



Designing Hearing Aids to Mitigate Perceived Stigma Associated with Hearing Impairment

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Abstract. Assistive technologies support people with disabilities in living independently. However, perceived stigma towards using assistive technologies can lead to issues such as non-acceptance or abandonment of these technologies. This study deconstructs stigma perception in people with hearing impairment supported by social psychology and design elements. Users' feelings towards hearing aid products and their stigmatization are illustrated through related literature and findings from an empirical study. The study revealed the stigmatization associated with hearing impairment and hearing aids, and strategies to overcome related barriers. We then developed a series of hearing aid prototypes in a design workshop and evaluated their efficacy in mitigating stigma in people with hearing impairments. We discuss our findings on stigma threats in hearing aid products, as they relate to the sources of stigma, strategies to eliminate stigma. We suggest considering inclusive design principles to develop mainstream hearing aid products.

Keywords: Human-Centered Design · Stigma · Hearing Aids · Hearing Impairment · Assistive Technology

1 Introduction and Related Work

Peoples' ability to hear is one of the most significant tools to explore the world since it provides them with vital information about their surroundings. Hearing loss affects more than just the ability to hear and has become more frequent in recent years across all age categories. As a result of hearing loss, people may feel socially isolated and communicate ineffectively, even be stigmatized, with their mental health and quality of life detrimentally influenced [14]. Assistive technology (AT) is any item, piece of equipment, software program, or product system that is used to help people with disabilities increase, maintain, or improve their functional abilities across a variety of living domains [2, 17]. Despite the abundant advantages of AT devices, people with disabilities may refuse to utilize these products due to various reasons, including cost, discomfort, a sense of foreignness, stigmatization, social rejection, and embarrassment [7]. The use of assistive technologies can be affected by users' acceptance and acceptability of the products [18].

For a person living with disability, stigmatization is often a reality having varying effects, including, but not limited to, 1) less treatment; 2) disrupted social relations;

3) personal avoidance, anxiety, and depression; and 4) disordered self-image and poor self-esteem [6]. People of any age can feel stigmatized by AT devices that represent their loss of physical functions. The majority of studies of ATs are primarily concerned with functionality and usability, ignoring the value of self-expression and social context in determining the long-term adoption of these technologies [7]. Social context is an essential element that influences people's attitudes towards those with specific impairments and use of AT devices. Many psychosocial factors, including personality, response to disability, and the environment or social milieu where the technology is applied, affect the acceptability of AT. Social acceptability has been identified as one of the critical elements impacting whether a person uses a particular AT device [9]. People's acceptance of AT products is an important factor contributing to higher volume manufacturing and engaged use, thus reducing the risk of product abandonment [11].

Currently, design has moved to human-orientation shifting from designing for users to designing with users. Considerable emphasis has been placed on the exploration of the relationship between AT products and stigma, and several design strategies are used to achieve destigmatization [15]. The first strategy is to reshape the societal context. As a response to product-related stigma in this context, one should choose interventions that either produce fundamental changes in attitudes and beliefs or change power relations that underlie the ability of domain groups to act upon their attitudes and beliefs [5]. The second strategy is to reshape the meaning of the products. Factors such as shapes, material qualities and other sensory demonstrations, are considered as design elements. Through their presence coupled with other sensory elements, a product has the potential of imposing a stigma on its users or wearers, both physically and psychologically [10]. The means of managing stigma can be divided into three categories: disguising the stigmatizing features, shifting the attention from the stigmatizing features to other features, and transforming stigmatizing elements into features that convey prestige or a higher social status [4]. To identify factors that affect the perception of stigma, this study conducted an online survey and semi-structured interviews to ascertain whether people with hearing loss faced stigmatization and identify the origin of stigmatization. We then developed proof-of-concept prototypes of hearing aids to evaluate their benefit in potential reduction of stigmatization in people with hearing impairment.

