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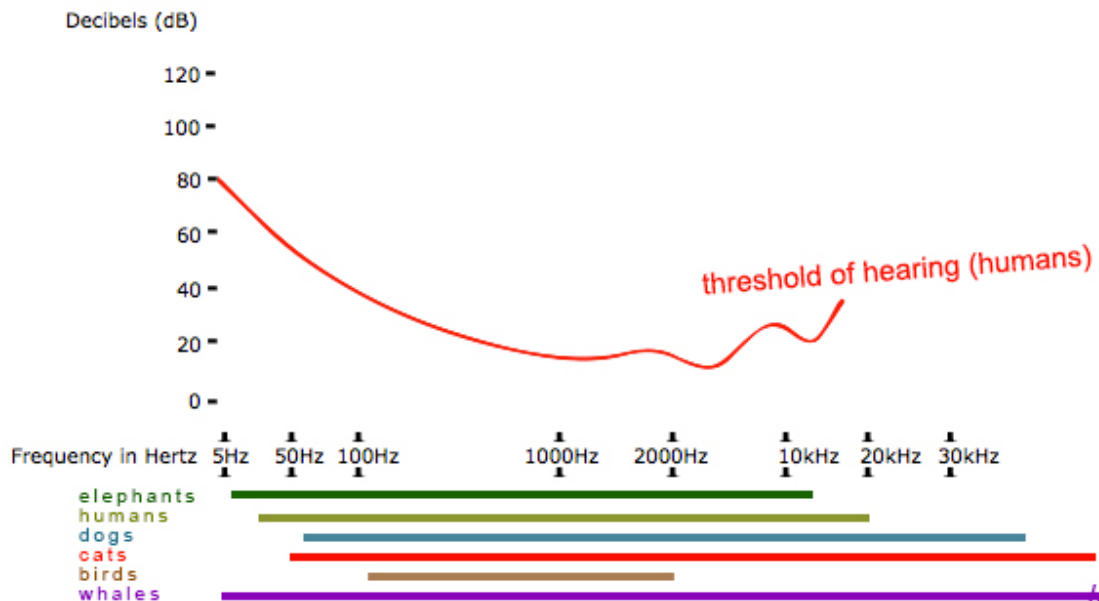
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The Threshold of Hearing

Mike Wereski

I came across a great question when I was researching headphones and speakers. I was curious to know if speakers or headphones which fall out of the range of human hearing, what effect it has on the human ear and or other parts of the body. This question will be answered below after of course we state the facts. The human ear responds to frequencies in the range of 20 Hz to 20,000 Hz (20 kHz), although most speech frequencies lie between 100 and 4,000 Hz. Frequencies above 20,000 Hz are referred to as ultrasonic. Humans can discern a difference in frequency of just 0.1 percent. This means that humans can tell the difference between sounds at frequencies of 1,000 Hz and 1,001 Hz.

One of the things that I thought about is how many people are buying speakers or headphones with frequencies that are far beyond the human curve. Yes there is a cutoff and linear curvature to sound when looking at an equalizer but how much of that frequency is damaging or disrupting functions of our body? This really sparked my interest from being a DJ in nightclub for several hours and being around loud music, sometimes your headphones when turned down are really your only line of defense against outside noise. Ear plugs of course won't do because you still have to hear what you are playing and all of the music's finite changes. This can even be applicable to sound mixing in a sound studio because after a while there is something called "ear fatigue" which is what mixers experience when hearing similar frequencies over and over. It's almost like the brain adapts to the sound as well as the physiology of the ear so that over time certain sounds become muted.



According to (Kugler et al. 2014) the inaudible low end frequencies that are below 20kHz actually do have an effect on our hearing. At very low frequencies (less than 250 Hz), however, the sensitivity of human hearing, and therefore the perceived loudness of what we are hearing is poor. In this study it was found that short exposure to these sounds affected the micro mechanics of the ear causing dampened hearing for a period of 2 minutes. These low frequency sounds strongly stimulate the human cochlea and change the amplification processes in the frequency range of what a person hears

Furthermore, Binaural beats or binaural tones are neurophysiological changes that occur in the body from something that is heard. If two frequencies are played and within a 30Hz range of each other in separate ears using headphones for example, the pulsation of that tone will be perceived even though there may not be pulsation to that tone. One example is if the left ear was given the frequency of 200 Hz and the right 210 Hz the perceived frequency would come out to 10 Hz. This end frequency is known as the binaural frequency.

What this leads to is not only the physical change in the inner ear from the impact of outside frequency but the stimulation of cognitive processes in the brain. (Chaieb L et. al 2015) found that auditory beat stimulation may be an important tool and that monaural- and binaural-beat frequencies affect cognition and mood states.

Besides just the human species whose range of hearing is very limited compared to marine mammals, many naturally occurring sounds are modulated in both amplitude and frequency and are used in communication for mammals, marine species, birds, and even insects. Dolphins for example communicate at 8 Hz and an odd coincidence is that the frequency coinciding with the rhythm of human brain waves is in the lower Alpha state which happens to be the same. Alpha brainwaves oscillate between 8 – 12 Hz and has been found to be active during times of relaxation or peace. Growing evidence indicates that brain oscillations in the alpha band (~10 Hz) not only reflect an “idle” state of cortical activity, but also take a more active role in the generation of complex cognitive functions. According to a recent study, more than 60% of the observed inter-subject variability in perceptual learning can be ascribed to ongoing alpha activity. This evidence indicates a significant role of alpha oscillations for perceptual learning and hence motivates to explore the potential underlying mechanisms. An example of an alpha oscillation would be frequencies in the brain occurring between 7-12Hz. And according to Wolfgang Klimesch’s article their purpose could be further investigated that these alpha waves creates access to information when needed as well as inhibit information when it is not needed. So consciousness of knowledge as well as orientation can be displayed in the role of brain activity.

According to Turner et Al's 2007 study many structures of the brain, hormones, and neurotransmitters actually are involved in the process of responding to noise. Ach, acetylcholine; ACTH, adrenocorticotropin hormone; CRF, corticotropin releasing factor; NE, norepinephrine. These all had unique responses when the subject was stimulated with sound. What was also found is that the only animal with a better low frequency range than that of humans was the "Indian Elephant."

Ko Da H's et al's 2015 study displayed that in older adults there is a strong correlation between hearing loss and balance. The tests administered to this Korean mini-mental state examination (K-MMSE). Dynamic balance ability was evaluated by the timed up and go (TUG) test, and static balance ability was tested using a one-leg stance test (OLST). It was found that as people get older, their hearing and cognition, as well as their balance abilities deteriorate and all of these factors happened to be in correlation with one another.

In conclusion frequency and sound can affect brain function, hormonal function, recollection of information and mood as well as physiological aspects of our hearing such as damage to our ears as well as balance. Furthermore, not all musicians are engineers so it's hard to even realize sometimes that you could be damaging your ears. So it's important to take the necessary precautions and to listen to music or audio at a comfortable level. Whether your occupation is in science, arts, music or service stimulating your ears can lead to so many great results including an increase in concentration or better relaxation. The fine details of that is now a whole different topic.

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