Psychoacoustics Introduction

Music Information Retrieval Workshop, University of Utrecht

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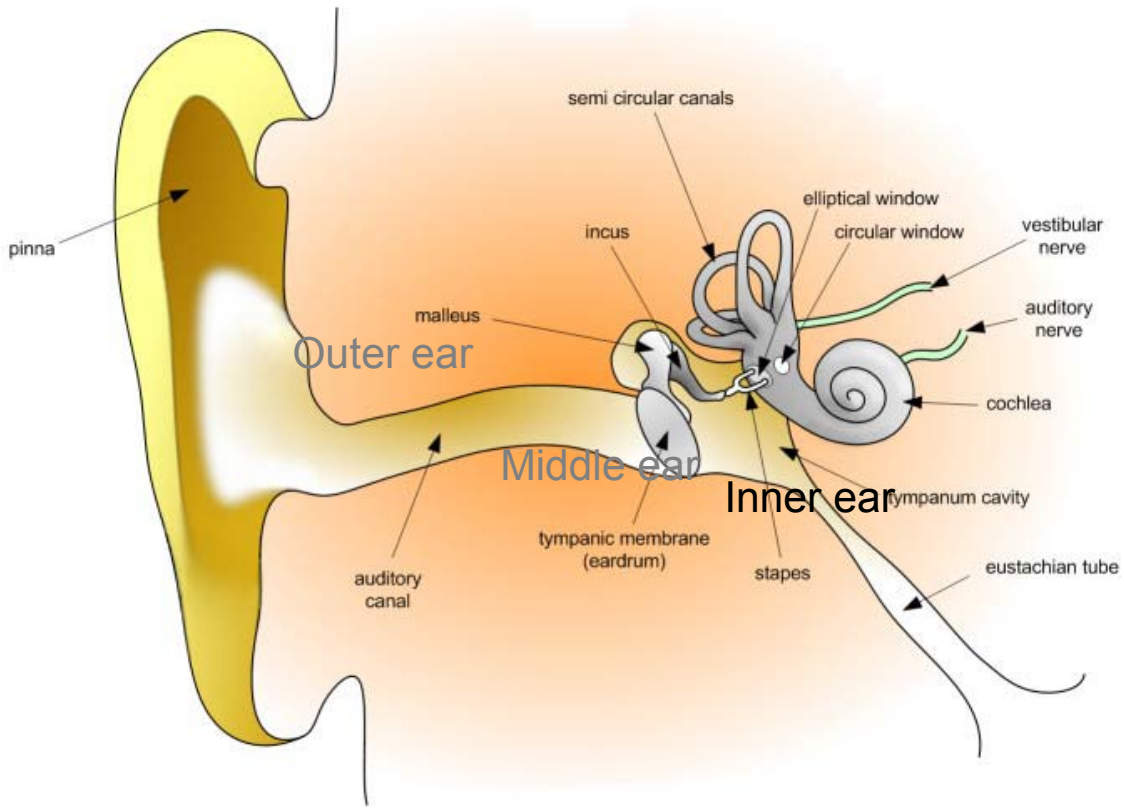
Information & Communication Theory group

Delft University of Technology

Outline

- Auditory System
  - inner ear: Cochlea
- Psychoacoustics
  - Masking
    - Simultaneous masking
      - Critical bandwidth
    - non-simultaneous masking
- Conclusions

The Auditory System



Inner ear

- Cochlea:
  - Tube folded in a spiral form
  - Snail is Cochlea in Latin
  - Energy enters the cochlea via the oval window
  - Mechanical motions are converted into fluid motions
  - Acts as a 'spectrum analyzer'

