah Andrew, Kristen Shinohara, and Matt Huenerfauth. 2022. Remotely Co-Designing Features for Communication Applications using Automatic Captioning with Deaf and Hearing Pairs. In *Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems (CHI '22)*, 1–13. <https://doi.org/10.1145/3491102.3501843>
- [106] Kristen Shinohara and Jacob O. Wobbrock. 2011. In the shadow of misperception: assistive technology use and social interactions. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '11)*, 705–714. <https://doi.org/10.1145/1978942.1979044>
- [107] Scott Snibbe. 2025. Boundary Functions (1998) — Scott Snibbe - Interactive Art. *Scott Snibbe*. Retrieved September 10, 2025 from <https://www.snibbe.com/art/boundaryfunctions>
- [108] Staatsblad. 2014. *Appropriate Education Act*. Retrieved July 22, 2025 from <https://wetten.overheid.nl/BWBR0032176/2018-01-01>
- [109] Laurence Steinberg and Amanda Sheffield Morris. 2001. Adolescent Development. *Annual Review of Psychology* 52, Volume 52, 2001: 83–110. <https://doi.org/10.1146/annurev.psych.52.1.83>
- [110] Erik Stolterman and Mikael Wiberg. 2010. Concept-Driven Interaction Design Research. *Human-Computer Interaction* 25, 2: 95–118. <https://doi.org/10.1080/07370020903586696>
- [111] Tirza F K van der Straaten, Jeroen J Briaire, Evelien Dirks, Wim Soede, Carolien Rieffe, and Johan H M Frijns. 2021. The School Career of Children With Hearing Loss in Different Primary Educational Settings—A Large Longitudinal Nationwide Study. *The Journal of Deaf Studies and Deaf Education* 26, 3: 405–416. <https://doi.org/10.1093/deafed/enab008>
- [112] H. Christiaan Stronks, Jeroen J. Briaire, and Johan H.M. Frijns. 2022. Beamforming and Single-Microphone Noise Reduction: Effects on Signal-to-Noise Ratio and Speech Recognition of Bimodal Cochlear Implant Users. *Trends in Hearing* 26: 2331216522112762. <https://doi.org/10.1177/2331216522112762>
- [113] Dag Svanæs and Louise Barkhuus. 2020. The Designer's Body as Resource in Design: Exploring Combinations of Point-of-view and Tense. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems (CHI '20)*, 1–13. <https://doi.org/10.1145/3313831.3376430>
- [114] E Terlektsi, J Kreppner, M Mahon, S Worsfold, and Colin R Kennedy. 2020. Peer Relationship Experiences Of Deaf And Hard-Of-Hearing Adolescents. *The Journal of Deaf Studies and Deaf Education* 25, 2: 153–166. <https://doi.org/10.1093/deafed/enz048>
- [115] Stefan Timmermans and Iddo Tavory. 2012. Theory Construction in Qualitative Research: From Grounded Theory to Abductive Analysis. *Sociological Theory* 30, 3: 167–186. <https://doi.org/10.1177/0735275112457914>
- [116] Christian Tsalidis, Ali Adjorlu, Lone Marianne Percy-Smith, and Stefania Serafin. 2024. Earscape: A VR Auditory Educational Escape Room. In *Proceedings of the 30th ACM Symposium on Virtual Reality Software and Technology (VRST '24)*, 1–2. <https://doi.org/10.1145/3641825.3689512>
- [117] Yung Ting Tsou, Boya Li, Mariska E. Kret, Johan H. M. Frijns, and Carolien Rieffe. 2021. Hearing Status Affects Children's Emotion Understanding in Dynamic Social Situations: An Eye-Tracking Study. *Ear and Hearing*. <https://doi.org/10.1097/AUD.0000000000000994>
- [118] Nancy Tye-Murray. 2003. Conversational Fluency of Children Who Use Cochlear Implants. *Ear and Hearing* 24, 1: 82S. <https://doi.org/10.1097/01.AUD.0000051691.33869.EC>
- [119] Jose Luis Vargas, Manuel Sainz, Cristina Roldan, Isaac Alvarez, and Angel de la Torre. 2012. Long-term evolution of the electrical stimulation levels for cochlear implant patients. *Clinical and Experimental Otorhinolaryngology* 5, 4: 194–200. <https://doi.org/10.3342/ceo.2012.5.4.194>
- [120] Anneke Vermeulen, Leo De Raeve, Margreet Langereis, and Ad Snik. 2012. Changing Realities in the Classroom for Hearing-Impaired Children with Cochlear Implant. *Deafness & Education International* 14, 1: 36–47. <https://doi.org/10.1179/1557069X12Y.0000000004>
