

# Aural Perception: Space and Direction

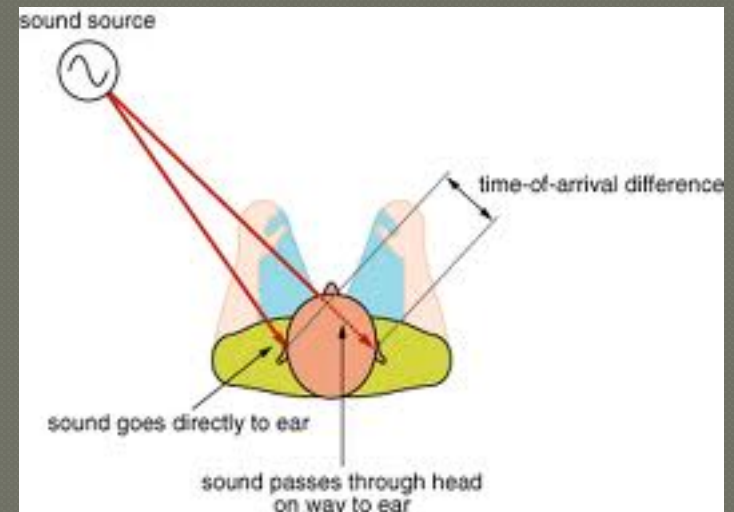
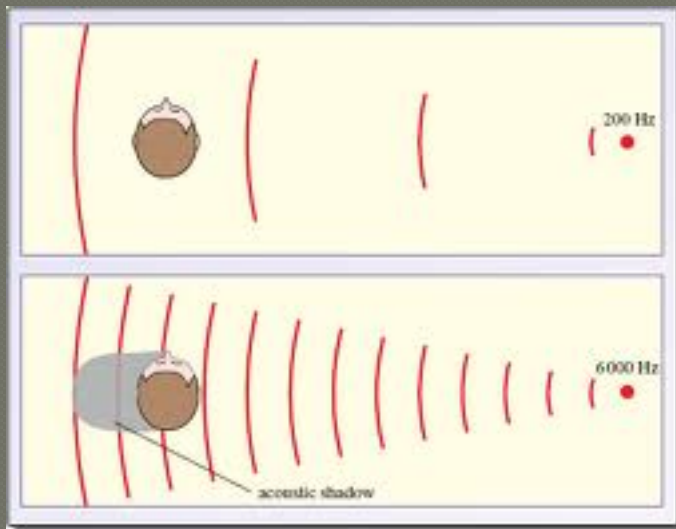
Audio Engineering I

# Binaural Localization

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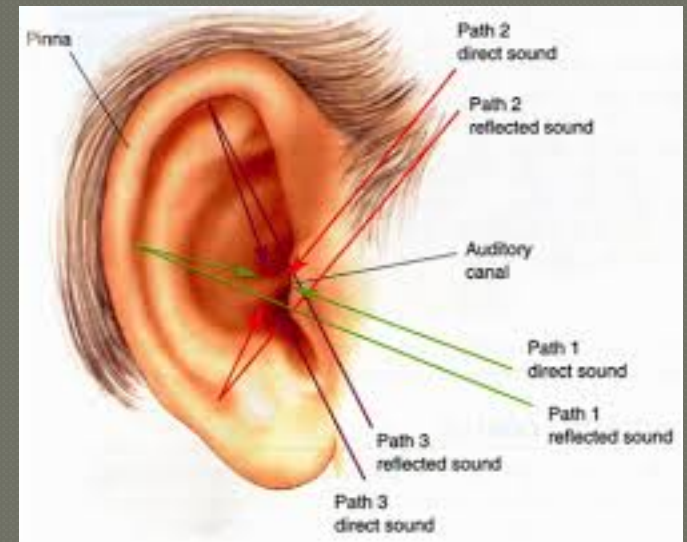
- 2 ears can detect the location of a sound's origin through:
  - Interaural *intensity* differences
  - Interaural *arrival-time* differences
  - Effects of the pinnae (outer ears)

- Middle and Higher frequencies
  - The ears use **intensity differences** to detect location
    - The head acts as a baffle, so the sounds reaching the more distant ear are reflections
- Lower frequencies
  - The ears use **arrival-time differences** to detect location
    - Lower frequencies are not blocked as easily by the head
    - Time differences between the two ears
- Both of these allow us to determine left/right localization, but not the front/back, or below.