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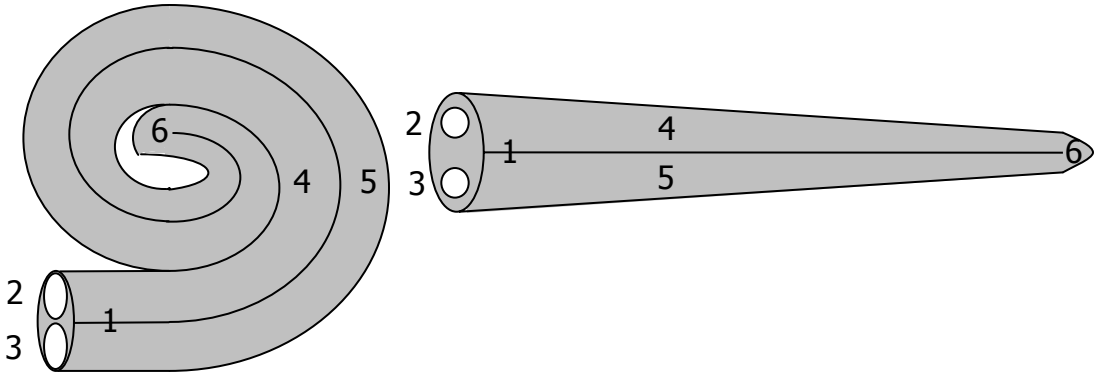
The Auditory System



1. Basilar membrane
2. Oval window
3. Round window
4. Scala vestibuli
5. Scala tympani
6. Helicotrema

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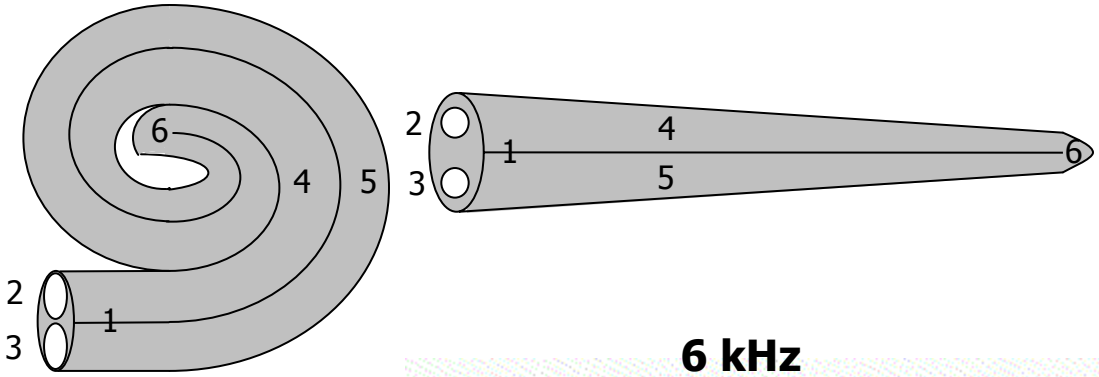

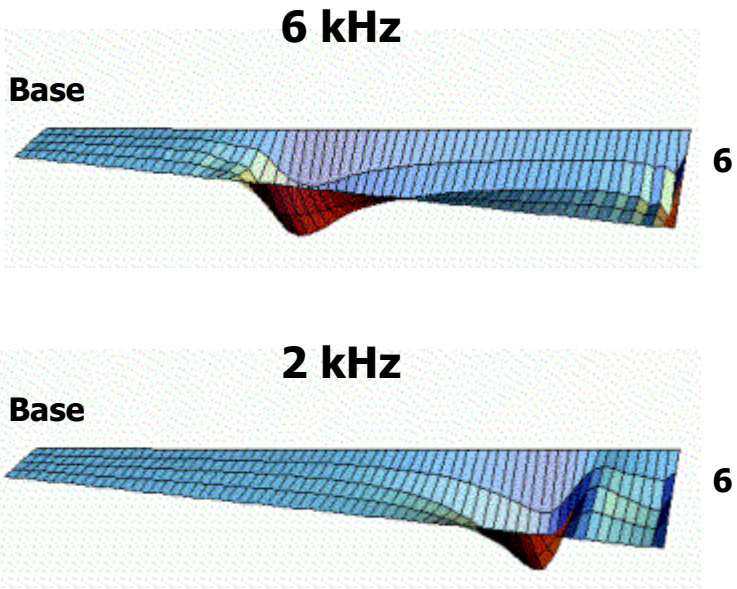

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  - Energy enters the cochlea via the oval window
  - Mechanical motions are converted into fluid motions
  - Acts as a 'spectrum analyzer'
  - Low frequencies cause a displacement near the helicotrema and high frequencies near the base of the cochlea

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Psychoacoustics

- How do we perceive sound?

