Uncovering Insights to Improve the Development of Hearing Aids for Musicians and Music Listeners

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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I. Introduction

In the United States, “hearing loss has been found in over 52% of classical musicians and 30% of rock and roll musicians” (Chasin, 2010, p. 30), and many hearing aid users “reported problems with pitch perception, hearing lyrics in music, and distortion, but those with more severe hearing loss were more likely to experience these issues, particularly in live contexts" (Drever & Hugill, 2023, p. 134). One study asked hearing aid users how they felt about their music listening experience using hearing aids and they responded with the following: “It’s just wobbly, that note is not holding its pitch at all, it’s going in and out of tune,” “Music comes out as just a noise... a lot of it doesn’t make sense,” “I used to be part of that, loved it, but that’s one of the things I can’t do any more,” “I’d love to improve listening to CDs, but I don’t think it’ll happen in my lifetime” (Drever & Hugill, 2023, p. 138 - 140).

To address these issues, Greasley, Crook, and Beeston (2019) proposed recommendations for hearing aid manufacturers, musicians, audiologists, and researchers to improve the development and adjustments of hearing aids for music enhancements. They noted that there is “significant potential to develop future partnerships” among the key stakeholders (p. 24). Similarly, McKee et al. (2022) analyzed the influence of the health system, providers, and patients in overcoming communication barriers between patients and healthcare providers. Thus, researchers seek to understand how to promote effective collaboration between the hearing aid manufacturers, audiologists, musicians, and users.

Without addressing these communication barriers, the dissatisfaction among musicians and music listeners using hearing aids will persist. For example, “hearing loss and tinnitus are particularly problematic for musicians because hearing problems affect musical performance skills and limit employment opportunities, as well as impacting on communication and quality of

life” (Drever & Hugill, 2023, p. 125). Also, "many listeners reported experiencing anxiety, frustration, and depression, and some had stopped participating in musical activities as a result" (Drever & Hugill, 2023, p. 135).

In my research, the development of specialized sport prosthetic (SP) limbs for para-athletes serves as an analogy for the development of hearing aids for musicians. This analogy reveals the often-overlooked challenges that hinder effective collaboration among hearing-impaired patients, audiologists, and manufacturers. By analyzing the process through which SP limbs were developed including how they transitioned from ineffective to effective collaboration frameworks and successfully delivered tailored products for individuals with disabilities, I uncovered valuable lessons from past mistakes and strategies that could enhance the development of hearing aids for music. My research question is: What insights from the collaborative efforts and priorities in developing SP limbs for para-athletes can be applied to improve the development of hearing aids for musicians and music listeners?

I found that effective collaboration can be improved by addressing these three insights: there is a stigma surrounding hearing aids due to insufficient and often negative media representation by associating these devices with aging and frailty, which discourage their use; there are significant financial barriers that restrict access to essential services, making it difficult for individuals to obtain the services and support they need; and there is a lack of inclusivity within healthcare environments that hinders effective communication between patients with hearing loss and healthcare providers. Addressing these challenges is essential to fostering better collaboration and ensuring equitable access to care.

II. Problem Definition: Addressing the Communication Gaps in Hearing Aid Development for Musicians

Greasley, Crook, and Fulford (2020) found that "67% of hearing-aid users reported some degree of difficulty listening to music," yet "58% of hearing-aid users had never discussed music in a clinic" (Greasley, Crook, & Fulford, 2020, p. 1). This indicates that despite a majority of users experiencing problems with music, the topic is rarely brought up during appointments. To further analyze this issue, Greasley, Crook, and Beeston (2019) conducted clinic surveys and the results were found in the figures below.

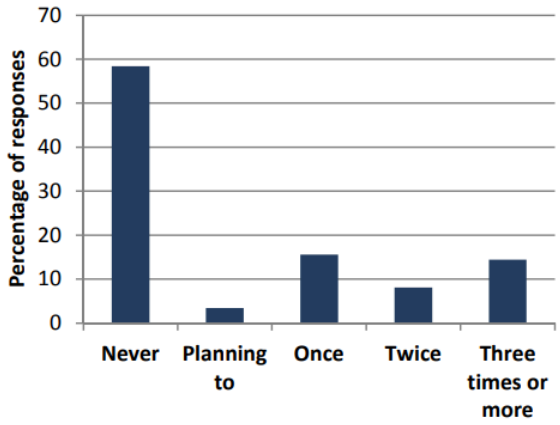

Figure 1. Frequency of discussion about music in clinic
A significant majority of participants reported that music was never discussed during their clinic visits (Greasley, Crook, & Beeston, 2019, p. 12).

