9.35 Sensation And Perception
Spring 2009

Hearing

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April 14, 2009

Psychoacoustics

- Ask listeners how sounds are perceived
- Pressure (dB) => loudness
- Frequency (Hz) => pitch
- Critical bandwidths

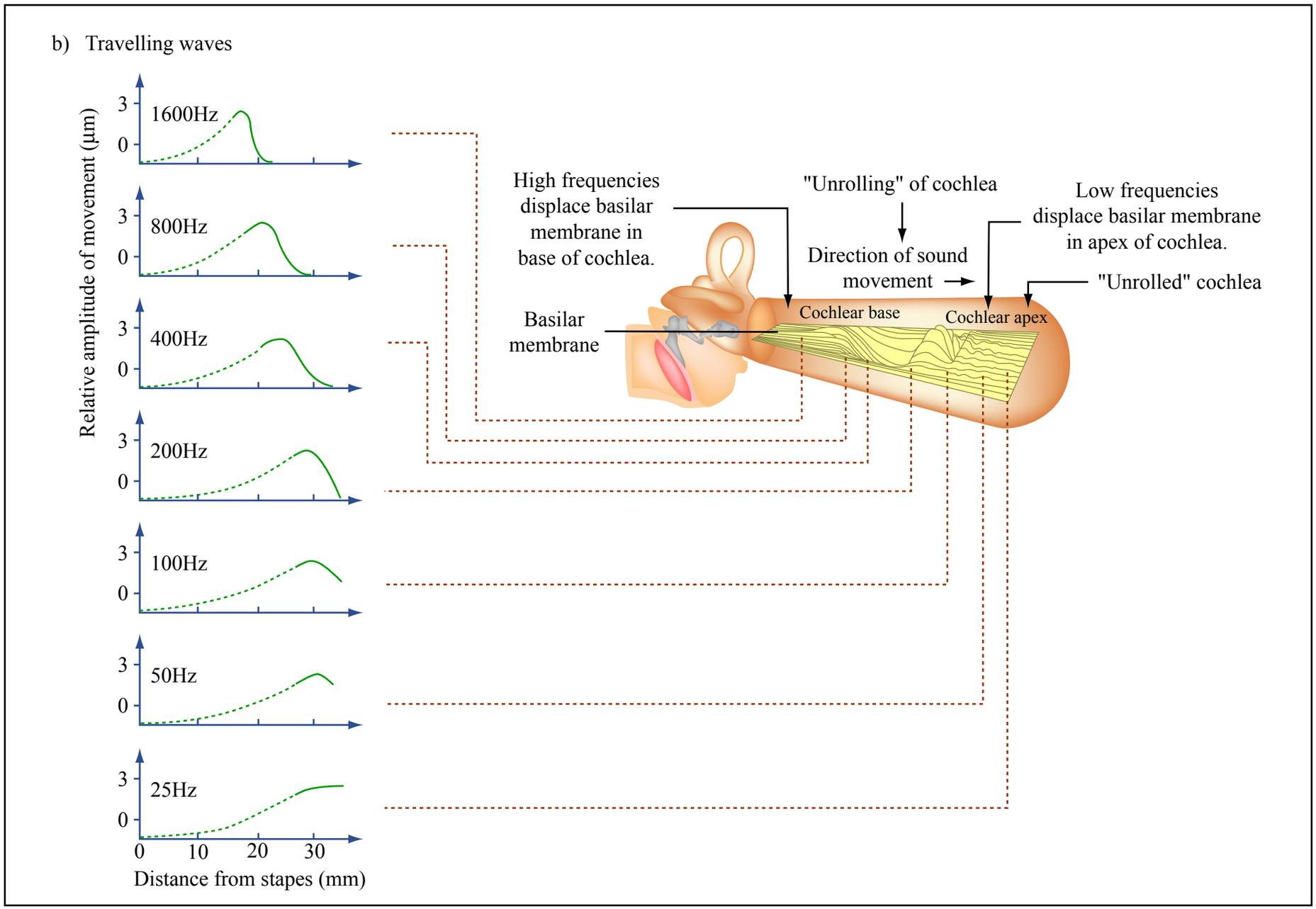
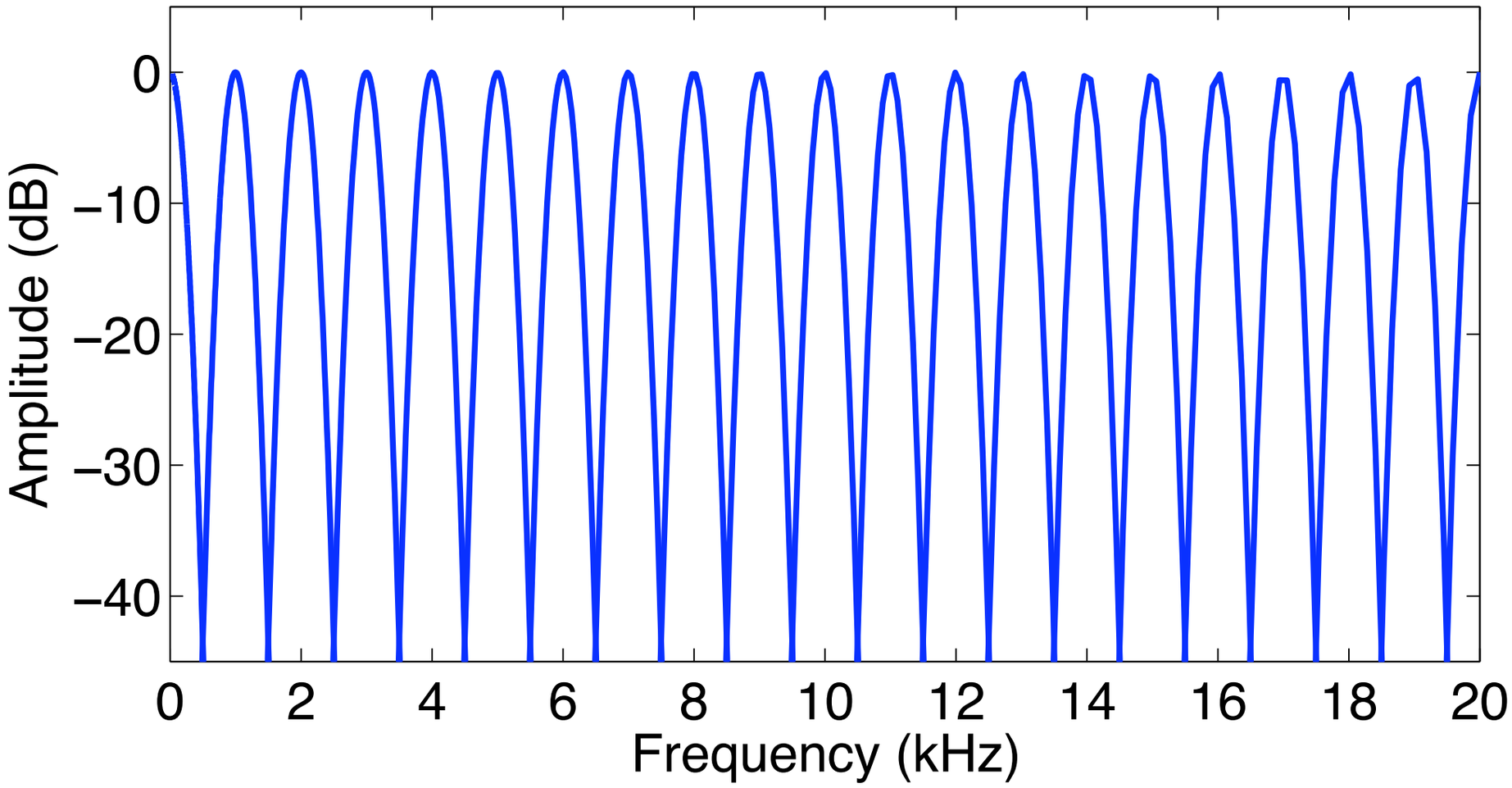


Figure by MIT OpenCourseWare.

