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AURALDIVERSITY: DO YOU HEAR DIFFERENTLY?

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YOUNG REVIEWERS:

BROOKLYN
AGE: 11

ELISA
AGE: 13

JOAN
AGE: 15

TINA
AGE: 15

This article explores the sense that opens us to the world of sound: hearing. Textbooks often repeat the same numbers and figures on the sensitivity of human hearing, as if we all share the same set of symmetrical mechanical ears. Here, you will discover hearing as we experience it day-to-day: the different kinds and qualities of hearing you, your friends, and your family may have experienced, and how hearing may change as we grow older. We call this real-life approach to understanding hearing auraldiversity. This article will tell you about some important kinds of hearing differences such as hyperacusis, misophonia, and tinnitus, and it will explain the brief changes in hearing sensitivity that sometimes occur, such as after sudden loud sounds. Hearing can open us up to the world in a very powerful way, but we must remember that it is a vulnerable sense that needs protecting from too much loud sound.

NOT EVERYONE HEARS IN THE SAME WAY!

This article explores the sense that opens us to the world of sound: hearing. Textbooks tend to repeat the same numbers and figures on the sensitivity of human hearing as if we all share the same set of symmetrical mechanical ears. As you read this article, you will discover hearing as we experience it day-to-day: the different kinds and qualities of hearing that you, your friends, and your family may have experienced, and how hearing may change as we grow older. We call this real-life approach to hearing, **auraldiversity** [1, 2].

AURALDIVERSITY

Difference in our hearing from each other and how it changes throughout our lives.

THE HEARING SYSTEM IS INTRICATE AND COMPLEX

Hearing means using the ears to receive sounds and to recognize, understand, enjoy, or be annoyed by them. The ears include much more than the visible flaps on the sides of the head. The flaps are part of the outer ear, called the pinna, and they play an important role in how we get information about the space around us from the sounds we hear. The ears are one of the most intricate and compact organs because they have so many parts, including tiny bones, which must all work together. In addition to the outer ear, the hearing system includes the middle ear and the inner ear, as well as the nerves and the brain (Figure 1). When a person's hearing is not working as well as it could be, hearing professionals called audiologists or otolaryngologists can try to find out which part or parts of this complex system are at fault.

Figure 1

The anatomy of the ear.

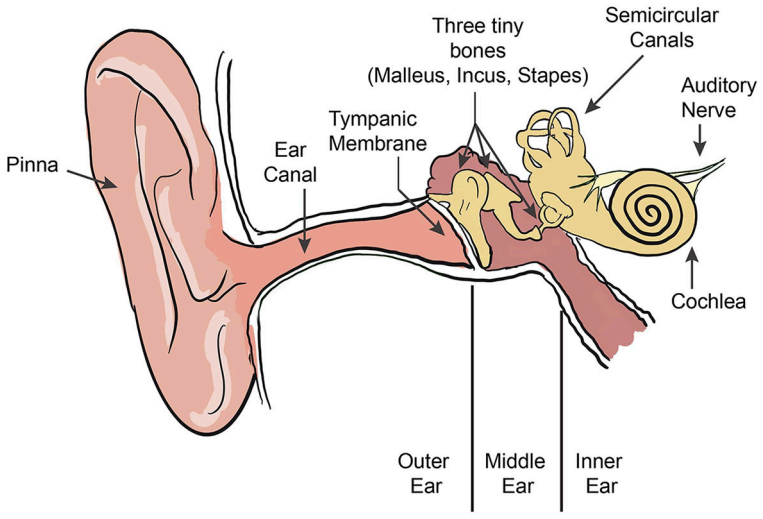

Figure 1

Hearing involves more than just the ears! Depending on the situation, the senses work together to help us understand and navigate the world around us. For example, you might not realize it, but you probably watch people's lips, eyes, and eyebrows moving when they speak. When you do so, your vision is helping your hearing to understand what is being said!