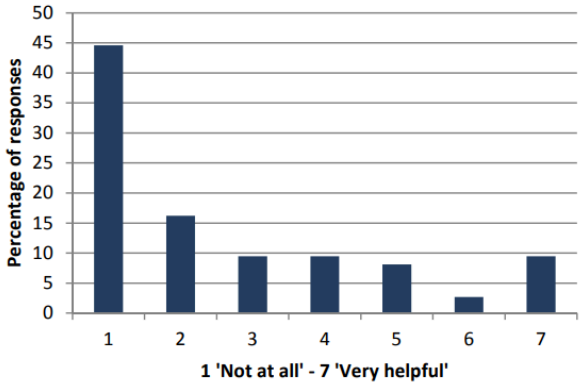

Figure 2. Ratings of whether discussions about music improved outcomes
A significant majority of participants reported that, even with discussions about music, it did not lead to significantly improved outcomes in the performance of their hearing aids' music enhancement capabilities (Greasley, Crook, & Beeston, 2019, p. 12).

It was found that, despite music being rarely discussed during clinic visits, when music was discussed, it did not significantly improve the music enhancement capabilities of their

hearing aids. However, “there was a link between increased time spent discussing music with audiologists, specific tailoring hearing aids for music and positive outcomes for music listening experiences” (Greasley, Crook, & Beeston, 2019, p. 12). This means that when more time is spent discussing music with audiologists, hearing aids can be better tailored to enhance music listening, improving users' ability to enjoy good quality music.

However, while musicians who use hearing aids are advised to seek out audiologists with expertise in music adjustments, access to those audiologists are limited. This is due to the fact that “music is not a required part of any audiology curriculum,” and “63% of practitioners reported having no training in terms of fitting hearing aids for music” (Greasley, Crook, & Beeston, 2019, p. 16). As a result, many musicians may struggle to find audiologists with the necessary skills to address their specific needs, widening the communication gaps between the users and audiologists.

Additionally, audiologists also play a crucial role in helping manufacturers understand the technical specifications needed for effective music programs (Greasley, Crook, & Beeston, 2019). However, for audiologists to do this effectively, they rely on manufacturers to provide detailed information about their music programs, but most hearing aid brands either keep this information proprietary or do not fully disclose how their music programs differ from speech programs (Sandgren & Alexander, 2024). This lack of communication and transparency between manufacturers and audiologists hinder the development of optimal hearing aids for musicians and limit audiologists' ability to recommend the best devices for their patients' musical needs.

Moreover, musicians with the same hearing loss diagnosis, like mild or moderate hearing loss, often have very different listening needs and experiences, which emphasizes the need to tailor hearing aid fittings to each individual (Drever & Hugill, 2023). Audiologists have stated

that “there was no ‘one-size-fits-all’ approach” in adjusting hearing aids for their patients (Drever & Hugill, 2023, p. 135), which is similar to how “the development of a SP is individualized for each participant” and that “there may be significant variability in the designs among participation in the same sports” (De Luigi, 2024, p. 2). Thus, analyzing the strengths and challenges in the implementation and adoption of SP can help identify barriers to effective communication among stakeholders and reveal strategies for fostering collaboration between patients and healthcare providers to improve the development of music-enhanced hearing aids.

III. Research Approach: Using Analogies to Gain Insights for Improving Collaboration in Hearing Aid Development

I used Schwarz-Plaschg’s (2018) framework on analogies to better understand the challenges and constraints in the collaborative efforts of key stakeholders involved in developing music-enhanced hearing aids. The title of the selected source to guide my research approach is “The Power of Analogies for Imagining and Governing Emerging Technologies” by Claudia Schwarz-Plaschg. I chose this source because it shows how analogies can help the public and stakeholders better understand the hidden constraints and potential outcomes of emerging sociotechnical systems, such as the rise of hearing aids with music-enhanced capabilities. I applied Schwarz-Plaschg’s framework to draw parallels between the development process of hearing aids designed for musicians and music listeners and the development process of specialized prosthetics for athletes. This framework uses three main concepts: analogical imagination, anticipation of the future, and analogical sensibility. These concepts helped me identify collaboration barriers in designing music-enhanced hearing aids, identify potential ways to overcome them, and explore how these insights can shape public and stakeholder perceptions of hearing aid development for music-enhancement.

The first key concept is analogical imagination, which uses analogies to connect familiar ideas with new ones, helping people envision how emerging sociotechnical systems might be integrated and accepted by society. Analogical imagination also fosters “productive imagination," which “is rooted in existing knowledge while simultaneously transforming it” (Schwarz-Plaschg, 2018, p. 142). In other words, productive imagination enables stakeholders to apply lessons from existing sociotechnical systems to create an emerging sociotechnical system that is valuable to its end users and can be successfully integrated into society.

Not only can analogies offer lessons on how to avoid past mistakes in previous sociotechnical systems, but they can also help anticipate future challenges and potential outcomes. Schwarz-Plaschg notes, “anticipatory analogies are not mere prospective tools but likewise work to present certain future scenarios as more plausible than others” and “analogies are crucial resources for underpinning expectations and promises, as different social groups make use of different analogies to mobilize for their preferred version of the future” (Schwarz-Plaschg, 2018, p. 144). In other words, analogies help people understand what to expect in the emerging sociotechnical systems and clarify what is being promised, so different groups of people use different analogies to support and push for the future they want to see happen. This shows how analogies can help the public and stakeholders advocate for their preferred outcomes. It’s important to consider how these sociotechnical systems may be perceived and used by others, especially since the public perceptions can differ greatly from the developers' original intentions. This is particularly relevant for developing music-enhanced hearing aids, where user satisfaction is a top priority. Ensuring that users perceive the device positively is essential for its successful integration into society.

