Do You Hear What I Hear?

Human Hearing Frequency Range

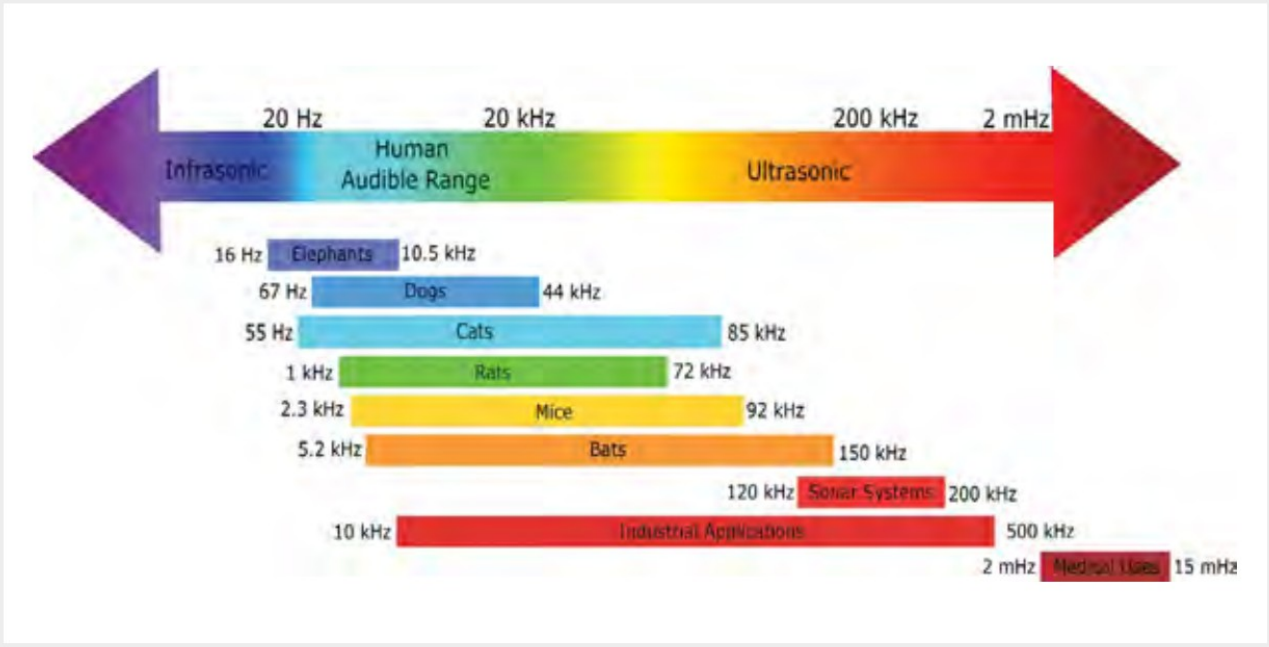
Human hearing range is most often considered to be **20 Hz to 20 kHz**, the latter usually associated with young children.

Hearing tests by audiologists frequently measure response up to 8 kHz, optionally 16 kHz upon request.

Ultrasonic sounds, defined as frequencies above **20 kHz**, are generally **inaudible** to humans because the hair cells (**cilia**) in the cochlea do not respond effectively to these high frequencies. However, **ultrasonic hearing** is a recognized phenomenon where some individuals can perceive these sounds through **bone conduction**, which directly stimulates the **basal turn of the cochlea**.

Research indicates that **ultrasonic sinusoids** up to **120 kHz** have been successfully perceived by some humans, particularly those with **intact inner hair cells**. Two primary theories explain this effect: **direct stimulation** of cochlear hair cells or **non-linear demodulation** where the brain modulates the ultrasonic signal into an audible range. Additionally, **bone-conducted ultrasound** can transmit **speech information**, allowing even profoundly deaf individuals to perceive modulated speech.

While pure airborne ultrasound is typically silent, some people report hearing **faint hissing or whining** from sources near the upper hearing limit, such as **aging electronics** or **pest repellents**. **Long-term exposure** to high-intensity ultrasound has been studied for adverse effects like **headaches** or **nausea**, but controlled studies show **no consistent evidence** that inaudible ultrasound causes physiological harm or alters brain structure, with any reported symptoms often attributed to **nocebo effects**.



Animals with exceptional high-frequency hearing include:

- **Dogs:** Dogs generally hear up to 45–60 kHz, allowing them to perceive high-pitched sounds inaudible to humans.
- **Cats**: Domestic cats can detect sounds up to **64 kHz**, helping them hear the ultrasonic calls of prey like rodents.
- **Rats and Mice**: These small mammals hear up to **70–76 kHz**, facilitating communication via ultrasonic signals.
- **Dolphins**: Toothed whales like dolphins and porpoises can hear frequencies up to **160 kHz**, which aids in underwater echolocation.
- **Bats**: Many species can hear up to **200 kHz**, utilizing this range for echolocation to navigate and hunt in darkness.