2 Methodology

2.1 Online Survey

A ten-question survey was dispersed to Facebook groups, including Hearing Aid Forum, Community for the Deaf and Hard of Hearing, and Living with Hearing Loss Group. In the first phase, 98 people took the survey. Basic demographic information, including age, gender, and the cause of hearing impairment, was collected to understand the difference between various user groups. Participants shared their feelings, current habits, and concerns regarding hearing aid through open-ended survey questions. We coded their responses (PS-1 to PS-98) to protect their identities. This study has been reviewed and approved by the Institutional Review Board (IRB) at Georgia Tech.

2.2 Semi-structured Interview

Remote interviews were conducted after the completion of the survey to collect more in-depth data concerning participants' perception of stigmatization. Seven participants were recruited through Facebook groups, who had completed the online survey and were willing to share more about their experiences with hearing loss and hearing aids. The semi-structured interview centered around users' feelings regarding hearing loss, their experiences with current hearing aids, their perception with stigmatization when wearing assistive products, and their expectations towards next generation products. Participants included 5 females and 2 males ranging in age from 35–70. All interviewees used hearing aids in their daily lives. Their names were coded (PI-1 to PI-7) to protect their identities. Answers from the survey and interviews were organized into an affinity diagram to identify emerging themes and underlying codes.

3 Results

3.1 Stigmatization Associate with Hearing Impairments

Communication. Communication, and self-perception [16] in people's daily lives are subject to the influence of hearing loss, thus resulting in the occurrence of stigmatization. Analysis of the survey results revealed that almost every participant had difficulties in communication, even those with hearing aids. Hearing aids improved their hearing by amplifying sounds around them, but at the same time, noises were amplified as well. It was revealed in the online survey that, given the noise from hearing aids, approximately 37% of the participants refused to wear any hearing aid. Additionally, PS-11 said that hearing aids did not reduce noises, and her voice resonated through traditional hearing aids: *"I tried a traditional hearing aid but did not like it because the sound was muffled like it was underwater, but it was also way too loud regardless of how much I turned it down. Plus, my voice resonated through the hearing aids"*.

Although newer technologies have effectively reduced noise, some people suffering from hearing loss still have trouble communicating. They cannot follow every word when talking, especially when the pitch is too low (males) and too high (children). In the survey, some participants complained that communication required more effort on their part, which made them less willing to talk with others. Daily communication is still a difficult task, and barriers in communication can bring negative emotions to people with hearing impairment. As PI-6 stated in the interview,

"I worked in the library, so I need to talk with different people. I feel embarrassed if I cannot hear them clearly or cannot understand what they say. There are lots of men in my previous work, and their pitch is very low, so I cannot hear them. I need to talk to different people. And if I couldn't hear them, they got frustrated, and I got frustrated. I will show less confidence about that".

To tackle these issues, participants shared strategies they use such as speech-text software, sign language, and lip-synch. However, PS-70 noted in the survey that *"with the use of face masks I now realize I was relying more on lip-reading than I thought"*.

People's hearing loss significantly affects their ability to participate in social activities, which derives from their inability to converse with more than one person at a time as PS-57 shared: *"When I talk to a group of people, I cannot hear them clearly, and I need to interrupt them. It is very awkward and impolite"*. Lack of ability to communicate in group activities cause sensation of isolation as one of the stigmatizing factors. For example, PI-1 mentioned in the interview: *"In some social activities, everything is emphasized, including hearing loss and my isolation from crowds. Everyone involved in this activity would know that I have a hearing impairment"*.

Self-perception. Functional disability affects people's self-perception, which can be referred to as stigmatization. In the survey, participants under the age of 45 were more concerned about their hearing loss, which hampered their personal development, and they felt stigmatized. People with hearing disabilities have long refused to mention or try to talk about their disabilities, and they are sensitive to words not directly related to their bodies, such as "deaf," since they feel that these words carry malice. Participants shared ideas about how their perceptions were affected by hearing loss and hearing aids, and how they thought of others' perceptions of them. For example, PS-45 stated that:

"Some people think that deaf people are not smart, so they treat me differently. I mean with my training and the help of hearing aids; the hearing function can be restored a lot. I don't need their special treatment. These treatments just reminded me that I was different from others, and I would feel stigmatized". She also noted that she felt hearing loss *"diminishing one's authority"* and that authority mattered considerably in her work role.