Moreover, analogies play a crucial role in changing people's perceptions and influencing their decisions by shaping how emerging sociotechnical systems are discussed and understood, which is referred to as analogical sensibility. Schwarz-Plaschg wrote, "analogies are powerful devices in constructing views of reality and legitimizing actions" (Schwarz-Plaschg, 2018, p. 149). In other words, analogical sensibility is the ability to recognize and analyze how analogies influence the way people justify actions and decisions in sociotechnical systems, such as how stakeholders collaborate with end users, promote sociotechnical systems, and prioritize different aspects of its development. For example, comparing an emerging system to an existing, well-known one can cause the stakeholders of the emerging system to justify decisions like where to allocate funds, what safety measures to adopt, which experts to involve, and how they want to promote it to the public. This relates to developing specialized hearing aids for music listeners because stakeholders may be more likely to prioritize customized solutions, user-centered designs, or extensive testing if the analogies suggest these actions are key to ensuring user satisfaction.

The figure 3 below provides a holistic approach of using Schwarz-Plaschg's framework as a series of steps.

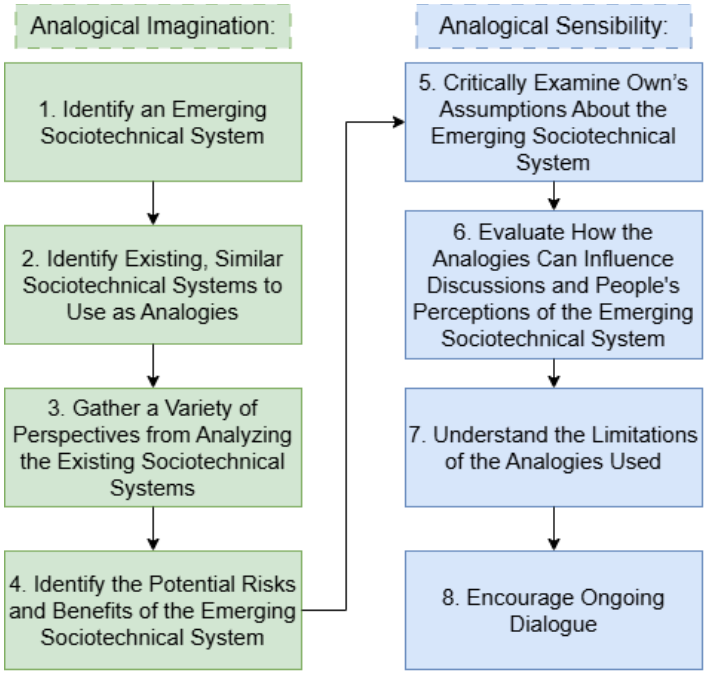

Figure 3. The Holistic Approach to Resolution as a Series of Steps
The holistic approach to resolution involves using the analogical imagination and sensibility concepts. It begins with identifying an emerging sociotechnical system, gathering diverse perspectives, assessing potential risks and benefits, questioning one's own assumptions, evaluating the influence of the analogies, acknowledging their limitations, and promoting ongoing dialogue. (Created by Author)

The approach starts with using analogical imagination by first identifying an emerging sociotechnical system that has uncertain outcomes. Then, it looks at existing sociotechnical systems with similar stakeholders or stakeholder relationships and end goals to help clarify the uncertainties of the emerging sociotechnical system. By analyzing the existing sociotechnical systems from step 2, different perspectives will be gathered to identify potential risks and benefits that could be relevant to the emerging sociotechnical system. During the data gathering stage, it's important to reflect on one's assumptions to avoid biases and uncover insights that challenges how society commonly perceives the emerging sociotechnical system.

Next, using the concept of analogical sensibility, the next step will be to evaluate how the identified insights influence the stakeholders' and public's perceptions and understanding of the

emerging sociotechnical system. This shift in understanding can influence the stakeholders' future decisions on how they will further develop the sociotechnical system. However, it's crucial to acknowledge the limitations of analogies because while analogies can simplify complex sociotechnical systems for better understanding, they can also oversimplify or misrepresent key aspects, which can lead to assumptions that overlook the unique challenges of different sociotechnical systems. The last step is to encourage further research by fostering ongoing dialogue. Figure 4 below provides the research approach I used for this research paper as a series of steps.