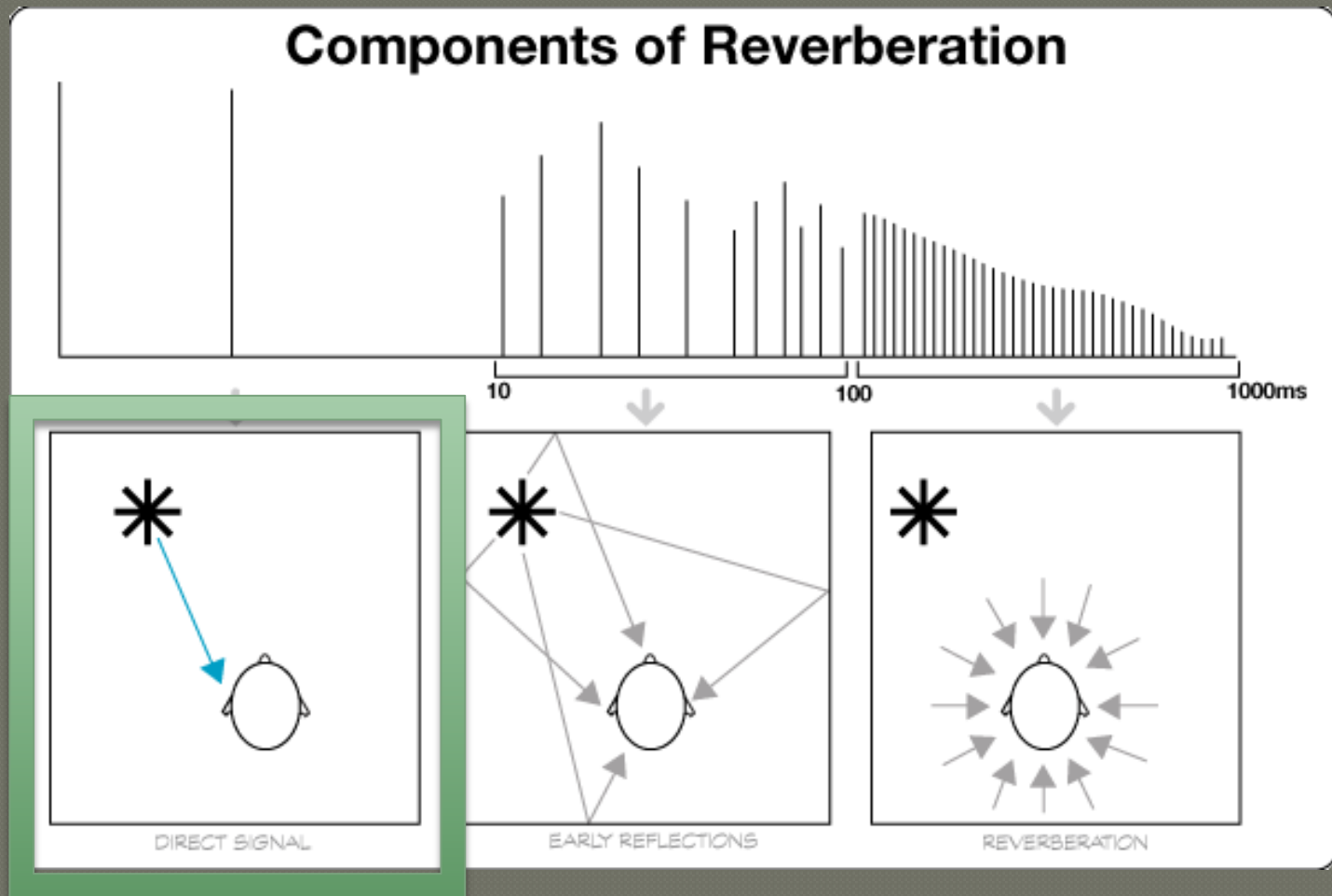
## ● Pinnae

- The ridges on our ears cause tiny time delays
- The brain compares the time delays as well as the frequency responses from each ear
- Helps with front and rear, as well as vertical localization