"I am a teacher, but sometimes it is hard for me to follow students. I cannot have eye contact with students. I need to look at their lips. That's why there was a certain distance between the students and me. Parents may not trust me, a teacher with hearing loss. They would doubt my capacity to communicate effectively with pupils and the quality of my instruction".

Overall, hearing loss itself can cause stigma, mostly in the form of obstacle to communication and altered self-perception. The survey and interview results revealed that, adults can expose to more psychological strain while dealing with problems brought by hearing loss. When people had been accustomed to a certain way of life, a sudden shift in their sensory system could be jarring. This sensation of psychological discord was accompanied by challenges in daily life and manifested as the perception of stigma. As PS-4 shared, children were more receptive to hearing loss and hearing aid devices: *"for children/babies, they underwent surgery at a very young age, so they will not suffer hearing problems during growth. And they could accept hearing devices more easily than teenagers and adults"*.

3.2 Stigmatization Associated with Hearing Aids

The primary reason for perceived stigmatization shared by participants with hearing loss was associated with wearing hearing aid products. From the survey, about 87% of participants stated that hearing aids could help them improve their hearing in most

situations, but some still refused or struggled with hearing aids. While hearing aids amplify the sounds around people, they also amplify/accentuate one's personal defects, i.e., a person with hearing impairment will be more easily noticed so several participants shared they do not want to expose their impairment to the public. PI-3 stated that:

“Without my hearing aids, I wouldn't be able to communicate. They work well. I would compare this with visual impairment. If you have a visual impairment, you can wear glasses. And you still look like a normal person. But if you wear a hearing aid product, everyone will know that I have a problem with hearing”.

She also remarked that she, like many others, tended to conceal her hearing aids. The invisible design conceals not only the hearing aids but also the stigmatization that surrounds them:

“Anyone who says they are not embarrassed wearing hearing aids is lying. I choose the CIC variant as nearly invisible. In my case, it makes me an ‘old man’ before my time. It might be better for women with longer hair. They can hide BTE aids better.”

Participants shared their concerns about products in the actual use process, not only for the practical support, but also for the humanistic care behind additional items. People prefer hearing aid items that hide their impairments and make effort to hide the items. For example, PI-7 shared how she helped her son hide his hearing aids:

“My son had a cochlear implant when he was very young. I was worried that he would receive discrimination and feel inferior because of his hearing aids, and I would help him hide them in his hair. He now has a haircut that looks like a little hat to block his hearing aids”. She stated she made many compromises to hide the hearing aid: “Since his cochlear implant surgery, my kid has had the same hairstyle, and it hasn't changed in years. Even though it's hot, many little girls may leave their hair long for a long time to conceal their cochlear implants.”

3.3 Strategies to Overcome Stigma

Not all participants were impacted by the perception of stigma. For example, some participants decorated their hearing aids instead of hiding them and gave their hearing aids a different definition, which was easier for others to accept their functional impairments. As shared by PI-7, her son designed many stickers for his hearing aids. He would show his hearing aid to his friends and tell the children around him that it was a gift from an anime character:

“He figured out how to make his hearing aids look cool. It was hard for him to make friends because of his hearing before. But ever since he got into watching anime, he started to think about how he could make himself look like anime characters. So, he started designing anime peripherals and combining these with his hearing aids. He showed his design to the kids around him and soon attracted many of them. This was also an opportunity for him to integrate into the circle of his peers slowly”.