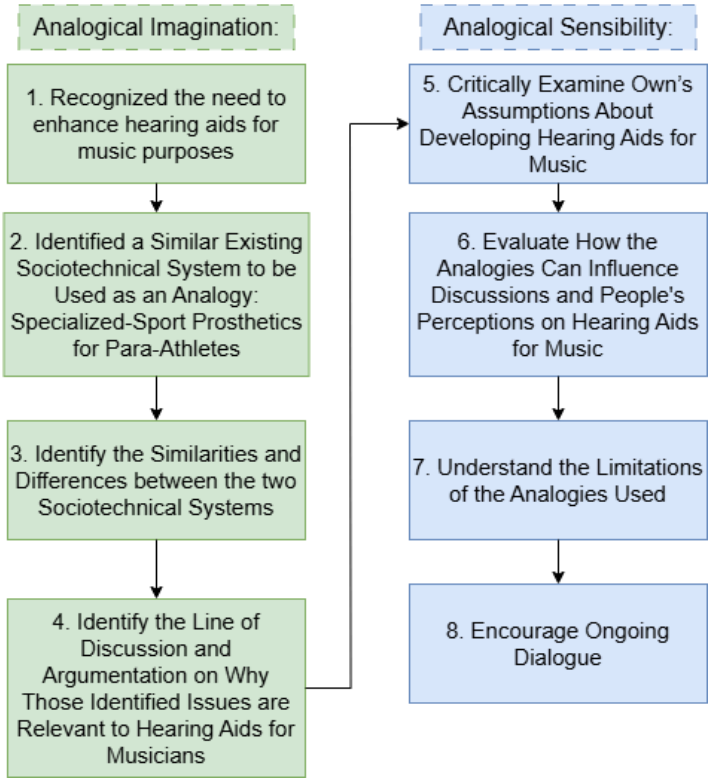

Figure 4. My Approach to Resolution as a Series of Steps
I used Schwarz-Plaschg's concepts of analogical imagination and analogical sensibility to better understand the challenges in developing hearing aids for musicians and music listeners and to uncover insights and strategies for fostering effective stakeholder collaboration. (Created by Author)

I first identified an issue within an emerging sociotechnical system, which is that hearing aids need enhanced music processing capabilities for musicians and music listeners. However, there is limited research on how stakeholders can collaborate effectively to design hearing aids that meet the users' music-specific needs. I then found an analogy to compare with the emerging sociotechnical system, which was specialized sports-prosthetics for para-athletes. Both systems involve similar stakeholder relationships and dynamics, with medical professionals collaborating with end users and manufacturers to develop highly specialized, customized products focused on user satisfaction. I then analyzed key similarities and differences between the two sociotechnical systems to understand how the key differences affect user satisfaction, acceptance, and collaborative approaches. Next, I explored how specialized prosthetics were effectively designed for Paralympic use and identified ways these design strategies might inform the development of music-enhanced hearing aids.

Afterward, using analogical sensibility, I analyzed my previous assumptions about hearing aids for music and highlighted how they differed from the insights gained. I then evaluated how these insights might influence discussions and shape public perceptions around developing hearing aids for musicians. I then examined the limitations of these analogies to avoid oversimplifying the unique differences between hearing aids for music and prosthetics for athletes. Finally, I developed new questions to encourage ongoing discussions. Following these series of steps allowed me to uncover overlooked issues and suggest strategies to improve the stakeholders' collaboration with each other.

I used research articles, journal articles, and books on how SP were developed, designed, and promoted to gather my results. One of the journal articles provided case studies on the design and development of SP for sports like running and cycling, offering lessons that can

inform the development of tailored hearing aids for musicians. When deciding how many sociotechnical systems to use as analogies, I chose to focus on just one instead of multiple. This approach gave me the chance to dive deeper into understanding the similarities, differences, and challenges both sociotechnical systems face. This can ensure that insights gained from the analogies are not oversimplified since each sociotechnical system has their own unique needs and challenges.

SP for para-athletes were chosen as an analogy for hearing aids because they demonstrate the positive outcomes of effective collaboration among stakeholders in designing for specific medical and physical needs, and both share similarities in goals because both rely on precision, customization, and collaboration between the user and healthcare provider to improve the users' quality of life. For example, similar to how audiologists adjust hearing aids for their patients' specific needs, "there is planning among the prosthetist, physician, and the person with limb deficiency to determine the appropriate modifications to the general prosthetic design to make it compatible with the given sport" (De Luigi & Cooper, 2014, p. 2). Thus, this analogy offers existing knowledge that can provide a better understanding on the barriers that hinders the effective communication among audiologists, musicians, and manufacturers in developing devices tailored for both everyday use and live performances.

Some of the key differences are that prosthetics are highly visible and widely recognized. SP often gains attention in the media, especially during events like the Paralympics. In contrast, hearing aids for musicians lack similar visibility since hearing loss is often considered an 'invisible' disability. This contrast can provide insights into how public awareness shapes development, funding, and cultural acceptance.