- [121] Luis Vila-Henninger, Claire Dupuy, Virginie Van Ingelgom, Mauro Caprioli, Ferdinand Teuber, Damien Pennetreau, Margherita Bussi, and Cal Le Gall. 2024. Abductive Coding: Theory Building and Qualitative (Re)Analysis. *Sociological Methods & Research* 53, 2: 968–1001. <https://doi.org/10.1177/00491241211067508>
- [122] Beijia Wang, Mengxiao Song, Yuting Han, and Duo Wang. 2019. HearU: An Integrated System to Raise Awareness of Hearing Loss. In *Extended Abstracts of the 2019 CHI Conference on Human Factors in Computing Systems (CHI EA '19)*, 1–6. <https://doi.org/10.1145/3290607.3309693>
- [123] Emily Q. Wang and Anne Marie Piper. 2018. Accessibility in Action: Co-Located Collaboration among Deaf and Hearing Professionals. *Proc. ACM Hum.-Comput. Interact.* 2, CSCW: 180:1-180:25. <https://doi.org/10.1145/3274449>
- [124] Yiwen Wang, Ziming Li, Pratheep Kumar Chelladurai, Wendy Dannels, Tae Oh, and Roshan L. Peiris. 2023. Haptic-Captioning: Using Audio-Haptic Interfaces to Enhance Speaker Indication in Real-Time Captions for Deaf and Hard-of-Hearing Viewers. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems (CHI '23)*, 1–14. <https://doi.org/10.1145/3544548.3581076>
- [125] Robrecht P. R. D. van der Wel, Cristina Becchio, Arianna Curioni, and Thomas Wolf. 2021. Understanding joint action: Current theoretical and empirical approaches. *Acta Psychologica* 215: 103285. <https://doi.org/10.1016/j.actpsy.2021.103285>
- [126] Blake S. Wilson and Michael F. Dorman. 2008. Cochlear implants: A remarkable past and a brilliant future. *Hearing Research* 242, 1: 3–21. <https://doi.org/10.1016/j.heares.2008.06.005>
- [127] Julia Woodward, Jesse Smith, Isaac Wang, Sofia Cuenca, and Jaime Ruiz. 2023. Designing Critical and Secondary Information in Augmented Reality Headsets for Situational Awareness. *Journal of Engineering Research and Sciences* 2, 3: 1–15. <https://doi.org/10.55708/jso203001>
- [128] World Health Organization. 2025. Deafness and hearing loss. Retrieved July 22, 2025 from <https://www.who.int/news-room/fact-sheets/detail/deafness-and-hearing-loss>
- [129] Yu-Han Xie, Milon Potmesil, and Brenda Peters. 2014. Children Who Are Deaf or Hard of Hearing in Inclusive Educational Settings: A Literature Review on Interactions With Peers. *JOURNAL OF DEAF STUDIES AND DEAF EDUCATION* 19, 4: 423–437. <https://doi.org/10.1093/deafed/enu017>
- [130] Anat Zaidman-Zait and Adi Dotan. 2017. Everyday Stressors in Deaf and Hard of Hearing Adolescents: The Role of Coping and Pragmatics. *JOURNAL OF DEAF STUDIES AND DEAF EDUCATION* 22, 3: 257–268. <https://doi.org/10.1093/deafed/enw103>
- [131] Anat Zaidman-Zait and Tova Most. 2020. Pragmatics and Peer Relationships Among Deaf, Hard of Hearing, and Hearing Adolescents. *Pediatrics* 146, Supplement_3: S298–S303. <https://doi.org/10.1542/peds.2020-0242J>
- [132] Fan-Gang Zeng. 2022. Celebrating the one millionth cochlear implant. *JASA express letters* 2, 7: 077201. <https://doi.org/10.1121/10.0012825>
- [133] Jing Zhao, Isabel Neto, Ana Cristina Pires, Catarina Tomé-Pires, and Hugo Nicolau. 2025. Digital Technologies for Deaf and Hard of Hearing Children: a Systematic Review, Critical Reflections, and Future Research Directions. In *Proceedings of the 2025 CHI Conference on Human Factors in Computing Systems (CHI '25)*, 1–19. <https://doi.org/10.1145/3706598.3714241>
- [134] Yunfang Zheng, Jacob Swanson, Janet Koehnke, and Jianwei Guan. 2022. Sound Localization of Listeners With Normal Hearing, Impaired Hearing, Hearing Aids, Bone-Anchored Hearing Instruments, and Cochlear Implants: A Review. *American Journal of Audiology* 31, 3: 819–834. https://doi.org/10.1044/2022_AJA-22-00006