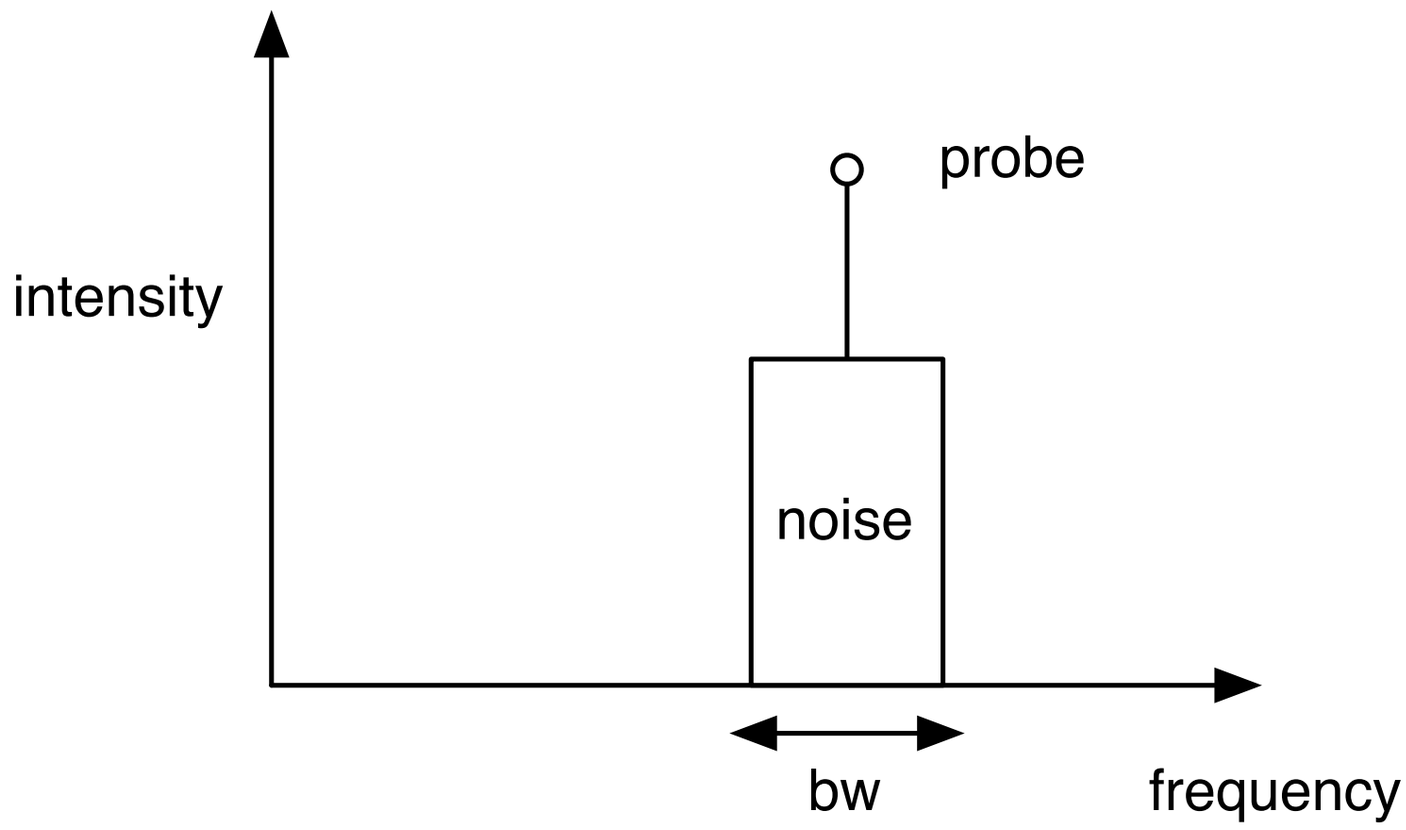
Critical bands

- Auditory filters



Critical bands

- Width of "auditory filters"
  - Fletcher (1938)
  - Zwicker (1960,1990)
  - Moore, Glasberg