- The **greater wax moth** holds the record for the highest frequency hearing in the animal kingdom, capable of detecting sounds up to **300 kHz**. This sensitivity is approximately 15 times higher than the upper limit of human hearing and serves as a critical defense mechanism against bat predation.

Understanding Ultrasonic Sound Frequency: Applications And Human Perception Explained

Ultrasonic sound frequency refers to sound waves with frequencies higher than the upper limit of human hearing, typically above 20,000 hertz (Hz). Unlike audible sound, which ranges from 20 Hz to 20,000 Hz, ultrasonic waves are inaudible to the human ear but possess unique properties that make them valuable in various applications. These high-frequency waves are utilized in medical imaging, such as ultrasound scans, industrial cleaning, non-destructive testing, and even pest control. Their ability to travel through materials, create precise vibrations, and generate detailed images makes them an essential tool in both scientific and practical fields, bridging the gap between technology and everyday life.

Characteristics	Values
Frequency Range	20 kHz to several GHz
Human Hearing Threshold	Above 20 kHz (inaudible to humans)
Wavelength (in air)	1.67 cm (at 20 kHz) to 0.00167 cm (at 20 MHz)
Applications	Medical imaging, industrial cleaning, non-destructive testing, sonar, pest control, and communication with animals
Speed in Air	Approximately 343 meters per second (at 20°C)
Directionality	Highly directional due to short wavelengths
Attenuation in Air	Increases with frequency and distance
Common Frequencies in Use	20-40 kHz (industrial cleaning), 1-5 MHz (medical imaging), 30-50 kHz (pest control)
Detection by Animals	Detected by dogs, bats, dolphins, and some insects
Energy Intensity	Can be focused into intense beams for precision applications

Can you actually hear 'inaudible' sound?

Limits of human hearing (infrasound and ultrasound) examined

Are wind farms harmful to humans? This controversial topic makes emotions run high. To give the debate more objectivity, an international team of experts dealt with the fundamentals of hearing in the lower limit range of the audible frequency range (i.e., infrasound), but also in the upper limit range (i.e., ultrasound).

Ultrasonic vibrations can be perceived as audible sounds when a piezoelectric transducer is pressed against certain areas of the human body. In the range of frequencies investigated (20 to 108 kHz), the threshold of perception seemed to lie near the threshold of feeling (about 10(-4) watt/cm(2)), and the perceived audible sound appeared to be between 8 and 9 kHz, as judged by six test subjects. The threshold of perception and the perceived frequency appear to be dependent upon the hearing characteristics of the individual.

Peripheral perception mechanism of ultrasonic hearing

Abstract

Ultrasound can be perceived by bone conduction, and its characteristics differ from those of air-conducted audible sound (ACAS) in some respects. Despite many studies on ultrasonic hearing, the details have not yet been clarified. In this study, to elucidate the perception mechanism, the masking of bone-conducted ultrasound (BCU) produced by ACAS and the sensitivity of BCU in hearing impaired subjects were evaluated. We found that BCU was masked by high frequency ACAS, especially in the frequency range of 10–14 kHz. The most effective masker frequency depended on masker intensity. For hearing impaired subjects, the pure tone thresholds at 1–8 kHz and the maximum audible frequencies at cut-off intensities of 70–100 dB HL were significantly associated with the BCU threshold ($p < 0.01$ or $p < 0.05$). No subjects with estimated total loss of the inner hair cell system in the cochlear basal turn could hear BCU. These results suggest the peripheral perceptual region to be located in the cochlea. The results of masking show the faster excitation spread to the lower frequency range, depending on the intensity. This faster excitation spread may be due to nonlinearity in cochlear mechanics, which may work even without cochlear amplifier, and induce unique characteristics of BCU.

Highlights

► Ultrasonic hearing is masked by high frequency air-conducted sounds. ► Effective frequency for the masking changes, depending on the intensity. ► Maximum audible frequency is associated with the threshold of ultrasonic hearing. ► The peripheral perceptual region of ultrasonic hearing is located in the cochlea. ► Excitation by bone-conducted ultrasound fast spreads to the low frequency range.

Listening Beyond Human Hearing: Lessons From Ultrasonic Plant Signals

A recent discovery from researchers at Tel Aviv University adds a new layer to how we understand sound in the natural world. Scientists found that certain moths can detect ultrasonic sounds emitted by stressed plants and use those sounds to guide their behavior. These frequencies sit well above what humans can hear, yet they carry meaningful information for insects that evolved to listen differently.

The plants are not signaling intentionally. When dehydrated, internal changes in their water transport system create vibrations that result in short, click-like sounds in the ultrasonic range. To human ears, these sounds do not exist. To insects, they can signal whether a plant is healthy enough to support the next generation.

This discovery challenges a human-centered view of sound and reminds us that audio has value and function even when it falls outside our perceptual limits.