PI-6 also stated that a considerable number of people had grown more accepting of ear electronics due to the presence of a wide variety of Bluetooth headsets. One of the participants eagerly expressed her expectation of the next generation of hearing aid to more closely resemble electronic products, to be more beautiful while maintaining functionality, thus allowing the technology to be blended into fashion trends in modern society: “*Although I can hide my hearing aid under my hair, if it is like the AirPods, I just look like a normal person*”.

4 Iterative Prototyping of Hearing Aids

4.1 Design Workshops

A design workshop was adopted in the project to develop design alternatives and elements that effectively reduce stigmatization in potential users. The research team created a design workshop with three design students. A design workshop was chosen to assist designers better understanding the usage scenarios encountered by hearing loss people. Before the establishment of the workshop, existing hearing aid models on the market were compared and their benefits and drawbacks were correspondingly evaluated. There are many different types of hearing aids available on the market, and their suitability is determined by the degree of hearing loss (see Fig. 1).

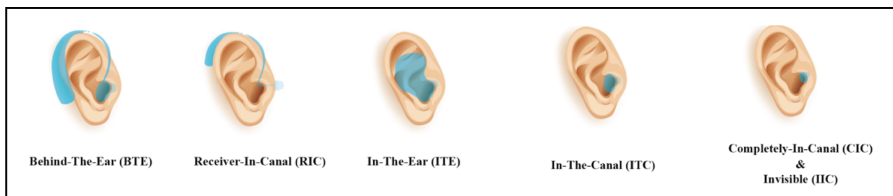


Fig. 1. Different types of hearing aids. Images are taken from hkincus.com.

The workshop was comprised of several activities, including the production of storyboards, 3D prototypes, and debriefing interviews. Each participant was asked to complete at least one storyboard, in which a usage scenario was predefined. The target users were further subdivided based on the defined scenario. Participants illustrated the action in the storyboard and considered the functional design and product form of a hearing aids. Participants were asked to draw sketches and create 3D models based on their proposed scenarios. They were provided with various modeling materials such as wire, pipe cleaners, and clay. Designers created different design scenarios and use cases. For example, a designer mainly focused on female users and combined hearing aid products with fashionable designs based on BTE Model. Other designers explored hearing aids to encourage participation in social activities and broaden the social circle of those with hearing impairments, thereby lowering stigma (see Fig. 2).

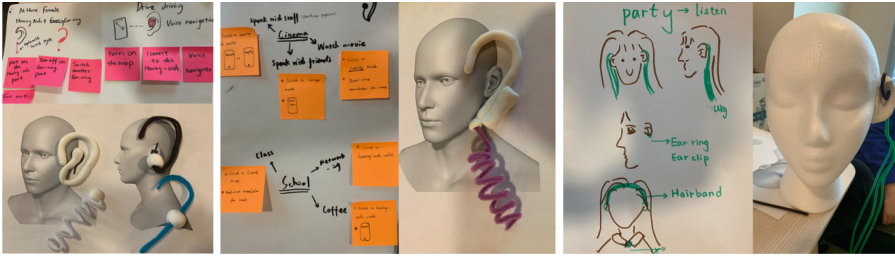


Fig. 2. Storyboard and prototype developed by designers in the design workshops.

4.2 Prototyping

Based on the result from the workshop and the preliminary empirical findings from the survey/interview, we developed two design prototypes. The first strategy was to reshaping product by de-identification. This strategy can be divided to into camouflage and diversion of attention categories. Designers would utilize translucent or skin-colored materials in the camouflage method. The device was concealed consumer electronics so the user would not draw attention while wearing the product. There were two design directions available in the first strategy: the first was a binaural independent Bluetooth earphone based on the ITE Model, while the second was a neckband headphone based on the RIC Model (see Fig. 3). The second strategy was to reshaping product by identification. Personalization allows users to choose or change the product in such a way that it compliments and expresses their identity, for example, the adding of lifestyle components. Compared to the design of traditional hearing aids, this product was defined as smart jewelry to transform them into fashionable wearables (see Fig. 3).

