Phil Jones
Pure Sound.™

How We Hear Bass

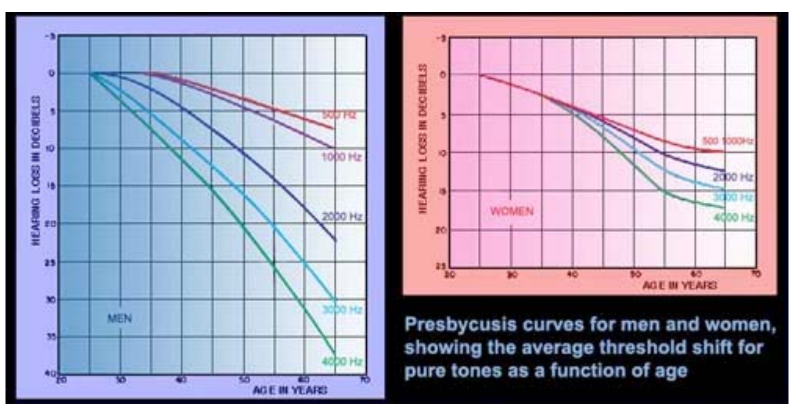
When I first started to learn to play bass guitar in the 60's I had a 10-watt amplifier. When I got my first 100-watt bass amp I thought I would be in heaven. After all, it was 10 times the power of my first amp so I would be loud enough for anything. I couldn't be more wrong. It wasn't ten times louder at all, in fact it just sounded like it was 20 watts not 100. It was then I discovered that power didn't equate to volume but I was not sure why. That moment in time was the start of my quest to learn just what was exactly going on. So I first needed to understand just how our hearing worked.

The Most Amazing Instrument You Have

The reason why I am putting this tech note in first is because in my opinion your ears are the MOST important tools you will ever have. They should last you a lifetime if you take care of them. If you don't they cannot be repaired or replaced.

The human ear does not hear in a linear fashion at all. On a loudness scale it is logarithmic. The difference in energy levels between hearing the smallest sound we are able to perceive to the loudest we can cope with is a staggering 10 billion to one. For a sound to be perceived as twice as loud we actually need 10 times the power to produce it. So a doubling of amplifier power only sounds slightly louder.

Hearing Changes with Health and Age



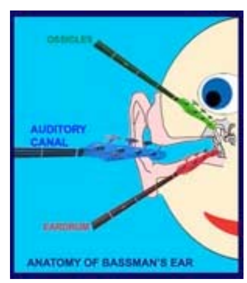
Presbycusis curves for men and women, showing the average threshold shift for pure tones as a function of age

We all know when we have a cold just how lousy everything sounds. Our ears have extremely fragile components in them, particularly in the frequency range where we are most sensitive: from about 2KHz - 6KHz. Throughout our lives the ears literally takes a bashing from various sounds as we go through life and it is the more fragile nerve endings in our inner ear the cochlea that give out first. The human hearing range covers a bandwidth from 20Hz to 20KHz. Most people can't actually hear up to 20KHz and it gets worse with age (presbycusis). Typically you can expect to lose around 1Hz per day, if you are not protecting your ears. That's over half bandwidth lost in 30 years!

A Lot Going on in There

Also the human ear is far from flat in frequency response. We have a greater sensitivity to frequencies between 2KHz–5KHz and this is due to a resonance phenomenon in part of the ear called the auditory canal. That's the part just before your eardrum. This evolutionary boosted presence response gives us a better resolution to hearing speech (and also crying babies!).