Israeli research finds that when plants talk - insects listen

https://www.youtube.com/watch?v=iTeJ5MieDLk

References:

Understanding Ultrasonic Sound Frequency: Applications And Human Perception Explained

https://soundcy.com/article/what-is-ultrasonic-sound-frequency

Can you actually hear 'inaudible' sound?
Limits of human hearing (infrasound and ultrasound) examined

https://www.sciencedaily.com/releases/2015/07/150710123506.htm

Perception of Ultrasound

https://pubmed.ncbi.nlm.nih.gov/17788293/

Highest frequency hearing – animal
https://www.guinnessworldrecords.com/world-records/highest-frequency-hearing-animal

Ultrasonic Hearing in Cats and Other Terrestrial Mammals

https://acousticstoday.org/wp-content/uploads/2021/03/Ultrasonic-Hearing-in-Cats-and-Other-Terrestrial-Mammals-M.-Charlotte-Kruger.pdf

Human ultrasonic hearing is induced by a direct ultrasonic stimulation of the cochlea
https://www.sciencedirect.com/science/article/abs/pii/S0304394013000827

Peripheral perception mechanism of ultrasonic hearing
https://www.sciencedirect.com/science/article/abs/pii/S0378595511000074

Listening Beyond Human Hearing: Lessons From Ultrasonic Plant Signals
https://www.rareformaudio.com/blog/listening-beyond-human-hearing-ultrasonic-plant-sounds

Public Exposure to Airborne Ultrasound and Very High Frequency Sound

https://acousticstoday.org/wp-content/uploads/2020/09/Public-Exposure-to-Airborne-Ultrasound-and-Very-High-Frequency-Sound-Timothy-G.-Leighton.pdf

Correlation to high fidelity sound reproduction

There's Life Above 20 Kilohertz!
A Survey of Musical Instrument Spectra to 102.4 Khz

https://ttsetup.com/images/
Theres_life_above_20_kilohertz_A_survey_of_musical_instrument_spectra_to_102.4_kHz.pdf

A home audio system which accurately reproduces the full range of frequencies with high phase coherence, impulse response, and minimal distortion tends to be perceived as most lifelike. My personal refernce includes loudspeakers by Hill/Plasmatronics, LLC (https://hillplasmatronics.com) and Quad Electroacoustics Ltd.

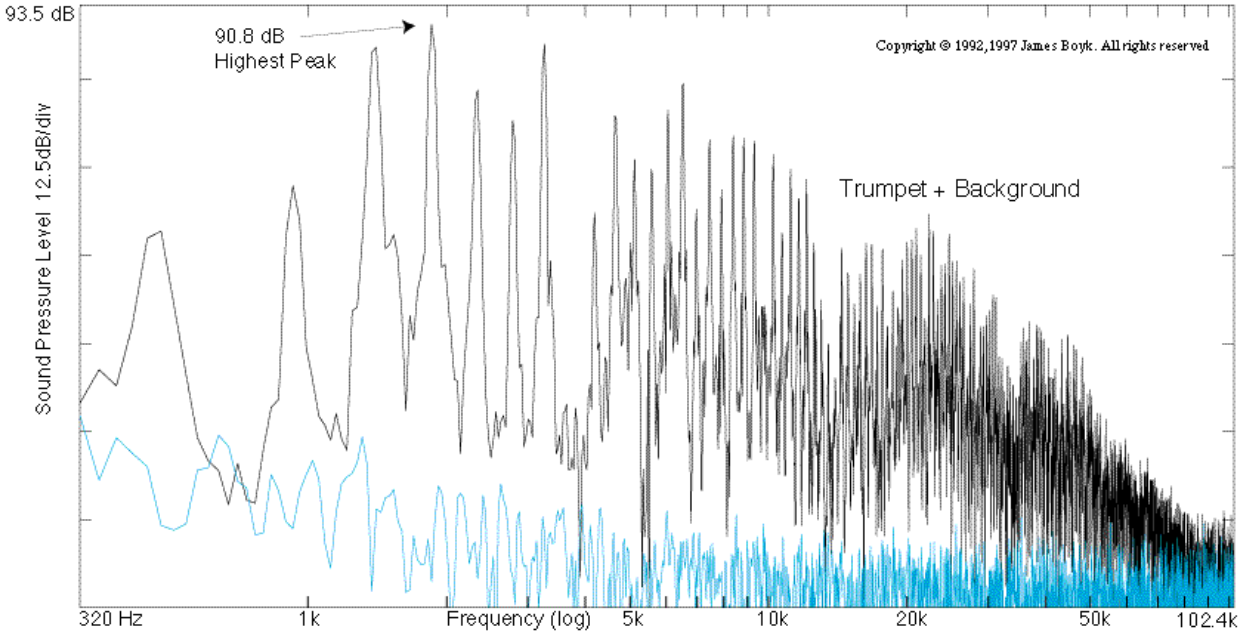


Figure 1(a) (Amplitude ⁄ frequency). **Trumpet with Harmon mute**; 95.5 dB at Aco 7016 microphone 4 feet away. Microphone aimed at bell, which was angled down about 20 degrees. Upper Trace: Trumpet + Background, corrected to 70 kHz (see text). Lower trace: Background alone.

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