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Simultaneous masking

- The noise of a passing train can make the signal from your portable music device inaudible
- The train acts as a *masker* for the audio signal
- Simultaneous masking: The masker and masked signal occur at the same time

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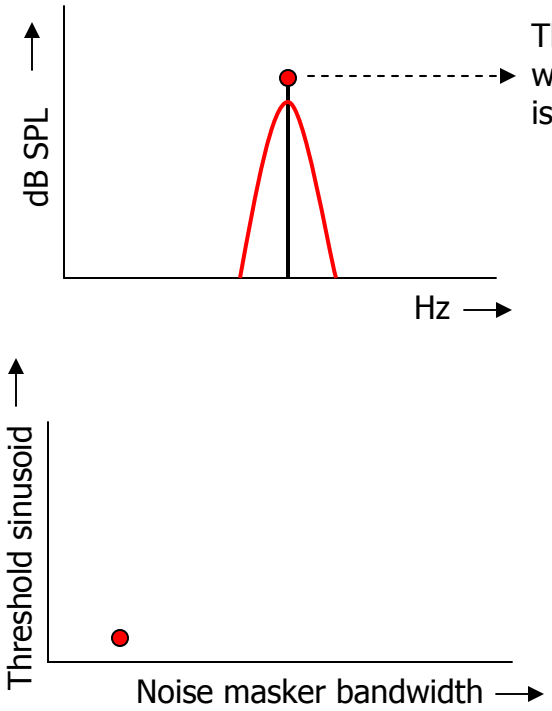

Simultaneous masking

- Fletcher(1940) performed tests with a band-pass filtered noise masker and sinusoidal test signal
- Frequency sinusoid is equal to center frequency of filtered noise

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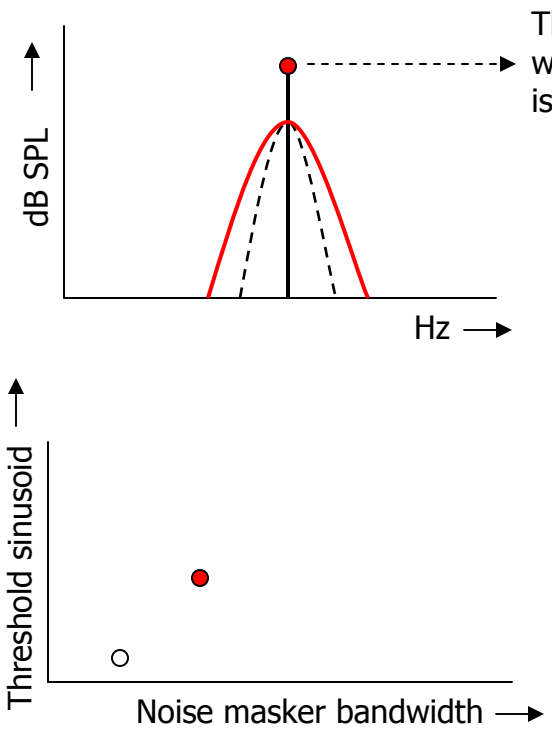