IV. Results: Applying Insights from SP Development to Better Understand Hearing Aid Adoption and Collaboration between Patients and Healthcare Providers

This research identified three key insights by using the development of prosthetics for para-athletes as an analogy to improve the collaboration in developing hearing aids for musicians and music listeners. The first insight focuses on why 80% of individuals who could benefit from hearing aids do not use them (McCormack & Fortnum, 2013). Hearing aids are often associated with old age, leading to a negative stigma and making users feel “less normal” or “older,” unlike for prosthetics, which are commonly viewed as tools that help individuals reintegrate into society and appear "more normal." By analyzing how para-athletes perceive media coverage about SP use, it was revealed that media campaigns focusing on users' disabilities rather than their athletic abilities can perpetuate negative stereotypes, stigmatize users, and make them feel self-conscious about their societal image. The second insight highlights how financial barriers and disparities between lower and higher income patients limit access to necessary hearing exams and adjustments for music-enhanced hearing aids. The third insight highlights how a lack of inclusivity and training in healthcare hinders effective communication between healthcare providers and patients, making it challenging to address the unique needs of hearing-impaired individuals. Figure 5 below illustrates these three insights and the potential positive impacts of addressing them.

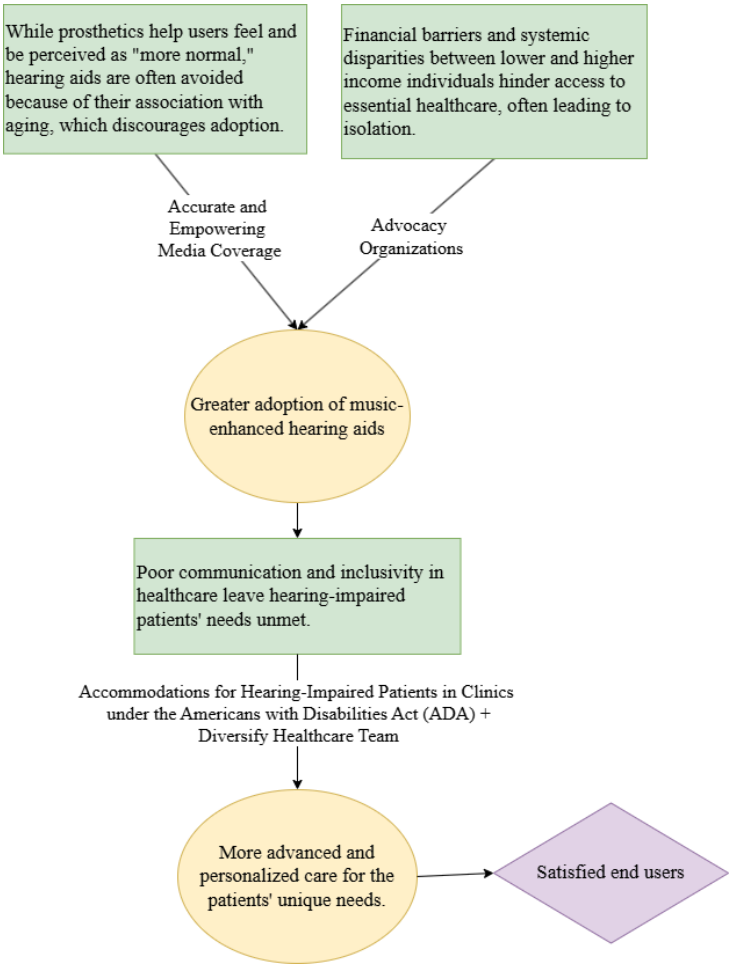

Figure 5. Block Diagram of Insights and Their Significance When Addressed
The green boxes represent the three main insights: stigma around hearing aids compared to prosthetics, barriers to accessing essential healthcare, and poor communication and inclusivity in healthcare. The arrows and yellow circles show how using the findings in this research can help address these insights, which can lead to greater adoption of music-enhanced hearing aids and improved personalized care to result in more satisfied end users. (Created by Author)

Figure 6 below is a table that organizes the main evidence in this results section to show the differences and similarities between the two sociotechnical systems.

Topic	**Hearing Aids for Musicians**	**Specialized-Sport Prosthetics for Para-Athletes**
Cultural Differences in Visibility	"Many deny and tolerate hearing loss for a considerable period of time before being coerced by a family member to seek medical care" (Sataloff R. & Sataloff J., 2009, pg. 1)	Prosthetics for para-athletes became widely recognized due to limb amputations after WWII and September 11th attacks (De Luigi, 2024), and are publically known due to the Paralympic games, helping publicize and increase funding due to visible needs (Dyer, 2020).