Critical bands

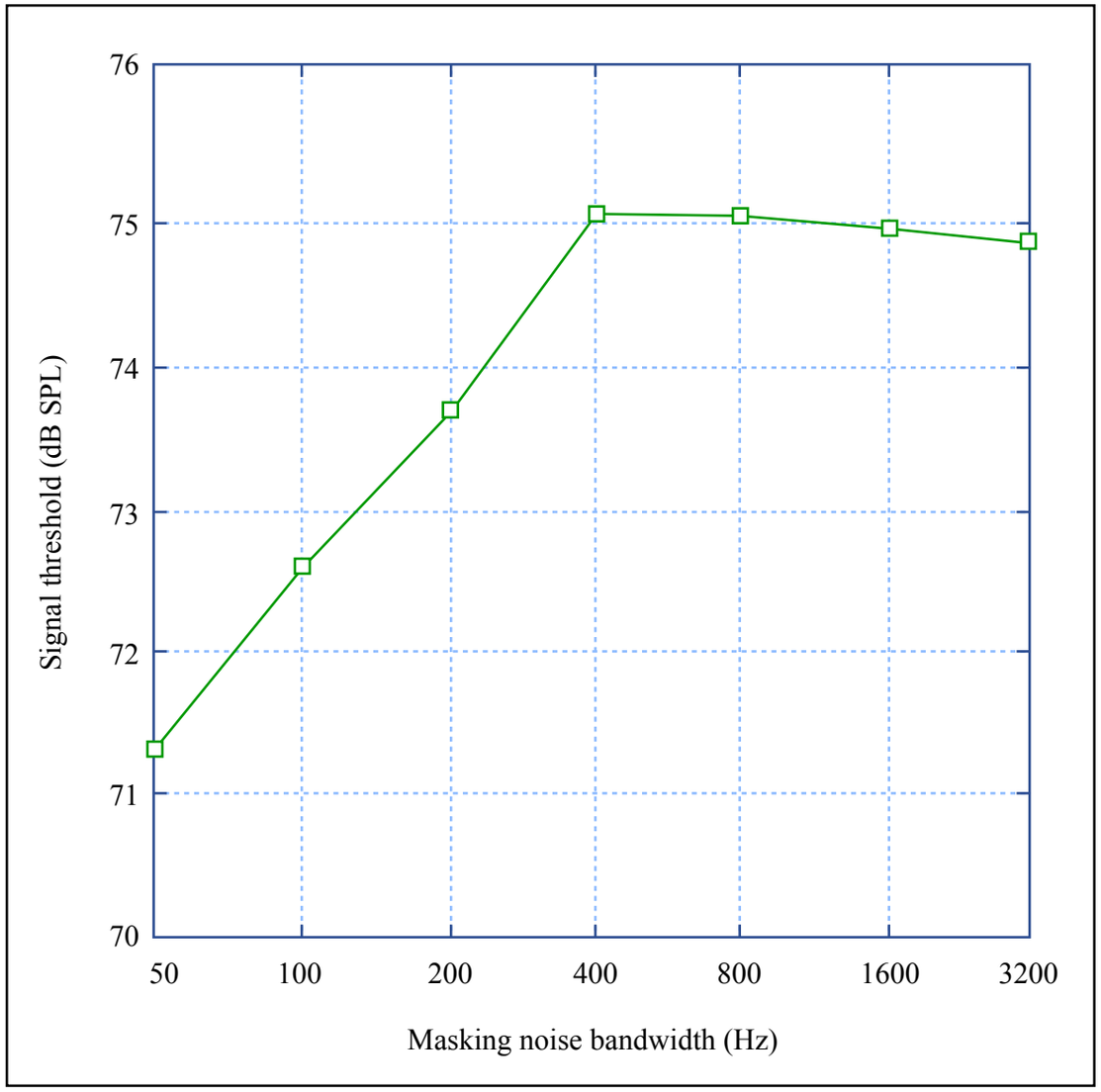