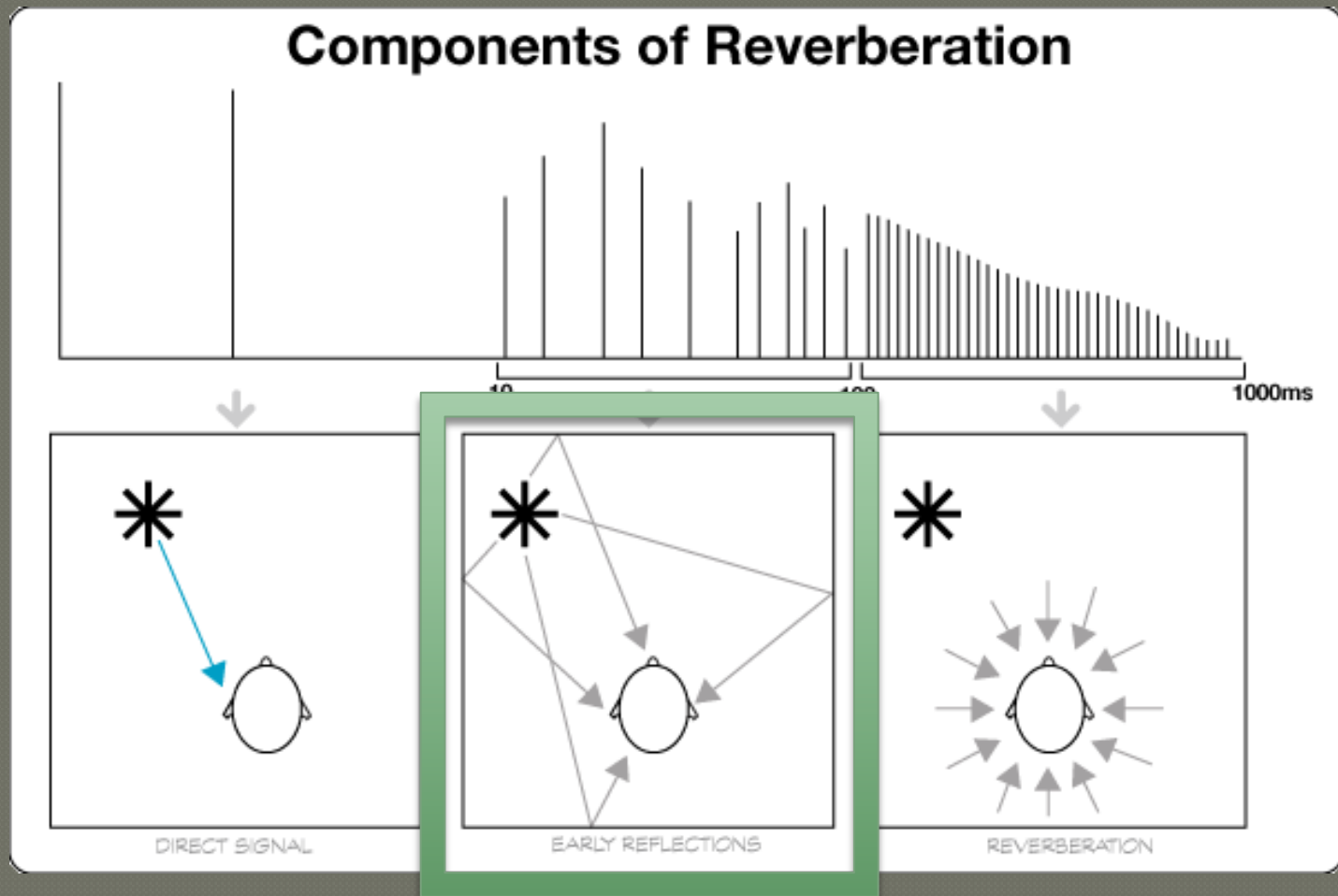
- If there's no difference between the two ears, the brain assumes the sound is the same distance from each ear.
  - **Phantom center** – the perception of a sound in between two sound sources – i.e. when two speakers are at the same level.
  - **Panning** - adjustments of the levels between the speakers causes us to perceive the sound coming from different directions between the two of them.