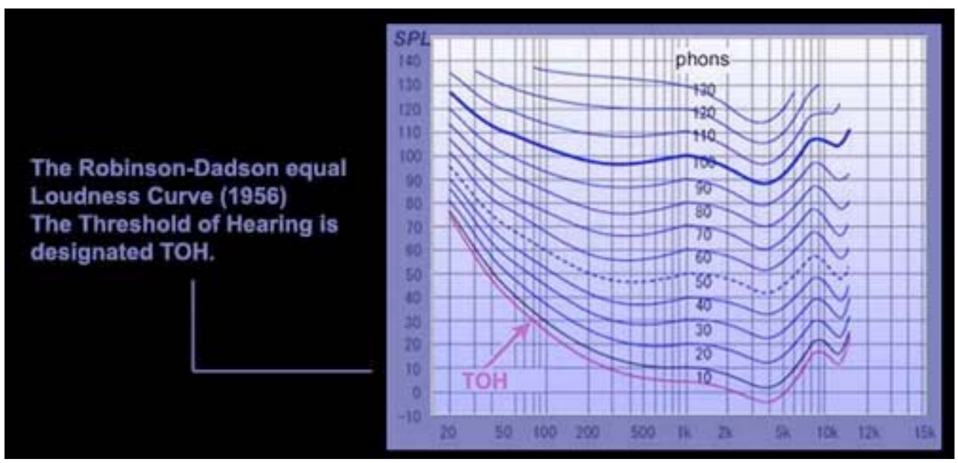
There is a built in protection system in the human ear that limits just how much energy is transmitted to the nerve fibers in the auditory canal. In the ear are three minute and delicate bones called The Malleus, Incus and Stapes (the ossicles). The function of the ossicles is to transmit and amplify sound waves across the tympanic cavity from the tympanic membrane to the oval window.



The ossicles are connected in such a way as to act as a lever system to increase the force of the vibration from the eardrum. In addition the force of vibration is intensified as it is transmitted from the relatively large surface of the eardrum to the smaller surface area of the oval window. The combined effect increases the force of vibrations roughly twenty times. Strapped across these bones are two tiny muscles: the tensor tympani that attaches to the malleus and the stapedius that attaches to the stapes. Whenever a loud sound is present the brain receives a signal from the ear, and reacts by sending a command to these muscles to tighten up. (Contraction of the stapedius muscle occurs as a reflex response to loud sounds above 80 dB.)

The tensor tympani pulls the malleus away from the tympanic membrane while the stapedius pulls the stapes away from the oval window and changes its orientation 90 degrees, sort of like a biological bandwidth-limited, compressor/limiter. The ossicles have limited movement and are not able to so freely send vibrations from the eardrum to the auditory canal. It works well but in its action it causes a change in how we hear sounds. This amazing mechanism is tuned for mid band attenuation and stops us from going deaf. It has virtually no effect on very low or very high frequencies we hear. This is why we often prefer music at a loud level because it makes the overall sound more full by giving us the perception of more lows and highs.

The most destructive sound to human hearing is high-level, percussive sounds. *i.e.* sound which has a fast attack rise in its amplitude envelope, like gunshots, pneumatic road drills and even slapped bass guitars (on good amps). The energy-pulse rises so abruptly that the tensor timpani and stapedius cannot react quickly enough to compensate. This hi-pulse energy is transmitted through to the cochlea and can be most destructive, causing permanent hearing loss of upper frequencies.



Two Bell lab engineers Fletcher and Munson came up with a graph in 1933 that was based upon people's perception of loudness at that time. These were made by asking people to judge when pure tones of two different frequencies were the same loudness. Although it is not strictly accurate by today's standards, it has become a cornerstone in the foundation of understanding human hearing, this was later refined in 1956 by Robinson & Dadson.

As you can see from these graphs, we are basically deaf to bass. We would need to produce huge amounts of energy to actually go deaf from low frequencies. The reason is that our ears are tiny compared to the size of bass sound waves even if your ears are like teacups! This is an acoustical mismatch, just like a single small loudspeaker cannot produce any significant levels of bass.

It is so important to take care of your hearing. Recently my father in his 80's quit playing his Saxophone. He had lost the hearing in one ear. The reason he quit? "Its just not fun in mono!"

Phil Jones