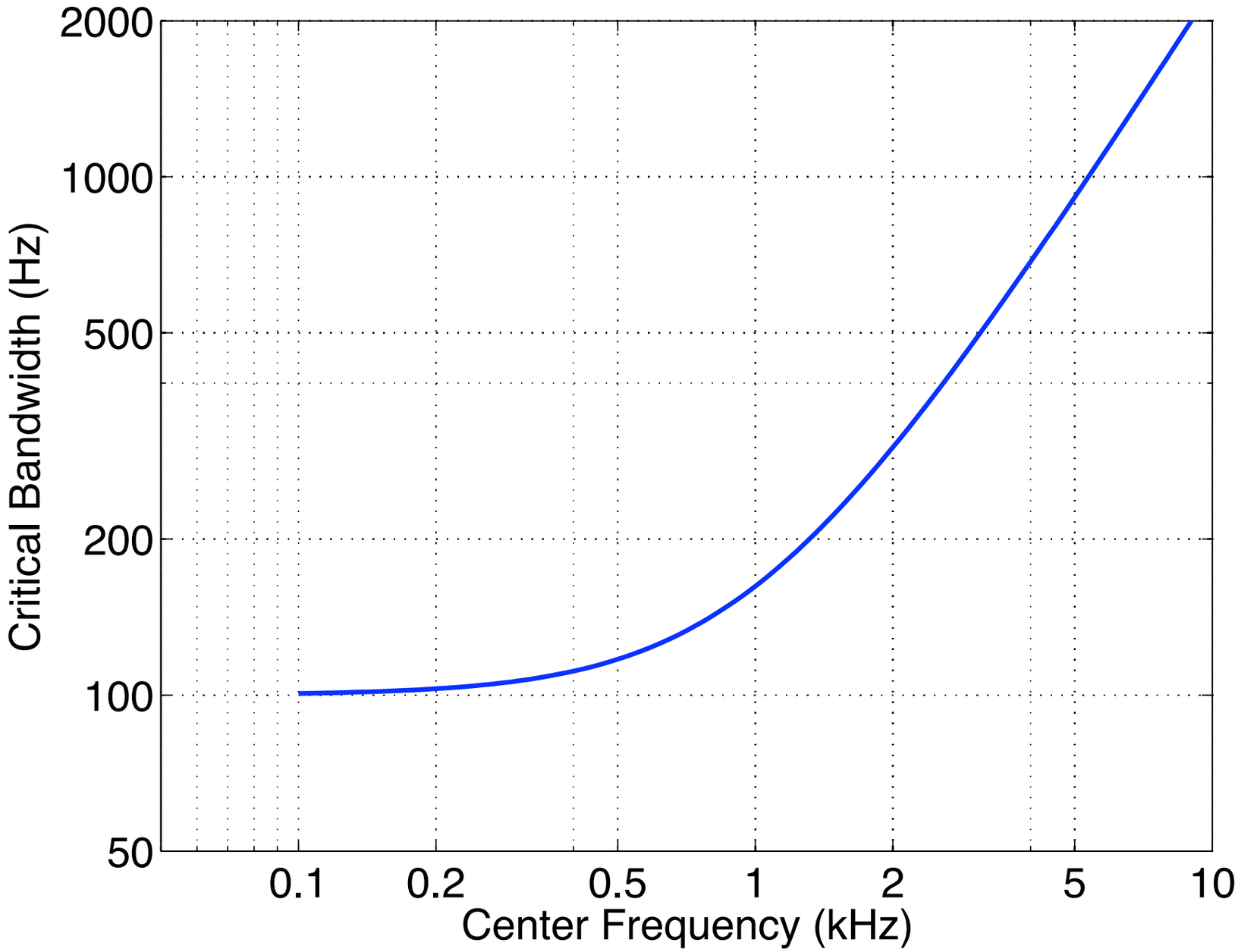


Figure by MIT OpenCourseWare.