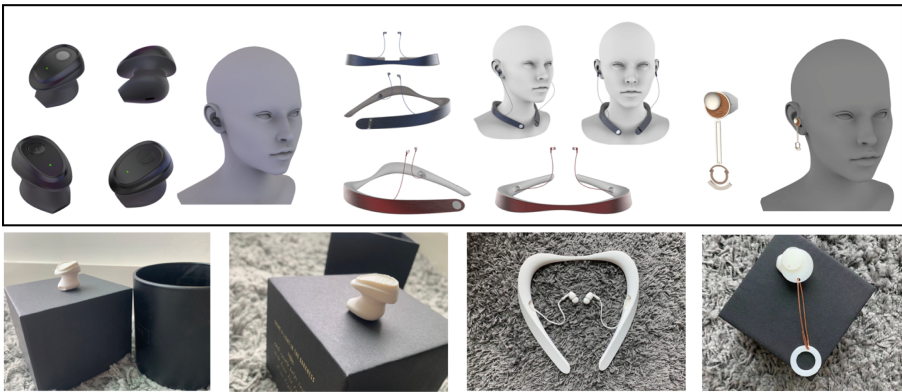


Fig. 3. From left to right: Binaural independent Bluetooth earphone based on the ITE Model; Neckband headphone based on the RIC Model; and Smart jewelry based on the ITE Model.

4.3 Interface Design

The interface design (see Fig. 4) is used to configure hearing aids. Users need to connect their hearing aids with the app via Bluetooth when they log in. They are allowed to check current hearing aids moods and make adjustments. They can also switch between different modes and link their aid with other electronic devices such as cell phones, iPads, and laptop computers. A sound enhancer and tinnitus management tool are used to fine-tune the sound output and make the sound output more acceptable for the hearing impaired. Based on the literature review and design workshop, different scenarios are defined in the interface design to satisfy the demands of various circumstances, including, modes for noisy places, transportation as well as speech to text option and microphone mode focuses on more private communication. The multi-functional hearing aid design avoids the need for users to switch between products while using them. Users can also monitor the current connection status and usage of their hearing aids, making it simple to manage their hearing aids.

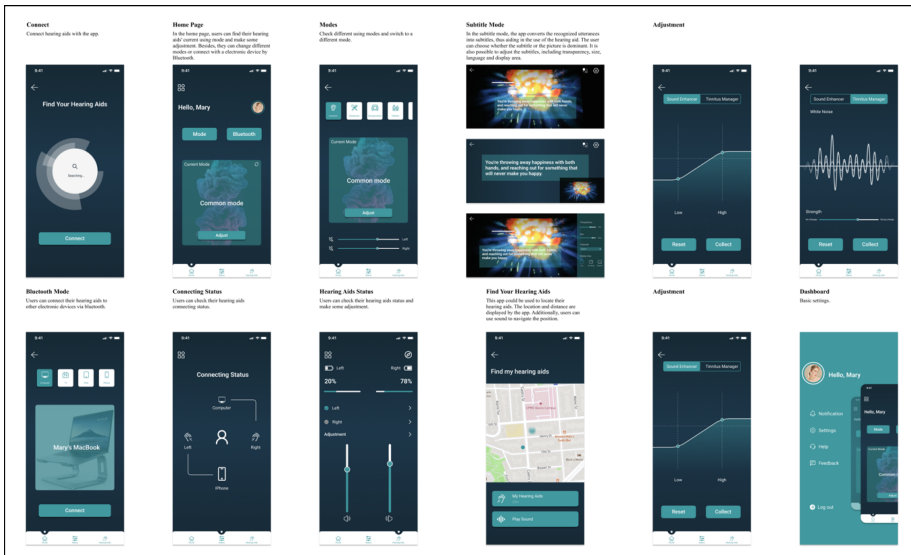


Fig. 4. Interface design associated with hearing aids.

