Music and Hearing Impairment

An informational guide and resource:

Hearing Impairment

Hearing Technology

Music for the Hearing-Impaired

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Through this, I have been able to develop further my knowledge regarding music and hearing impairment. I have been deeply inspired to continue researching and working in this topic to be able to serve my community, wherever I am.

Contact
If you have questions about the material within this guide, please contact Sera Bird at sannebir@umich.edu.
Introduction
This guide was created as part of an OnCampUS placement at the University of Sheffield to create awareness of hearing impairment and explore the current or potential role of music in the lives of those with hearing loss. It is vital for our students to be aware of the impact of their daily environment on their hearing. We also hope to provide foundational information for those students and staff interested in teaching hearing-impaired music students or understanding their own hearing loss in terms of music. We hope this will enable the Department of Music to be more hearing-impairment friendly.

Statement of Purpose
1) Protect hearing as music students and performing musicians
2) Support music students and performing musicians who develop hearing impairments
3) Support music students and performing musicians with a hearing impairment (and wearing hearing aids or a cochlear implant)

Hearing Impairment
What is hearing impairment? Hearing impairment describes any loss of hearing from very mild to severe. Damage to any part of the auditory system can cause hearing impairment.

How prevalent are hearing impairments in the UK? (2015)
- ~1 in 6 (11 million) with hearing loss
- By 2031, this number will INCREASE to 1 in 5, ~14.5 million
- 50,000 children (half are congenital, half lose during childhood)
- > 40% of people aged 50 and over have hearing loss
- > 71% of people aged 70 and over have hearing loss
- In the UK, >45,000 were deaf children
- > 800,000 people categorized as severely or profoundly deaf

The Human Auditory System

The human auditory system has two main components, the peripheral and central auditory systems. 

**Peripheral:** Sounds enter the ear canal (auditory canal) which amplifies the sound waves as they make their way to the eardrum (tympanic membrane). The three little bones in the middle ear convert **low pressure sounds to high pressure** so that the **cochlea** in the inner ear, which contains liquid instead of air, can **convert the waves to electrical signals**.²³

![Figure 1: The Peripheral Human Auditory System](image1.png)

**Central:** Next, the electrical signals arrive at various processing structures in the brain via **cranial nerve VIII**, and finally at the **thalamus**, the brain’s relay center. Information is further processed by the **primary auditory cortex**, located in the temporal lobe.⁴

![Figure 2: Conversion of sound waves to nerve impulses](image2.png)

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The audiogram above gives examples of sounds heard based on pitch (measured in Hz) and hearing level intensity (measured by decibels or dB). The “banana” shape illustrates the range represented in speech. For example, a piano is around 80 dB and 1000 Hz. For someone with severe hearing loss, piano sounds would be audible but normal conversation would be difficult or impossible to hear.

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... and the Music Watermelon – Range of Hearing for Music

The range for music, on the other hand is broader (40Hz to 100kHz) than the range for speech, forming more of a watermelon. For more on pitch in terms of music and instruments, click here!

![Figure 5: Audiogram with Speech and Music](https://ohns.ucsf.edu/audiology/education/peds)

Types of Hearing Loss

Hearing loss is often categorized as Mild, Moderate, Severe or Profound. Refer to Figure 4 for examples of the quietest sounds each degree of hearing loss can hear.

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**Types of Hearing Loss (Cont.) and Causes**

*Sensorineural* hearing loss occurs when the little hairs in the inner ear are damaged due to noise, aging, or illness. If the hearing loss occurs in high frequency sounds, it is called a *ski-slope hearing loss*. If the hearing loss occurs in mid-frequency sounds (but not high or low frequency), it is called a *cookie bite hearing loss*.

In other cases, the ear is unable to carry sound from the outer to the inner ear. This is called *conductive* hearing loss. Blockage, disease, and middle ear damage are all causes of this type of hearing loss.

Mixed hearing losses demonstrate characteristics of both sensorineural and conductive hearing loss.

Hearing loss can occur in one ear (unilateral) or both ears (bilateral) and can be temporary, permanent and/or sudden.

**Hearing Aids and Cochlear Implants**

Hearing aids and cochlear implants do enable improved hearing for many, but each person’s hearing loss is unique.  

*Hearing Aids*

Every hearing aid has five basic components:\(^\text{10}\):

1. Microphone (captures and transforms environmental sound waves to digital or electrical signals)
2. Microchip (mini computer)
3. Amplifier (makes signals stronger)
4. Battery (the hearing aid needs power)
5. Receiver (digital or electrical signals transformed to vibrations to go to brain)

**Analogue** and **digital** hearing aids are both used, with the main difference in that **analogue** convert sound waves to electrical signals instead of digital.

