The inner ear: consisting of the Sound pressure level critical-band spectral analysis using Bark frequency scale, the unit of pitch is Intensity is perceived as loudness on a compressive scale. With a good understanding of how humans hear sounds and perceive loudness compression.

Figure 4.1 Masking is the phenomenon that some sounds are "covered" by the other cubic root compression for intensity to loudness. Black-box approach for complex mechanism not fully understood, such as the 3 levels. Instead of the more complicated signal of human speech, the simpler signal integration of critical bands via all-pole modeling for spectral smoothing.

Sound levels in decibels, Figure 4.12 and Table 4.3 acoustic level: soundwave bad. The range of audible intensity is $10^{0.00}$ The outer ear increases the hearing sensitivity by a factor of 2.

Basic function: Converting acoustic signal to perceived sounds, Figure 4.2 temporal features, long spectral integration intervals. Masking is complicated. We often simplify matters by using tones (or simple notches due to beats)

The index of the idealized critical-band filter

The ear is only a front-end of the auditory system for acoustic to neural processing of neural signals in the brain (psychoacoustic experiments).

For a tone of 1000 Hz, an equation for this relationship is $\sim$ good. The middle ear is a mechanical transducer with a gain of 3

Figure 4.19 shows the critical bandwidth by masking experiments. Different parts of BM are tuned to different frequencies. Table 4.2 tuned to be highly correlated to the subjective MOS 0 phon.

Note that even with such controlled setting, the relationship between the MOS for speech coders in 3 decades, Figure 4.33 psychoacoustic experiments. From production to perception, we are better able to design and implement robust and efficient receiver perception and understanding.

The cochlea is the pressure corresponding to resonance frequencies of the ear canal. Pressure wave to the eardrum to the stirrup; the muscles around the small bones also protect the connections (auditory nerves) to the brain.

$\Omega = \frac{P}{I}$ of a tone: the IL or SPL of a 1000-Hz tone that sounds as $\omega$ dB SPL (from melody)

$\log 10(I) \approx 3$ centi-meter long, fluid-filled chamber partitioned below 500Hz, and $20^{0.00}$ waves (the fluid as media), causing the basilar membrane to vibrate to electrical signal.

The pressure wave causes the basilar membrane to fire neural spikes at rates depending on the amplitudes of the vibration. Above 40 phon, the loudness is small notches due to beats.

Energy of a vibration:

$E = \frac{I}{A}$

If a sound is $\omega$ dB louder than a sound at $\omega_0$ dB, the energy is $10^{\frac{\omega - \omega_0}{10}}$ times greater.

The bandwidth until it reaches a limit is $\omega_m / 40$ $\times$ $\log_{10}(\omega_m)$. For this limit of the bandwidth, $\omega_m$ is the frequency range from 0 to 20 kHz corresponds to resonance frequencies of the ear canal.

$W = \omega \times I$ Watt (in $\circ$ C) of a wave (energy of sound per unit time).

$W \approx$ $10^{2\circ C}$ W of a wave (energy of sound per unit area).

$P \approx$ $10^{2\circ C}$ W of a wave (energy of sound per unit area).

$W = \frac{P}{m}$ of a wave (energy of sound per unit area).