SOUND IS VIBRATION

Sound travels through the air, water, and other materials as vibrations. If sounds are low in frequency and full of energy, we can even feel them in our bodies. Think of standing at the roadside when a bus passes by. You may hear a loud, low rumbling in your ears and feel it in your feet and skin. The percussionist Dame Evelyn Glennie, who has been deaf since she was 12, wrote:

> Hearing is basically a specialized form of touch. Sound is simply vibrating air which the ear picks up and converts to electrical signals, which are then interpreted by the brain. The sense of hearing is not the only sense that can do this, touch can do this too... Deafness does not mean that you cannot hear, only that there is something wrong with the ears. Even someone who is totally deaf can still hear/feel sounds [3].

Glennie encourages her audiences to hold balloons in their hands so that they can use their sense of touch to help them enjoy the vibrations set into motion by the music.

MEASURING HEARING

Hearing is measured by comparing the relationship between two qualities of sound: frequency and loudness. Frequency, or how high or low a sound is, is measured in Hertz (Hz). Young adults can normally hear sounds from 20 to 20,000 Hz, and their hearing is most sensitive around the frequency range of the spoken human voice. As people get older, they start to lose the ability to hear the highest frequencies. In contrast, children and teenagers can be quite sensitive to high-energy, high-frequency sounds, which can make them feel dizzy or sick. Some security firms exploit this sensitivity by playing high-pitched sounds around private spaces, to keep teenagers away!

Loudness is measured with the decibel scale (dB). Acousticians (scientists who study sound and vibration) use a special decibel scale called A-weighting, which accounts for the way loudness changes depending on how high or low a frequency is. The scale spans from the ultra-quiet 0 dB, which is the lower limit of hearing, up to 120 or 140 dB, which is the level of sound that can cause pain (Figure 2). Sudden loud sounds, like high-speed hand dryers, might make people uncomfortable or jumpy [1]. This is the natural fight, flight, or freeze response kicking into action—it evolved to keep us safe from danger.

Figure 2

Examples of sounds, their measurements on the decibel (dB) scale, and how humans with typical hearing experience them.

