Psychoacoustics – Advanced

It is often said that there is a difference between perception and reality. This difference between perception and reality is the difference between acoustics and psychoacoustics. Acoustics explains how the ear responds to different sounds (reality). However, psychoacoustics relates to how we perceive these sounds (perception).

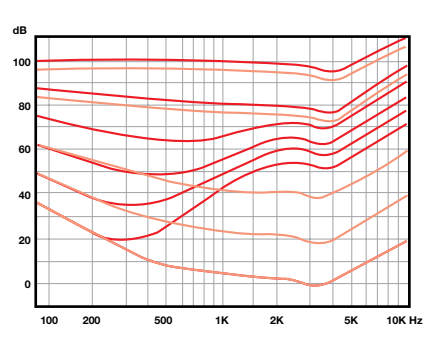
Acoustics vs Psychoacoustics

If a sound occurs at 40dB, then it occurs at 40dB. It can be measured and quantified. However, one person may perceive that 40dB sound as soft while another may perceive it as comfortable. The sound occurring at 40dB is related to acoustics. The perception of sound as soft or comfortable is related to psychoacoustics.

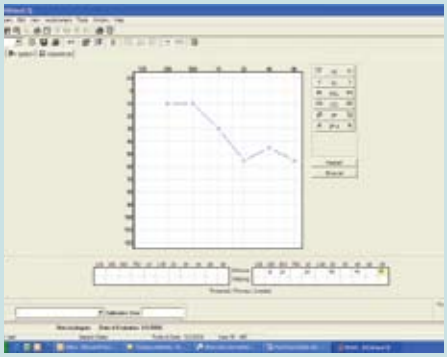
Equal Loudness Contours

To create a complete picture of psychoacoustics, frequency is an important factor.

Equal contour curves



Audiogram



This is indicative of a typical sensorineural hearing loss.

Equal contour curves

These curves are sometimes called Fletcher-Munsen curves, phon curves or equal loudness contours. While equal loudness contours and audiograms are plots of frequency versus intensity, intensity is plotted on equal contour curves in dB SPL and on audiograms in dB HL. The different decibel scales allow for more straight forward comparisons.

Decibel scales

The straight lines on an audiogram are easier to read than the equal loudness contours. The dB HL scale makes the straight lines possible. However, for hearing instruments output is reported in dB SPL as it is an indication of the sound pressure level at the eardrum. Hearing instruments exert more sound pressure on the eardrum than nature originally intended. Knowing the sound pressure exerted on the eardrum provides a clearer indication to the clinician of what is happening in the ear than a straight line.

dB SL is another decibel scale sometimes used in clinical settings to indicate the sensation level. dB SL shows how much above the patient's own hearing thresholds a sound occurs.

Example

If a patient has a hearing threshold of 30dB (at a particular frequency) and a sound occurs at 40dB, that sound can be said to occur at 10dB SL.

Minimal audibility curve

The bottom curve of the equal loudness contour represents a normal ear under a headphone. It is known as a minimal audibility curve and is closest to 0dB HL on a typical audiogram. This curve indicates that humans hear best between 1000Hz and 5000Hz. Both the low frequencies and the high frequencies must be more intense (in dB SPL) to be just barely audible.

At high intensities such as 100dB SPL, the curves flatten out. In the low and high frequencies, there is less difference in intensity for humans to perceive sounds as being loud. The bottom curve, representing softer inputs, covers a much larger range in intensity.

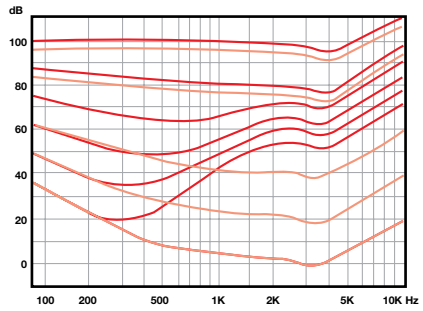
The minimum audibility curve shows differences in hearing sensitivity (i.e. not a straight line across frequencies) because of the non-linear function of the cochlea and also the physical properties of the outer and middle ear. The middle ear transmits some frequencies more easily than others because of its own properties of stiffness and mass. The outer ear has different resonances as well. The concha bowl resonates best at 4000Hz -5000Hz and the ear canal resonates between 1500Hz to 4000Hz with a peak around 2500Hz.

Loudness growth

The lighter curves on the equal contour curves illustrate loudness perceptions for normal hearing across the frequency range. Along each curve, each frequency sounds equally loud to normal ears. The dynamic range (the area between the top and bottom curves) is largest for the mid frequencies and smallest for the very low frequencies. This means that the loudness growth for the low frequencies is very fast compared to the mid frequencies.

For sensorineural hearing loss, indicated by the darker curves, the top curves are similar to those for a normal ear. However, the bottom curves are more elevated for mid to high frequencies. The curves that are squeezed together show a smaller dynamic range. This means that for the high frequencies a patient with a sensorineural hearing loss can not hear soft sounds but perceives loud sounds like a person with normal hearing.

Equal contour curves



Jargon Buster

dB HL is the abbreviation for decibels hearing level. This is the decibel scale that allows the use of straight (linear) lines on the audiogram to represent the non-linear function of the cochlea.

dB SL shows how much above the patient's own hearing thresholds a sound occurs. It is an abbreviation for decibels sensation level.

dB SPL shows the sound pressure level at the eardrum. It is an abbreviation for decibels sound pressure level.

Related information

Also refer to the section in this manual on **Ear anatomy and physiology**, **Pure tone audiometry** and **Hearing instruments electronic components**.