

## Week 9 Slides

Tuesday lecture  
Study Sessions on Tues 1:00-2:30  
And Wednesday 12:00-1:30 in LSCB 326  
(Psychology Conference Room)

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## Hearing Impairment

- Causes of Hearing Impairment (Demo)
  - Congenital or oxygen deprivation during pregnancy/birth
  - Disease/ototoxic exposure
  - Presbycusia
- Results of impairment
  - Sensory losses
    - Selective frequency insensitivity
    - Speech impairments
    - Tinnitus
      - Causes of tinnitus (peripheral to cortical)
  - Behavioral affects
    - Developmental challenges
    - Social isolation
      - “Deaf” culture vs. being deaf
- Hearing Corrections
  - Hearing aids
    - Mechanisms and function
    - Effectiveness
  - Tinnitus
    - Surgical to biofeedback
  - Cochlear implants (Demo)
    - Summed frequency into blocks



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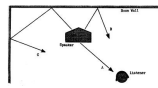
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## Hearing in Space

- Binaural = two ear hearing
  - Combination of ears to determine spatial position
    - Azimuth
      - Not distance
      - Not vertical position
  - Stationary localization
    - Different cues available with motion
- Interaural cues for binaural hearing
  - Interaural Loudness Difference (ILD)
    - Interaural Intensity Difference (IID)
  - Interaural Timing Difference (ITD)
  - Interaural Phase Difference (IPD)
    - <http://www.sinauer.com/wolfe2e/chap10/audlocf.htm>



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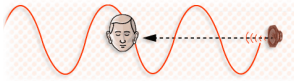
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### Interaural Phase Differences (IPD)

- Relative phase of stimulus across ears
  - Critical region is < 800 Hz
    - No IPD at 833, 1666 Hz
  - Noticeable differences of phase
    - Minimum noticeable displacement 0.2 ms
- Enduring sound events
  - Noise, speech
    - Change in phase triggers change in localization




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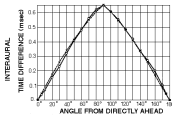
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### Interaural Timing Differences (ITD)

- Onset of auditory stimulation
  - Does not vary across frequency
    - Salient with lower frequencies (< 1500 Hz)
  - Maximum delay of < 1 ms
    - Dependent on head-size
    - Angle of stimulation
- Critical for short events
  - Clicks, bursts
- Less important for enduring events
  - Noise, speech




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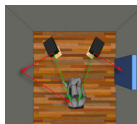
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### Hearing Precedence

- Original precedence
  - Four sounds
    - Ear1, Ear2, Ear2 lagging, Ear 1 Lagging
      - Simulates sound across the head and the first echo
      - Spectral matching across the sounds
  - Not quite precedence, but same idea
    - Two sounds: Lead and Lag
      - Leading sound takes "precedence" limited perception of the lagging sound
        - » (DEMO)
- What happens when precedence occurs?
  - Mismatch with a gap, mismatch with spectrum
    - Is the lagging sound suppressed? Misattributed? Ignored?
      - (DEMO)




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### Interaural Loudness Differences (ILD)

- Relative intensity across ears
  - Critical region
    - > 2 kHz
    - Ecological constraints 800 Hz
  - Up to 20 dB SPL attenuation (over 8 kHz)
    - Sensitive to 1 dB SPL difference
    - Total masking 8 – 10 dB SPL
      - Similar to natural head shadow
  - Hearing in cars



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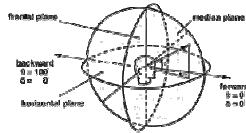
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### Duality Theory of Directional Hearing

- Frequency region determines salient cues
  - Lower frequencies 40 – 1500 Hz IPD, ITD
  - Higher frequencies 4 – 20 kHz ILD
    - Worst localization performance 1500-4000 Hz
- Harnessing Stationary cues
  - Difficult noises
    - Diffuse noise, enduring
    - Sinewave burst
  - Easiest to localize
    - Broadband click
      - Incorporates multiple cues



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