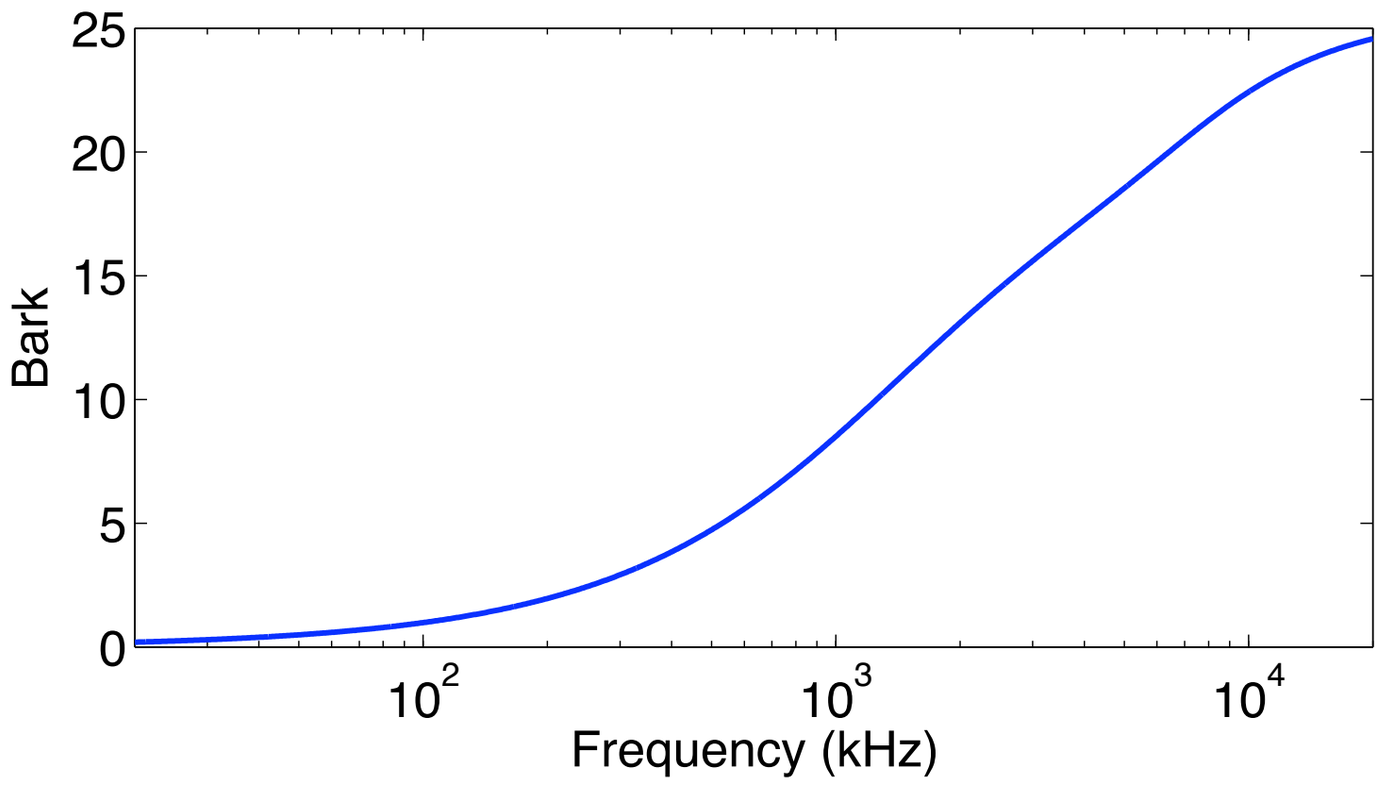
Critical bandwidth



Center frequency

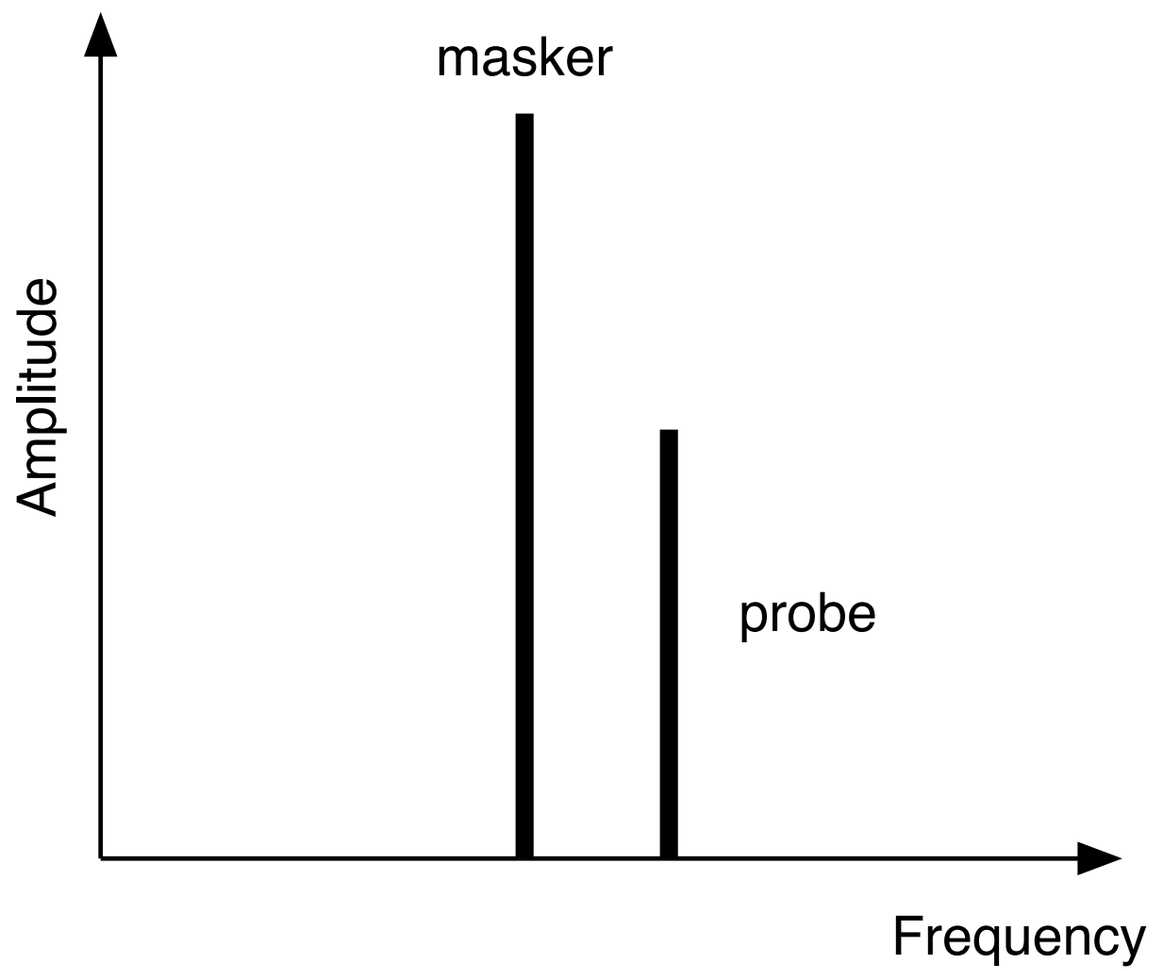
- Bark scale
  - Zwicker and Fastl, 1990

$$B(f) = 13 \arctan\left(\frac{0.76f}{1000}\right) + 3.5 \arctan\left(\left(\frac{f}{7500}\right)^2\right)$$



Masking

- Masking experiments to investigate frequency selectivity
- Tones masking tones demo