User Demographics	Primarily used by older adults experiencing hearing loss. Age is the strongest predictor of hearing loss among adults ages 20-69, with the greatest amount of hearing loss in the 60-69 age group (Hoffman, 2016).	Primarily used by younger, active individuals. “There was a spike in the number of younger, healthier individuals with amputations (compared to dysvascular amputations) who were seeking opportunities to continue with high-level physical activity despite limb loss” (Luigi, 2020, p. 1).
Funding	Medicare doesn't cover hearing aids or exams for fitting hearing aids (U.S. Centers for Medicare & Medicaid Services, n.d.).	Medicare covers prosthetic devices needed to replace a body part or function when a Medicare-enrolled doctor or other health care provider orders them (U.S. Centers for Medicare & Medicaid Services, n.d.).
Education for Adoption	Audiologists rely on manufacturers for details on music programs in hearing aids, but many brands keep this information proprietary, complicating recommendations for music enhancement (Sandgren & Alexander, 2024).	“It is important for physicians to educate their patients with physical disabilities about these growing and diverse opportunities” (De Luigi, 2020, p. 1).
Start with General-Use Devices	"It often took regular follow-up appointments to adjust the hearing aids for improved music listening" and in a case study, an “audiologist encouraged the user to bring his guitar into the clinic so he could tweak the music program whilst he was playing” (Drever & Hugill, 2023, p. 135-136).	“Prior to using a sports-specific prosthesis (SP), it is best to develop ambulatory skills using endurance training to transition from a deconditioned state starting with a traditional, general-use prosthesis” (De Luigi, 2020, p. 2)
User Comfort and Feedback	“The majority (80%) of adults aged 55–74 years who would benefit from a hearing aid, do not use them” due to “hearing aids not providing enough benefit and comfort” (McCormack & Fortnum, 2013, p. 1).	“The OPUS survey found that 88% of participants felt that factors like fit, ease of putting on, comfort, weight, and durability were crucial to their satisfaction with a prosthesis” (De Luigi, 2020, p. 2).
Design Specialization	People’s listening needs and experiences varied even though they had the same diagnosis, showing that an individual approach to fitting hearing aids is crucial (Drever & Hugill, 2023, p. 136).	A case study by (Dyer, 2020) revealed that when a SP design prioritized versatility, allowing the prosthetic to be used across multiple sports, the device couldn’t be fully optimized for peak performance in any single sport because adapting to multiple activities required trade-offs.
Healthcare Emphasis	“The majority (80%) of adults aged 55–74 years who would benefit from a hearing aid, do not use them” (McCormack & Fortnum, 2013, p. 1); “Music is not a required part of any audiology curriculum” and “63% of practitioners reported having no training in terms of fitting hearing aids for music” (Greasley, Crook, & Beeston, 2019, p. 16); “58% of hearing-aid users had never discussed music in a clinic” (Greasley, Crook, & Fulford, 2020, p. 1).	“With the technologic advances in medicine and an emphasis on maintaining physical fitness, the population of athletes with impairments is growing” (De Luigi & Cooper, 2014, p. 1).

Figure 6. Compare and Contrast Table for Hearing Aids for Musicians versus SP for Para-Athletes

This table shows the concrete evidence to showcase the differences and similarities in the design, development, collaboration, and promotion for hearing aids for musicians versus SP for para-athletes. It organizes the concrete evidence to better understand their cultural aspects, user demographics, accessibility through fundings, collaborative efforts, and healthcare priorities of the two sociotechnical systems to make it easier to reference the evidence in the results section. (Created by Author)

1. **Addressing Hearing Aid Stigma: Media Representation to Enhance Adoption and Empower Users**

While prosthetics are widely represented in media, embraced by society, and help users feel "more normal," hearing aids face stigma due to their association with aging, which discourages adoption. This was uncovered by analyzing the factors behind the popularity of prosthetics for para-athletes and examining how promoting para-athletes in an empowering and accurate way has contributed to their acceptance. De Luigi (2024) noted that "the majority of the new advances in sports-specific prosthetics occurred in the immediate time following the September 11th attack and the subsequent military conflicts, leading to an increase in the number of persons with traumatic amputations." Additionally, the popularity of the Paralympic Games (Dyer, 2020) played a significant role in raising public awareness about the need for prosthetics. There was also "a spike in the number of younger, healthier individuals with amputations who were seeking opportunities to continue with high-level physical activity despite limb loss" (De Luigi, 2024, p. 1). Therefore, there was significant awareness of prosthetics, driven by empowering media representation, particularly through events like the Paralympic Games. This awareness shifted the public's perception to view prosthetics as tools for showcasing resilience and capability, helping individuals reintegrate into society after tragedies or disasters.

In contrast, hearing aids are often associated with older demographics and viewed as an embarrassing sign of aging or infirmity, which discourages many from seeking necessary medical assistance (Sataloff & Sataloff, 2009). Age is the strongest predictor of hearing loss among adults aged 20-69, with the highest rates occurring in the 60-69 age group (Hoffman, 2016), and many individuals delay addressing their hearing loss, often tolerating it until a family

member intervenes (Sataloff & Sataloff, 2009). This stigma surrounding hearing aids prevents many from exploring opportunities to enhance their music listening experiences.

Hearing loss is far more common than limb loss, with 28.8 million U.S. adults who could benefit from hearing aids (National Institute on Deafness and Other Communication Disorders, 2024) compared to 2.3 million Americans living with limb loss (Caruso & Harrington, 2024), highlighting a significant need for hearing aid adoption. However, much of the focus has been directed toward improving physical abilities through prosthetics, which is driven by increased emphasis on physical fitness in the media and healthcare community, encouraging more people with limb impairments to use prosthetics (De Luigi & Cooper, 2014). As a result, hearing aids receive less media attention and research focus, particularly regarding their ability to enhance quality of life through music, which reduces awareness and leaves users feeling underrepresented.