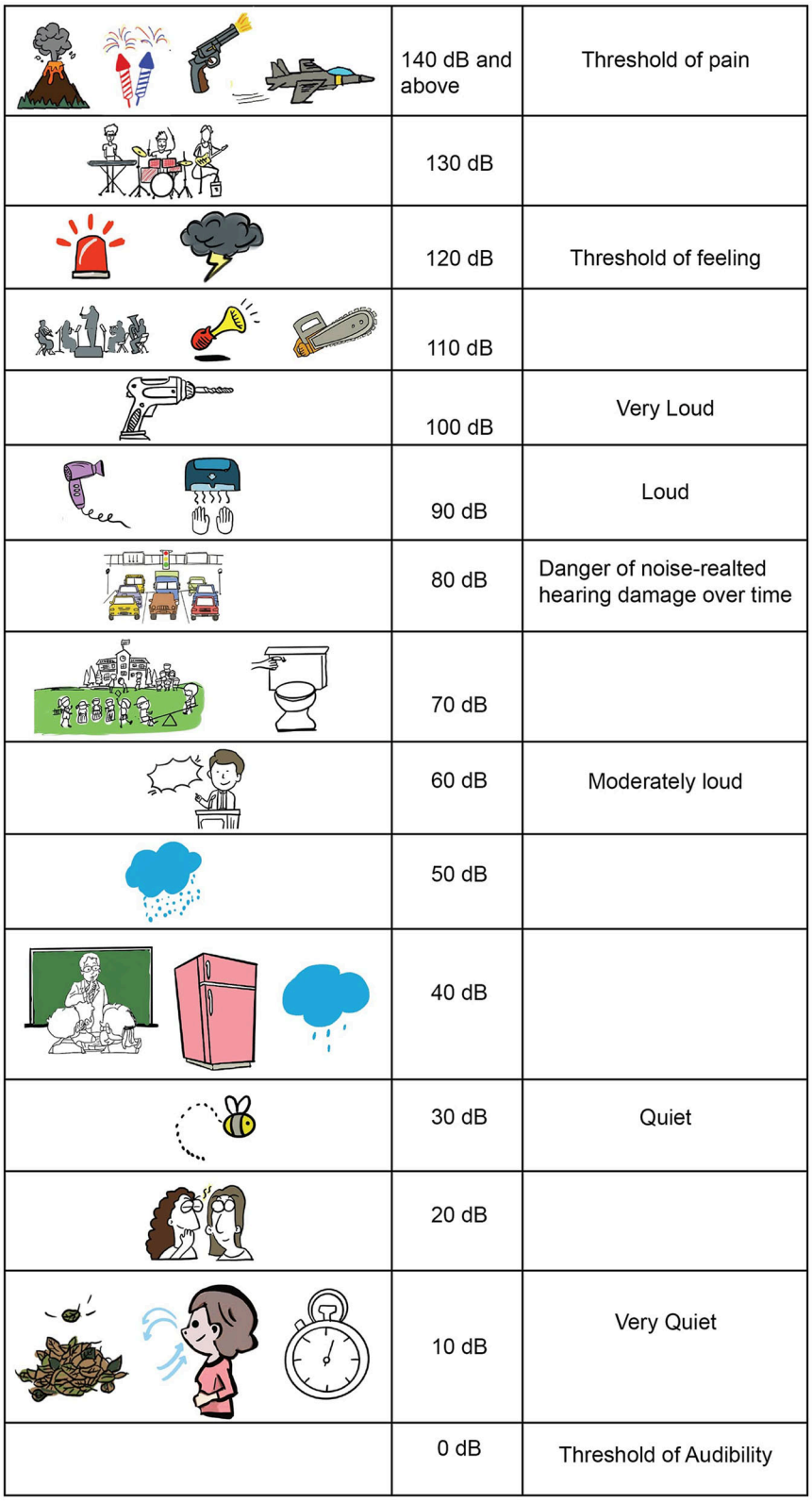

Figure 2

DIFFERENT KINDS OF HEARING

As mentioned at the beginning of the article, auraldiversity describes that we all hear differently. For most of us, this difference is unimportant, but for some, the same sounds can be experienced very differently. Here are some interesting examples.

People with a condition called **diplacusis** may experience new frequencies coming from their ears—quite different from the frequencies coming from the outside world—creating a kind of "double hearing." Diplacusis can be especially challenging for musicians, who depend on reliably recognizing pitch.

If people have a condition called **hyperacusis**, their pain threshold can be much lower than 120 dB. Everyday sounds, such as the waves at the beach or bird song, can be intolerable.

Sometimes the cause of the sound can be the problem. People with **misophonia** can get very stressed and angry by human-made sounds, like other people eating crisps or snoring. In contrast, some people find these sorts of detailed sounds comforting. **ASMR (autonomous sensory meridian response)** is the name of a pleasant, tingling sensation that some people get from listening close-up to crunching, whispering, or tapping.

In busy environments, most people can identify individual voices among the crowd. We call this skill the cocktail party effect. Studies have shown that people have evolved to ignore most of the sounds around them. They do this until there is some significant change that catches their attention, such as overhearing someone mentioning their name [4]. But this is not the case for everyone. Autistic people can have very sensitive hearing, and they can become overwhelmed and anxious in noisy environments. However, some autistic people are particularly good at separating out the many sound signals that weave together to make the **soundscape**.

Films often try to recreate sounds the way the characters would hear them. In action movies, for example, the sound of an explosion is often followed by a combination of muffled sounds mixed with a loud, high-frequency pitch that quickly dies away. These scenes give viewers a feeling of what it is like to live with a condition called **tinnitus**. People with tinnitus may hear this sort of high-pitched tone constantly. This sound is not coming from anything outside of the person, but it can interfere with hearing normal sounds. We usually think of tinnitus as being a high-frequency, steady tone, but the tone can be of any frequency and can sound like a whooshing or throbbing.

Some people experience fascinating and unique connections between their senses, such as seeing sounds as having specific colors, or experiencing words as tastes or smells! Artists and musicians have

DIPLACUSIS

A sound with one pitch is perceived as having two distinct pitches, known as double hearing.

HYPERACUSIS

Very sensitive hearing with a low pain threshold where every day sounds can feel too loud.