5 User Study

A user study was conducted after the prototypes were fabricated. The goal of the user study was to evaluate whether the proof-of-concept prototypes could reduce stigmatization and whether the mental application model established by the users matched conceptual design of the prototypes. Five users who had previous experiences with hearing loss and hearing aids were recruited, four of whom were female, and one was male.

In the user study, the participants were assigned to engage with both the mobile application and the 3D-printed prototypes. To guide their interactions, participants were asked to complete 7 tasks that had been developed for the user study:

- Participants wore different prototypes one by one.
- Participants adjusted the prototype to fit their ears.
- Participants connected the hearing aids with the App.
- Participants adjusted the volume of hearing aids using the interface prototype.
- Participants changed different usage modes through the interface prototype.
- Participants checked hearing aids connection status.
- Participants use the APP to find their hearing aids.

We observed their tasks and encouraged them to think out loud and describe their experience as they were exploring the prototypes. Following the user study, the participants completed a questionnaire consisting of Likert scale questions to evaluate their satisfaction with the design prototypes. After completing the questionnaire, participants were asked to voice their sentiments toward the system and evaluate the usefulness of the prototype and discuss how the conceptual model of the system deviated from their own. We asked questions such as, what do you think of our concept? Are you willing to wear them in your daily life? Are you willing to recommend these prototypes to your friends?

5.1 Results

All participants completed a post-usability survey to evaluate their overall satisfaction, which included seven questions, rated on a scale of 1 = strongly disagree to 5 = strongly agree (Fig. 5). We calculated the mean for each answer provided and found the overall average number for participants satisfaction rate (Q1 to Q7) is 4.085 out of 5.

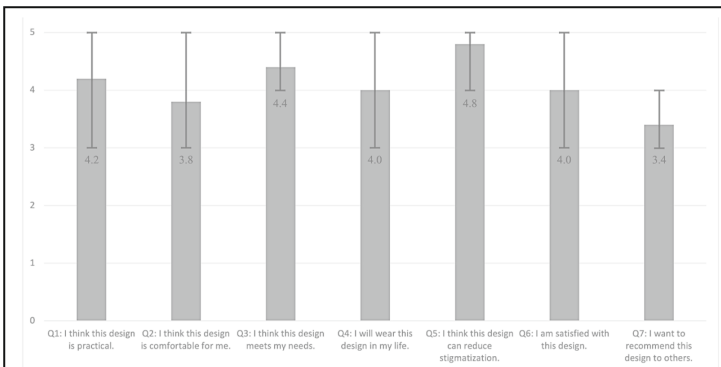


Fig. 5. The post-survey results on three prototypes’ satisfaction rates show the calculated average mean per question. Error bars represent the maximum and minimum values.

All five participants expressed that the prototypes could reduce the perception of stigma. They believed that disguising stigmatizing features was the most effective approach. People were less concerned about whether assistive technologies were worn in the

ear when they were hidden behind common consumer products. As P2 stated: *“I would think this is the best design solution! People wear headphones, maybe for listening to songs, maybe for navigation. If I wear the same product, people will think I’m listening to a song and won’t notice if I’m using a hearing aid”*. They also thought the smart jewelry design is appealing and regarded it as a demonstration of personality. These design concepts still have some drawbacks. P1 claimed that the friction of her hair may affect the effectiveness of the hearing aid. She had to tie her hair at the back of her head while she wore her hearing aids. P4 expressed his concern about the wearability of smart jewelry solutions. The hearing aid might fall out in case of quick movements: *“I don’t think it’s the accuracy of 3D printing. I mean, it wasn’t able to fit my ears perfectly. Will he fall out when I’m working out? Of course, a lot of headphones are not designed to ensure that they do not fall out completely during exercise”*.