One way to reduce the stigma surrounding hearing aids for music is through thoughtful media attention and promotion. Lessons from the media representation of para-athletes show that advertising influences public perceptions, and can unintentionally reinforce harmful stereotypes. For instance, many para-athletes feel they are portrayed either as “superheroes” overcoming disabilities or as victims defined by their impairments (Pearson & Misener, 2024). Janice, a Paralympic athlete, emphasized her desire for media coverage to highlight her athletic achievements, saying, “I don’t want it to be focused on my disability. I want it to be focused on my ability” (Pearson & Misener, 2024, p. 14). Similarly, Carlo, another Paralympian, said, “I view the word inspiration as sort of a dirty word because… people didn’t really care what kind of athlete I was or didn’t really see me as an athlete” (Pearson & Misener, 2024, p. 13). These examples highlight the importance of authentic representation in media, focusing on individuals'

strengths and abilities rather than perpetuating any negative stigmas of using medical assisting devices.

Hearing aids face similar challenges in overcoming stigma in media representations. Advertisements that depict hearing aids as a sign of aging or frailty reinforce negative stereotypes and discourage potential users. Instead, media campaigns or coverage should focus on showcasing the talents and accomplishments of hearing aid users, particularly musicians, to highlight hearing aids as tools that enhance their quality of life. These portrayals can reduce feelings of isolation and misunderstanding, shifting the narrative away from weakness and toward empowerment. By emphasizing abilities rather than disabilities, hearing aids can be normalized and therefore encouraging more adoption, especially among younger users and musicians. Similar to how the representation of prosthetics for para-athletes increased demand and user satisfaction, a more positive portrayal of hearing aids could lead to greater acceptance and recognition of their potential for improving people's quality of life through music enhancement.

2. **Addressing Financial Barriers: Advocacy for Equitable Access to Hearing Aids**

Access to hearing aids is limited for many due to financial barriers, particularly due to the lack of insurance coverage for hearing aids and hearing exams. While Medicare Part B covers prosthetic devices prescribed by Medicare-enrolled providers, it does not cover hearing aids or hearing exams for fitting them (U.S. Centers for Medicare & Medicaid Services, n.d.). This is especially concerning because Medicare primarily serves individuals aged 65 and older, and the group that experiences the highest rates of hearing loss are those over 60 years old (Hoffman, 2016). Despite the significant need within this demographic, Medicare offers no assistance for hearing aids or the associated hearing exams. Similarly, Medicaid, a joint federal and state program designed to provide health coverage for individuals with limited income, also offers

limited support for hearing aids. Only a few states require Medicaid to cover hearing aids for adults, leaving many low-income individuals without affordable options (Everett, 2023). These gaps in hearing aid insurance coverage contribute to their low adoption rates. This can be seen by how hearing loss affects 23% of individuals over age 12 and 75% of those 70 and older, yet only one in seven people with hearing loss seeks treatment (Everett, 2023).

This lack of insurance coverage creates financial barriers, especially for lower-income individuals who already face challenges in accessing healthcare. When looking at lower-income individuals who need prosthetics, a study shows that minority patients requiring prosthetics often face higher rates of major amputation due to lower income, limited insurance coverage, and restricted access to quality care at under-resourced hospitals (Henry et al., 2011). These inequalities lead to lower quality healthcare services and poorer health outcomes, highlighting the need for more accessible healthcare policies. Thus, affordability concerns disproportionately affect lower-income populations, limiting their access to advanced medical assistive devices like specialized sports prosthetics or music-enhanced hearing aids.

McKee et al. (2022) found that hearing-loss patients often have limited awareness of their legal rights to accessible healthcare, and hearing loss can be "isolating, resulting in a loss of social support and resources to address their needs" (p. 7). Advocacy organizations, such as the Hearing Loss Association of America and the National Association of the Deaf, provide "advocacy services, resources, and networking opportunities relevant to hearing loss. Many of their efforts center around advocating for better care and accessibility in health care" (p. 7). These organizations have also supported legislative efforts, such as the Over-the-Counter Hearing Aid Act, which reduces costs and improves accessibility for those with mild to moderate hearing loss (McKee et al., 2022). Connecting patients with these organizations highlights the

importance of empowering individuals to advocate for their needs while raising awareness of available resources. Additionally, the role of these organizations in making patient voices heard and raising awareness to the existing financial disparities, similar to those observed in prosthetics care for lower-income individuals, help to promote more accessible healthcare opportunities.

3. Addressing Ineffective Communication Between Patients and Healthcare Providers: Promoting Inclusivity in Clinics for Hearing Impaired Patients

A lack of effective communication and inclusivity in healthcare for hearing impaired patients leads to unmet needs and dissatisfaction, emphasizing the need for diverse healthcare teams and personalized connections between healthcare providers and patients. Many healthcare providers are not adequately trained to care for or communicate effectively with individuals with hearing loss, resulting in frequent miscommunication and poor understanding of patients' needs. For example, a study found that "87% of providers felt they communicated effectively with their deaf signing patients, even in the absence of interpreters, through lipreading and note writing," "yet patients with hearing loss commonly state they have problems communicating with their physicians" (McKee et al., 2022, p. 5). Thus, many healthcare providers are not aware of their ineffective communication towards patients with hearing loss.