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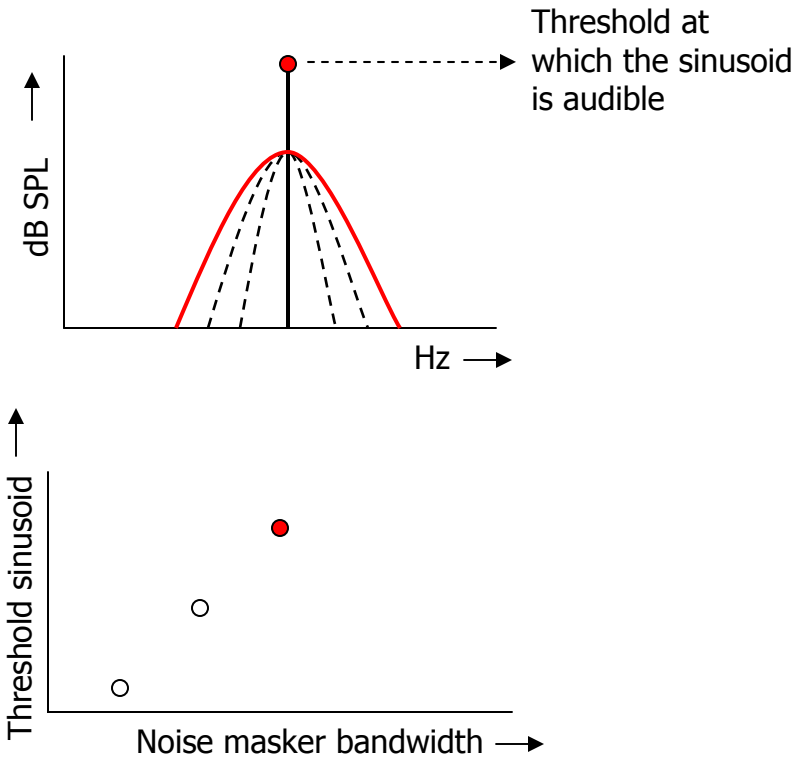

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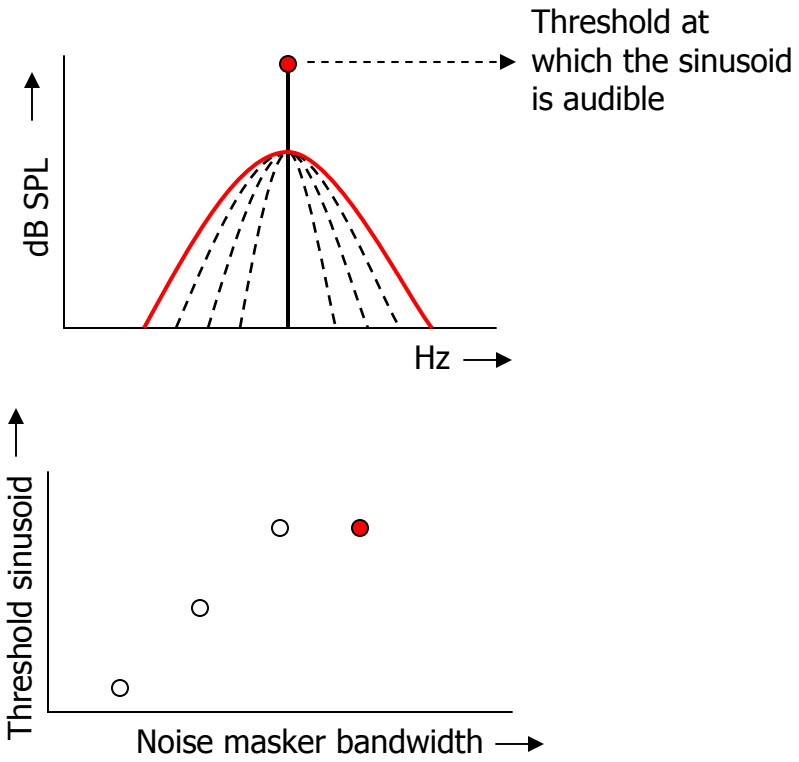

Simultaneous masking

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- Threshold remains constant at a certain bandwidth