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**Cochlear Implants**

While hearing aids use amplifiers and receivers to send auditory information to the brain, **cochlear implants** directly stimulate the auditory nerve. \(^{11}\) The diagram below shows the sound processor (1), similar function as the microphone in hearing aids. The digital signals travel through the coil outside of the head (2) to the implant’s electrodes inside (3). This directly stimulates the auditory nerve (4) which transmits that information to the brain. \(^{11}\) For more information on an example of a cochlear implant and how it works, click [here](https://www.cochlear.com/uk/).

**Accessibility and Cost\(^{12}\)**

In the UK, the NHS provides free hearing tests and diagnostics, but the wait time can be long and the fitting may not be as personalized as a private provider. The audiologists who adjust both hearing aids and cochlear implants must know their patients’ unique cases very well to adjust the devices effectively.

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Hearing Devices and Music

Hearing aids and cochlear implants are designed for **speech, not for music**, although hearing programs for music do exist. These programs use similar processing strategies as programs for speech. However, insufficient compression for the large range of loudness in music (40Hz to 100kHz) make the experience quite **uncomfortable** for users.

Current cochlear implants are **ineffective at accurately representing pitch and timbre**, as the devices are produced for speech, and not for music. Many prefer to listen to music using older analogue models, because by turning off the speech programs entirely, and with the amplifier strengthening the frequencies that are the most difficult to hear, people can focus on the melody, for example.

**What does music sound like with hearing loss?**

Without the hearing program, music, especially busy orchestral pieces, sound like “musical garbage.” Below are common descriptions of music with hearing aids and/or cochlear implants as well as a link to **sound samples** of what is heard when people have different kinds of hearing loss or **tinnitus**.

- Dull
- Abnormally loud
- Absent
- Acoustic space is disturbed
- Feedback
- Distortion
- Unbalanced (Loud is too loud etc.)
- Difficult to recognize individual instruments in the music

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Music Therapy and Music in Education
Music may not intuitively seem like a tool valuable to deaf or hearing-impaired children, but every infant has the neural networking to process the components of sound.\textsuperscript{17} Just as there are typical language milestones for babies,\textsuperscript{18} there are milestones for musical structures as well. (See Brandt, Gebrian & Slevc (2012) for an excellent figure of the parallels between language and music development.)

University of Sheffield Music and Hearing Impairment Workshops
Because of this, music becomes a valuable tool in many aspects of development for the hearing impaired, including speech and conveying emotion. One participant in the music and hearing impairment workshops at Sheffield was inspired by a poem, writing an entire piece for the workshop. Although the participant was an adult, this is a perfect application for children, as in Rocca’s research,\textsuperscript{19} where she pairs emotions from speech, stories and poems with musical sounds. The sounds are manipulated to sounds to mark one personality or emotion within the story or other linguistic material. Children then learn to express emotion by associating musical aspects with aspects of emotion.

Yorkshire Youth and Music
Yorkshire Youth and Music is a music education and training organization for a broad range of students including those with special needs.\textsuperscript{20} Music is taught not only as music, or to supplement cognitive skills, but also to soften barriers (physical, social, environmental) that might prevent children from receiving a good education.

Action on hearing loss charity org

Action on Hearing Loss

*Action on Hearing Loss* is a national charity with a wealth of statistics, information and support. The charity funds research on cochlear implants, hearing aids, genetics and prevention, and they also provide basic hearing checks through their [website](http://example.com) and by phone.

Awareness and Protection

It is important to get hearing tests, as hearing can degrade for a number of reasons and due to a number of causes as we go about our daily lives. Musicians also need to take care of their hearing, and as Lüders et al (2013) suggests, high frequency testing may be an early detection method for musicians. Similarly, other tests can be employed to monitor one’s own hearing loss.

All Ears

Sheffield’s own “All Ears” organization passes out ear protection at clubs and music events as well as helping people be aware of tinnitus. This group celebrates music and the cultures that come with it, but they also emphasize the importance of preserving and protecting hearing.

Support

Finally, it is important to emphasize that hearing impairment, whether congenital, sudden, temporary etc., is something that requires a lot of support. Family involvement in speech or music therapy, patience with oneself as hearing loss occurs, and help in adjusting to a new sound environment is vital. Professionals in the field must be able to communicate and help patients clearly communicate the symptoms and hearing environment the patient is experiencing. Outreach events in the community, sensitivity to those who may have never considered music a part of their lives, and greater awareness will promote healthy hearing habits and effective hearing care and support.
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