- Perception of Space: Sound Reflections



Direct Signal: Helps us determine sound's location and true timbre

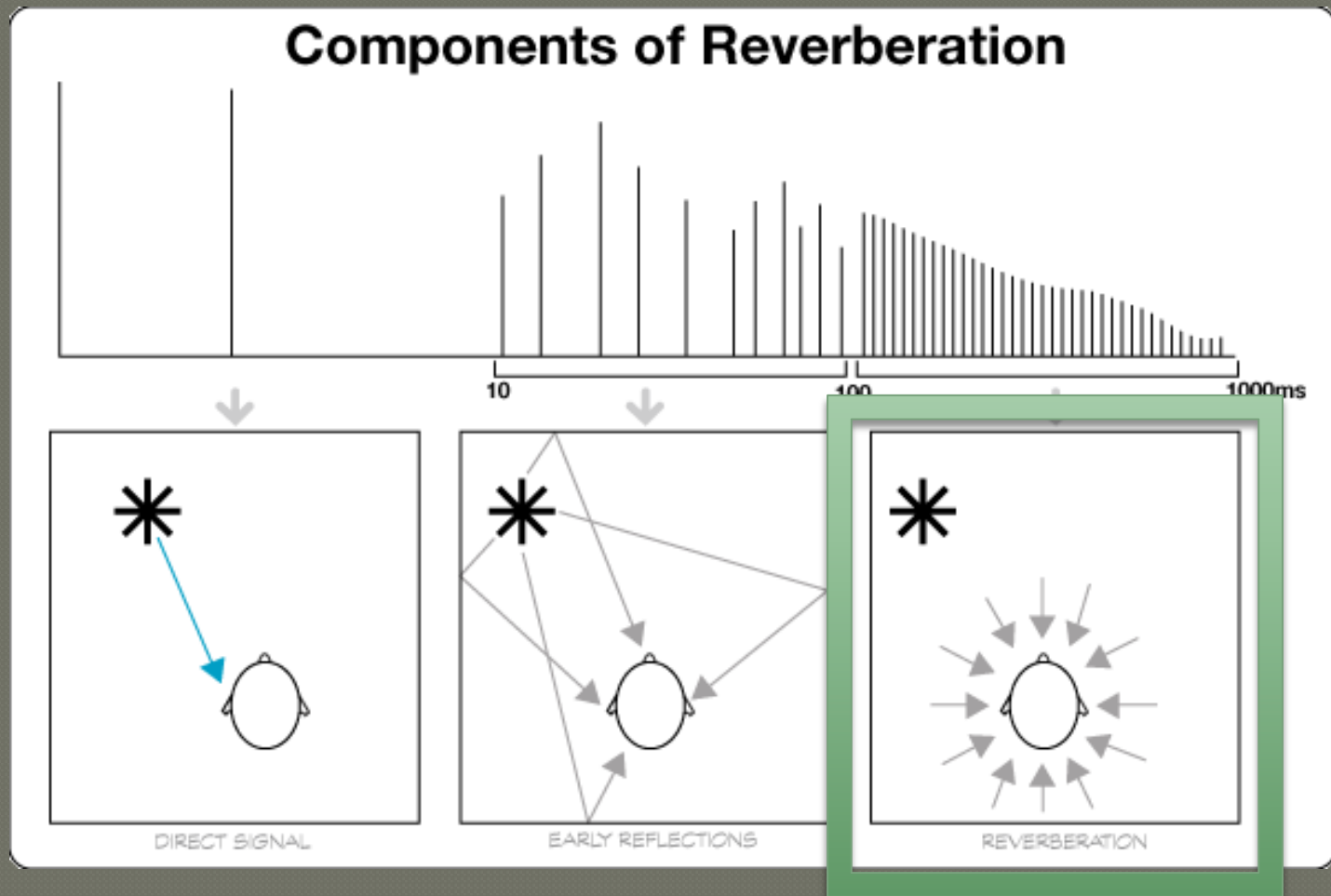
## ● Perception of Space: Sound Reflections



**Early Reflections:** Reflections off the largest boundaries in a room. The longer the delay, the larger the room.

**Temporal fusion:** sounds arriving within 30ms are “fused” with the direct sound in our minds. (depending on timbre and envelope of the sound)

- Perception of Space: Sound Reflections



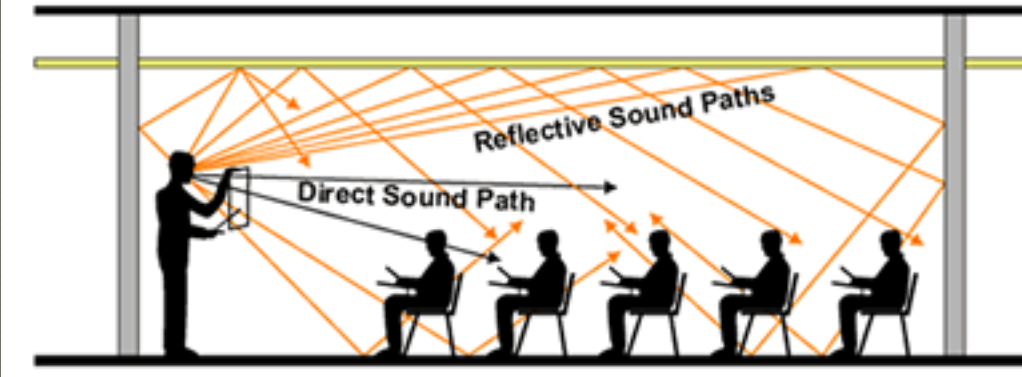
**Reverberation:** Random and continuous stream of reflections arriving from all directions



## REVERBERATION

The time it takes for reflected sound to die down by 60 decibels from the cessation of the original sound signal (measured in seconds).

- Reflected sound tends to "build up" to a level louder than direct sound. Reflected sounds **MASK** direct sound.
- Late arriving reflections tend to **SMEAR** the direct sound signal.



- **Decay Time (Reverb Time):** the time it takes for a reverberant sound to decrease by 60 dB
  - Helps listeners judge the size of the room and the hardness of its surfaces
  - Difference between loudness of Direct Signal and Reverb helps listeners judge their distance from the sound source.
- Audio Engineers can create artificial reverb by programming direct reflections and random delays to emulate random reverb, as well as change the balance between reverb and signal to “place” the sound’s distance from the listener.



## ● Doubling

- Repeating a signal with a slight delay (4-20 ms) can cause the brain to perceive two instruments are playing.
- Longer delay – “slap back echo” can also fatten up a sound, and have a distinctive sound (popular in the 50’s and 60’s, but also revived in electronica and other genres)

