

Reverberation

Prepared by Arun Rama Varma

- Reverberation is the multiple repetition of an audio signal that becomes more closely spaced with time.
-
- ***Direct Sound*** - sounds reaching the listener by a direct path; ***Indirect sound*** - reflection of audio signals reaching the listener at a delayed time.
-
- Reverberation is the sum total of all of the reflections of a particular sound, even though they arrive at different times, to a given point.

- Our perception of sound reflections helps us to determine the distance of the sound source.

- The reverberant sound in an enclosed space, like an auditorium dies away with time as the sound energy is absorbed by multiple interactions with the surfaces of the room.
- It will take longer for the sound to die away and the room is said to be ***'live'***.
- In a very absorbent room, the sound will die away quickly and the room will be described as acoustically ***'dead'***.

Psychoacoustics

- Psychoacoustics may be broadly defined as a study of the complex relationship between physical sound and the brain's reaction and interpretation of them in a sound field.
- Some of the traditional psychoacoustic concerns involve the perception of pitch, loudness, volume and timbre.

Binaural Localization

- Our ability to locate the source of a sound in three dimensional space is known as ***binaural localization***
- With binaural sound source localization, it is possible to identify the spatial position of sound sources using two acoustic sensors (ears for biological systems; microphones for technical systems).

- There are two major cues that are used for sound localization by animals and humans:
 - Interaural time differences (ITDs)
 - Interaural time differences are caused by the different propagation times by which, a the sound wave from the source reaches both our ears. For e.g. if a sound source is on the left side, the sound wave will reach the left ear slightly before it reaches the right ear
 - Interaural level differences (ILDs)
 - Interaural level differences are caused by the acoustic "shadow" of the head. For e.g. if a source to the left, the sound wave will arrive at the left ear slightly louder than at the right ear.

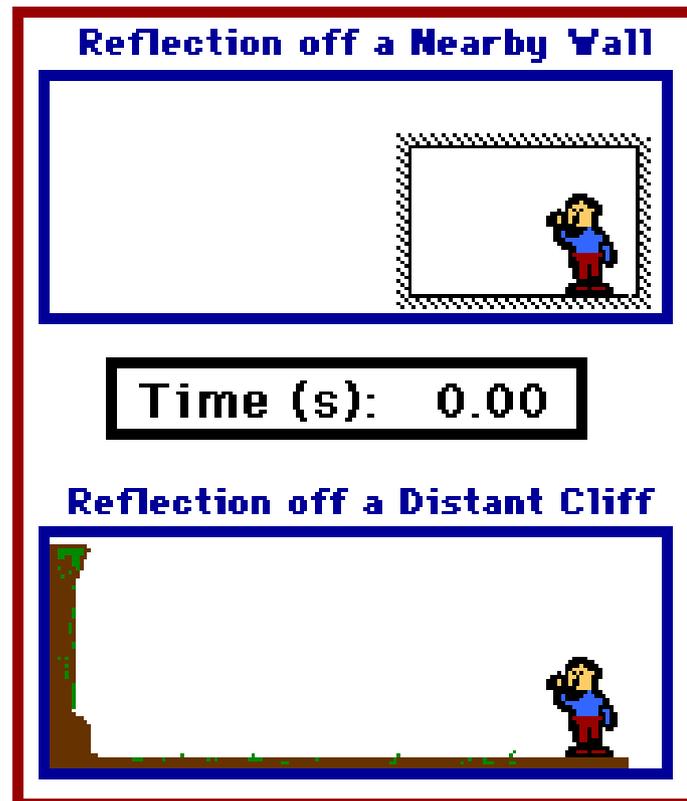
Haas Effect

- Also called the ***Precedence Effect***, or ***Law of the First Wave front***, describes the human psychoacoustic phenomena of correctly identifying the direction of a sound source heard in both ears but arriving at different times.
- Due to the head's geometry (two ears spaced apart, separated by a barrier) the direct sound from any source first enters the ear closest to the source, then the ear farthest away.

- The Haas Effect tells us that humans localize a sound source based upon the first arriving sound, if the subsequent arrivals are within 10 milliseconds.
- If the later arrivals are longer than this, then two distinct sounds are heard.

Echo vs. Reverberation

A reverberation is quite different than an echo. The distinction between an echo and a reverberation is depicted in the animation below.



- A reverberation is perceived when the reflected sound wave reaches your ear in less than 0.1 second after the original sound wave. Since the original sound wave is still held in memory, there is no time delay between the perception of the reflected sound wave and the original sound wave. The two sound waves tend to combine as one very prolonged sound wave.

- If the reflected sound wave takes more than 0.1 seconds to reach our ear, there will be a small time delay between the perception of the original sound and the perception of the reflected sound.
- We hear reflected sound as a separate sound, which is called 'Echo'