This communication gap is made worse by many healthcare providers not fully understanding their legal responsibilities under the Americans with Disabilities Act (ADA). A 2018 survey revealed that "37% of people were denied an interpreter in a healthcare facility" and "35.8% of 714 physicians surveyed knew little or nothing about their legal obligations, while 71.2% answered incorrectly regarding who determines reasonable accommodations" (McKee et al., 2022, p. 5). The ADA mandates that healthcare providers are legally responsible for ensuring accommodations such as qualified sign language interpreters or that personal sound amplification devices are made available upon request. When physicians fail to meet their ADA

responsibilities, it becomes particularly challenging for individuals with specific needs, like musicians, to request and receive necessary adjustments to their hearing aids for music.

To address these barriers, lessons can be drawn from the design practices and development process of SP for para-athletes. Successful case studies of SP development often involved close communication, a trial-and-error approach, and clear expectations for users regarding the duration and gradual improvement of the process. For instance, De Luigi (2020) emphasizes that "prior to using a sports-specific prosthesis, it is best to develop ambulatory skills using endurance training to transition from a deconditioned state, starting with a traditional, general-use prosthesis" (p. 2). This process of making gradual adjustments through trial and error to medical assisting devices requires consistent and clear communication between patients and healthcare providers to effectively address unique user needs. Thus, clear and effective communication between patients and healthcare providers is necessary for successfully implementing this design process, highlighting the importance of healthcare providers providing the necessary resources to facilitate effective communication with their patients.

Moreover, McKee et al. (2022) highlight that diversifying healthcare teams is essential to better addressing the unique needs of diverse patients, stating that "training a diverse health care workforce provides opportunities to improve care for a larger segment of the population" and "when the health care workforce mirrors the background of patients, it leads to positive effects on patient care and access for marginalized groups" (p. 7). Thus, diversifying the healthcare or audiology team by including audiologists with expertise in music-enhanced hearing aids, personal experience with hearing loss, a background in music, or familiarity with different music genres can help them better understand and address the unique needs of their patients. Close and continuous communication between providers and patients is necessary when designing complex

and specialized devices because it ensures the device meets the unique needs of each individual. More diversity in the healthcare teams not only provides new technical knowledge and viewpoints, but also fosters empathy and understanding to the patients with similar backgrounds, enabling healthcare providers to form stronger connections with their patients.

Conclusion

Initially, I thought that raising general awareness about the challenges of developing hearing aids for music would be enough to inform the public about the need to improve music-enhanced hearing aids. However, I now realize that empowering and accurate representation is crucial for changing societal perceptions and destigmatizing the use of hearing aids. Drawing from the experiences of para-athletes, it's clear that portraying individuals by their abilities, rather than by their disabilities, is essential to avoid reinforcing negative stereotypes. When users feel defined by their disabilities, it diminishes their sense of value and identity. A limitation of this insight is that even with destigmatization efforts through media campaigns, achieving consistent and widespread media representation is challenging and requires time to shift deeply ingrained societal attitudes.

Another realization is the need for diverse healthcare providers who are well-equipped and informed about their legal responsibilities under the ADA. Previously, I believed the lack of discussion around music-enhanced hearing aids in clinics was simply due to audiologists not prioritizing the benefits of music on quality of life or patients giving up on improving their hearing aids' ability to process high-quality music. Now, I understand that this lack of communication stems from the barriers hearing-impaired patients face in clinics, making it difficult to express even basic needs like improving speech settings, let alone specific preferences for better music quality. Without recognizing their patients' dissatisfaction with

communication during visits, healthcare providers will continue to fall short on providing the necessary resources for effective interactions with their patients, leaving their patients' specific needs unmet. However, a limitation of this insight is that even with ADA training and diverse healthcare teams, systemic changes in hospital design are necessary, such as ensuring consistent access to ASL interpreters and personal sound amplification devices into clinics.

Additionally, I initially believed that addressing affordability concerns for hearing aids primarily depended on Medicare coverage for hearing aids and hearing exams. However, I now recognize the value of seeking social and financial support from advocacy organizations like the Hearing Loss Association of America or the National Association of the Deaf to help hearing-impaired individuals. A limitation of this insight is the need for healthcare providers to actively connect patients with advocacy organizations that offer accessible communication methods, such as visual alerts, captioned resources, and user-friendly websites or hotlines tailored for individuals with hearing loss.

In conclusion, these three insights highlight the importance of addressing the technical, organizational, and cultural aspects of the music-enhanced hearing aid sociotechnical system. Progress in one aspect must align with advancements in other aspects to create lasting change, fostering an environment where individuals feel empowered to seek healthcare support, communicate their needs effectively, and adopt hearing aids that improve their quality of life, enabling them to enjoy high-quality music and pursue their musical passions.

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