The jewelry requirements for women varied greatly in different situations, they hoped that basic kits could be available for users to design their hearing aids. They hoped the design could give users more color schemes to meet the preferences of different people. Color is a design element that can reveal the user’s personality. *“Women’s requirements for accessories will change depending on the occasion. I don’t think a single smart jewelry design can fully satisfy my social needs”*. P5 expressed a desire for the jewelry’s appearance to be more exaggerated. As a social opportunity point, the current design is a bit conservative: *“This design may be a bit ordinary for being a talking point. It may attract attention, but far less than a more exaggerated design”*.

Additionally, Participants shared that the numerous modes created in the application, could be a useful for people wearing hearing aids and help them better participate in social events. Bluetooth mode could make it easier for them to utilize a range of electronic devices in a variety of scenarios without being overwhelmed. Hearing aids could become more powerful due to their systematic design solutions. The design prototypes could be integrated into people’s daily lives life, breaking the constraints of the original AT products. These design concepts could offer them substantial assistance in a variety of settings and make them more confident participating in social activities: *“The design of the usage modes is really helpful! I can participate in different social scenarios, encouraging me to be proactive socially”*. Furthermore, the subtitle model was found to be useful. Even with hearing aids, many people with hearing loss struggle to communicate with others, and some still rely on visual signals to read information. Subtitle mode could be customized to fit several situations. As P5 stated: *“The subtitle mode allows me to study and work more efficiently. The subtitle mode is designed with details that consider the difference between users and is very useful”*.

6 Discussion

The perception of hearing aids as being stigmatized is a key impediment to hearing loss people’s development. Much of the stigma among those with hearing loss is related to wearing hearing aids, rather than the hearing loss itself [19], defined as the “hearing aids effect” first mentioned in 1977 by Blood, Blood, and Danhauer [1]. This study revealed stigma problems from different perspectives, including social behavior and self-esteem. Social participation is defined as a person’s involvement in social activities

that provide them with interaction with others in the community [6]. Social engagement, as interactions with potential ties in real life, provides individuals with a coherent and consistent sense of role identity, companionship, and sociability as well [3]. People with hearing impairments have a substantially lower level of social participation due to their functional deficiencies and designing appropriate hearing aids can improve their social involvement and activities. Additionally, self-perception, or people's personal views about themselves, has a significant impact on the type of activity people engage in, the efforts they will put into that activity, and the likelihood that they will engage in that activity [12]. Self-perception, along with the judgment of individuals from others, helps assess the quality of social relationships [13].

Designing hearing aids should consider improving self-perception and promoting social engagement in people with hearing impairment. By deconstructing the using process and refining the system of hearing aids, the perception of stigma can be reduced regarding design elements and functionality. Designers should consider adopting an empathic and human-centered design approach to designing hearing aids (and other ATs) to better understand people living with impairments needs and enhance their well-being by proposing mainstream product solutions that improve their self-esteem and social interaction. The social acceptability of using hearing aids can be affected by their functional flaws so designers should be aware that these products should psychologically assist people with disabilities.

Adults with hearing loss are more likely to have a poorer personal and family socio-economic position, leaving them more frequently exposed to negative life events, and unhealthy behaviors, thus resulting in increased physical and psychological stress. They may experience rage and irritation on a regular basis, in adjusting to a world that is not built for them. We suggest designing hearing aids following inclusive design principles, which emphasizes the notion of mainstream products, which eliminate the need for ATs in the definition: "*The design of mainstream products and/or services that are accessible to, and usable by, as many people as reasonably possible on a global basis, in a wide variety of situations and to the greatest extent possible without the need for special adaptation or specialized design*" [8]. Considering product semantics can be useful in solving stigma-related design concerns. This study has some limitations. Firstly, during the COVID time, part of the design research and usability tests were conducted remotely, so important information might have been overlooked. Second, given that the participants were mostly women, the final design outcome may not be fully representative of the entire community. Future research needs to be conducted to further develop and explore mainstream ATs and hearing aid design alternatives to reduce or eliminate perceived stigma in people with hearing impairments.

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