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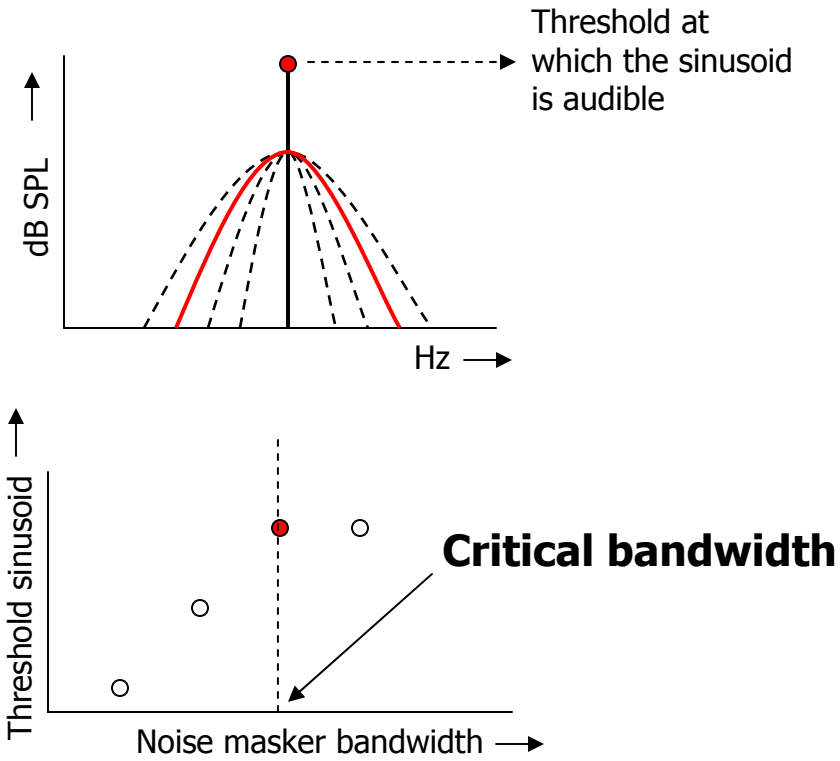

Simultaneous masking

- Fletcher(1940) performed tests with a band-pass filtered noise masker and sinusoidal test signal
- Frequency sinusoid is equal to center frequency of filtered noise
- Bandwidth is increased while determining sinusoid threshold
- Threshold remains constant at a certain bandwidth: Critical bandwidth

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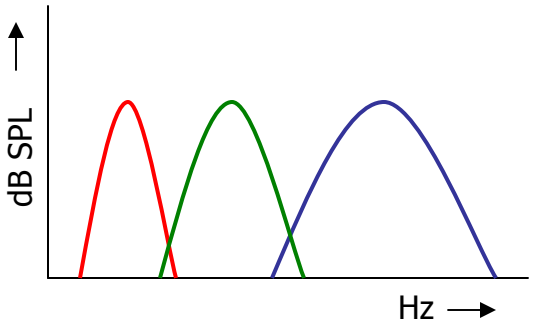

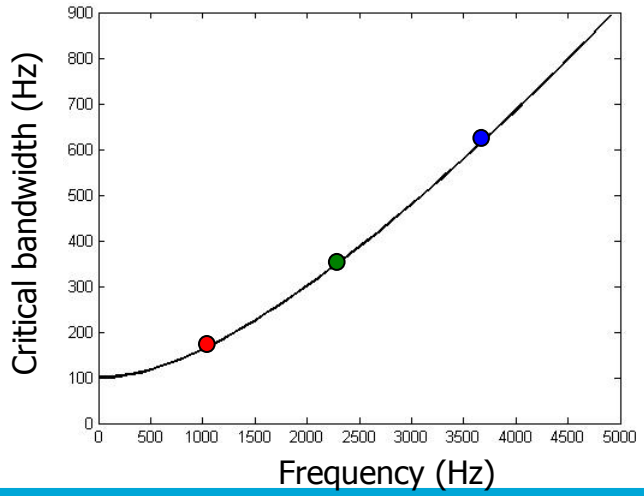

Simultaneous masking

- Critical bandwidth is frequency dependent
- At low frequencies the critical bandwidth is small
- At high frequencies the critical bandwidth is large

