



Warmth (reverberation)

Warmth is defined as psychoacoustic term for prolonged reverberation time in 150-500 Hz range and it depends slightly on the level for the reverberation signals. Warmth is typical for some concert halls for romantic and post-romantic music.

Liveness is psychoacoustic perception for increased level of early reflections in 500-2000 Hz range.

Spatial Impression is a psychoacoustic perception for spaciousness depending on the energy and interference between reflections at about 400 Hz, arriving to a listener 10-100 mS after the direct sound.

Binaural localization

Hearing analyser in human brain localizes a sound source by binaural effect - comparing the time and amplitude differences in the information perceived by both ears:

- localization below 200 Hz is considered bad or impossible
- localization between 200-500 Hz is based on binaural time differences
- localization between 500-5000 Hz is based on binaural time and amplitude differences
- localization above 5000 Hz is based on binaural amplitude differences

Localization errors are 3-4 degrees for the horizontal plane and from 10-15 degrees for the vertical plane.

Localization allows the hearing analyser to reduce the masking between the sound sources. Incorrect localization also causes tonal distortions in perception.

Psychoacoustics of the binaural hearing in the Warmth frequency range

The energy of the natural sound sources is concentrated in 200-500 Hz range. Time differences in the perception by left and right ear have major influence on localization at that range.

The perception at the start of every reverberation process is dominated by a small number of reflections and their interference. While reverberation process expands, the number of reflections increases and their level/time differences are compared to the information accumulated in the hearing memory. This comparison allows to decrease the influence of the interferences over the hearing analysis. At the end of the reverberation process, perception of reflections actually depends only on their total energy.

The time structure of the reverberation signal is different for the left and the right ear. The correlation between left and right perceptions allows the hearing analyzer to decrease the influence of the interferences. Localization of reflections, as part of the reverberation perception, allows the hearing analyzer to decrease their mutual masking.

Influence of Warmth on binaural hearing.

When reverberation time in the 150-500 Hz range is prolonged (*Warmth*), localization errors occur. Time shifting of the reverberation process for these frequencies leads to:

- Sustained influence of interference over the total energy of reflections in 150-500 Hz range;
- Decreased influence of interference over the total energy of reflections above 500 Hz;
- The hearing analyzer makes mistakes as a result of hearing memory overload and masking between reflections - *Spatial Impression* decreases.
- Source localization errors cause mutual masking of the different sources. That leads to frequency distortions in the sources' images. Masking is higher around centre of sound picture.

In general, the sound picture has a decreased localization, frequency distortions and smaller size.

If *Liveness* occurs in addition to *Warmth*, there is sense of abnormal deepness of sound picture compared to its horizontal size.