MISOPHONIA

Sensitivity to specific sounds, commonly made by the mouth such as chewing, resulting in a negative emotional experience such as anger.

ASMR (AUTONOMOUS SENSORY MERIDIAN RESPONSE)

Pleasurable sensitivity to subtle sounds such as whispering.

SOUNDSCAPE

Our individual experience of the sounds of the environment.

TINNITUS

The experience of a phantom sound with no external cause, often a continuous high-pitched tone, but can also be low and throbbing or whooshing.

SYNESTHESIA

Unique and consistent connections that some people experience between the senses, such as sound and color, or words as taste or smell.

embraced these cross-sensory mixes, called **synesthesia**, to produce highly original works. For Wassily Kandinsky, famous for his brightly colored abstract art canvases, his synesthesia was much more than a metaphor:

> Color is the keyboard, the eyes are the hammers, the soul is the piano with many strings. The artist is the hand which plays, touching one key or another, to cause vibrations in the soul [5].

TEMPORARY THRESHOLD SHIFT

The dulling of hearing sensitivity for a short time after being exposed to loud sound.

Finally, if people are exposed to loud sounds, their hearing can adjust using what is called a **temporary threshold shift**. You might have noticed that your hearing becomes dulled if you listen to very loud music on headphones. Usually, the normal sensitivity returns once the sound has gone, but repeated exposure to sounds above 85 A-weighted dB, or exposure to a really loud blast of sound, can result in permanent hearing damage—so please take care of your ears!

CONCLUSION

This article has shown that hearing is not the same for everyone, and that our hearing will keep changing throughout our lives—this is called auraldiversity. To be sensitive to auraldiversity, we must learn about and have empathy for other people's hearing needs and celebrate the many forms of hearing that exist!

To conclude, it is important to remember how wonderful the sense of hearing can be. Here are the inspiring words of John M. Hull, who kept a diary of his experience and emotions as he became increasingly blind. This process made him feel very sad, but he opened up his world to a new reality by concentrating on his sense of hearing. Listening to the sound of the rain outside his kitchen window gave him a new perspective:

> ...the rain gives a sense of perspective and of actual relationships of one part of the world and another [...] I am presented with a totality, a world which speaks to me [6].

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CONFLICT OF INTEREST: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

YOUNG REVIEWERS

BROOKLYN, AGE: 11
Brooklyn likes to dance and hang out with her friends playing volleyball, ball hockey, and soccer.

ELISA, AGE: 13
Elisa is a young girl with a curious mind. She is very passionate about science, especially related to health. She is interested in research and would like to start getting involved in conducting her own explorations in high school. She hopes that, with her critical thinking, her love for health discoveries and her drive, she will be able to contribute to science through journal review.

JOAN, AGE: 15

In Joan's freetime, she can be found throwing a Frisbee with Tina, participating in DECA case studies, or simply enjoying a leisurely loiter on her school's property.

TINA, AGE: 15

Tina is a high school student. In her free time, you can find Tina either baking, working on her articles for the school newspaper, or playing Frisbee. Tina also enjoys going very fast down hills in the wintertime with two boards strapped to her feet (skiing).

AUTHORS

JOHN L. DREVER

John is passionate about all aspects of sound and hearing. He spends a lot of his time making sound recordings from the environment. He likes people to join him on soundwalks, to savor and learn about everyday soundscapes. Most recently, he collaborated with Rural recreation on the School of Insects, recreating insect stridulation sounds with rubbish from the recycle bin at Trumpington Park Primary School, Cambridge. He is Professor of Acoustic Ecology and Sound Art at Goldsmiths, University of London. When he is not working with sound, he is out in the countryside with his Italian water dog, hunting curious smells. *j.drever@gold.ac.uk

VINITA BHARAT

Vinita Bharat, Ph.D. holds the position of Assistant Director of Science Communication and Research Development Training in the Department of Pediatrics at Stanford University, USA. With her vast research experience, she has developed an appetite for communicating science to a broader audience. She runs an online platform called "Fuzzy Synapse" (http://fuzzysynapse.com) to bridge the gap between science and the world. She aims to make science accessible to everyone.