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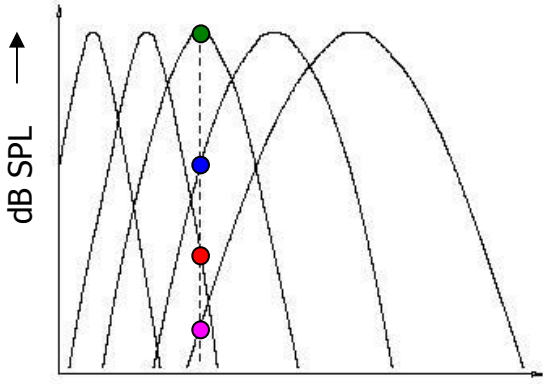
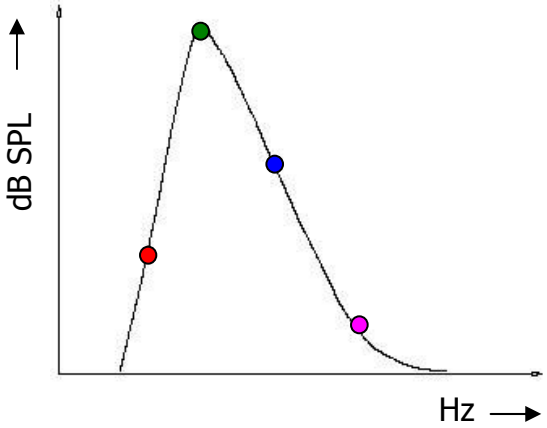


1 kHz sinusoid masker



Simultaneous masking

- Assumption: If the power of the masker signal within a critical band exceeds the power of the test signal the test signal is masked

- Sounds below curve are inaudible: Masking threshold

- Masking threshold can be used to 'hide' noise due to compression

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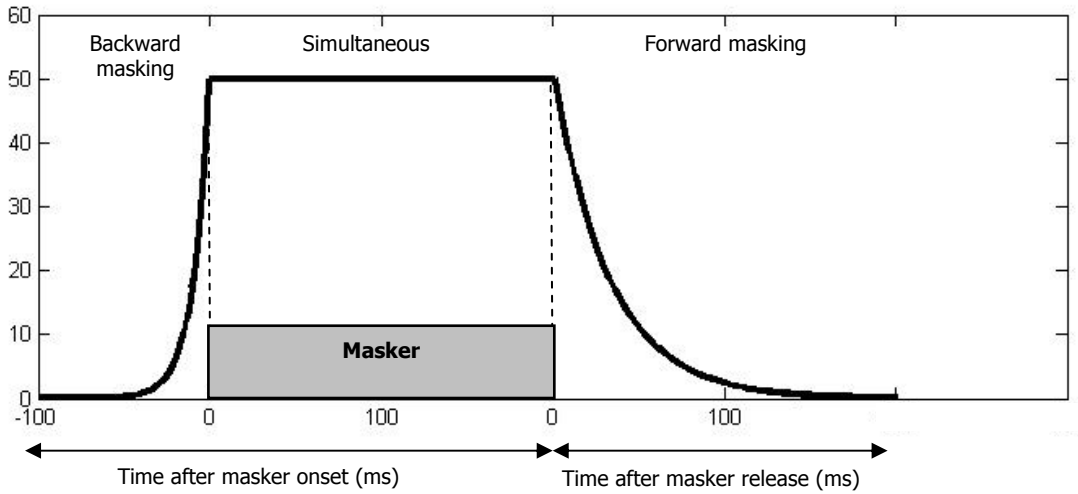
Non-Simultaneous masking



- Non-simultaneous masking occurs before and after a certain masker
- Forward masking
  - Around 150 ms after the masker is turned off
- Backward masking
  - Around 5 ms before the masker is turned on

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Conclusions

- Cochlea performs like a spectrum analyzer
- Simultaneous masking
  - Critical bands are frequency ranges in which one sound can mask another
  - Masking threshold of a masker determines which frequencies at which levels are masked
- Non-simultaneous masking
  - Sounds before and after the on/offset of a masker can be masked

Questions?