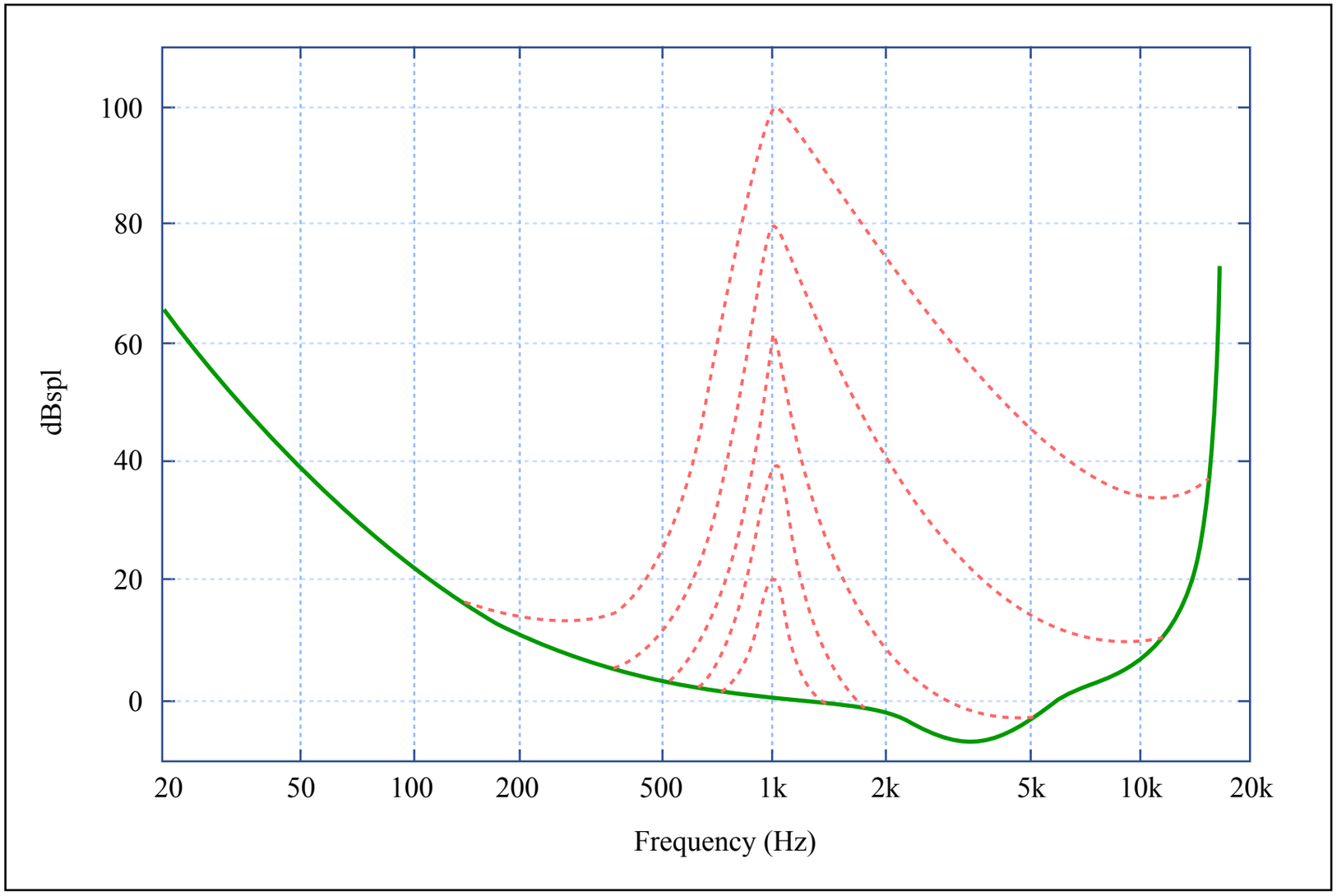


Figure by MIT OpenCourseWare.

Zwicker and Fastl, 1990

Upward spread of masking

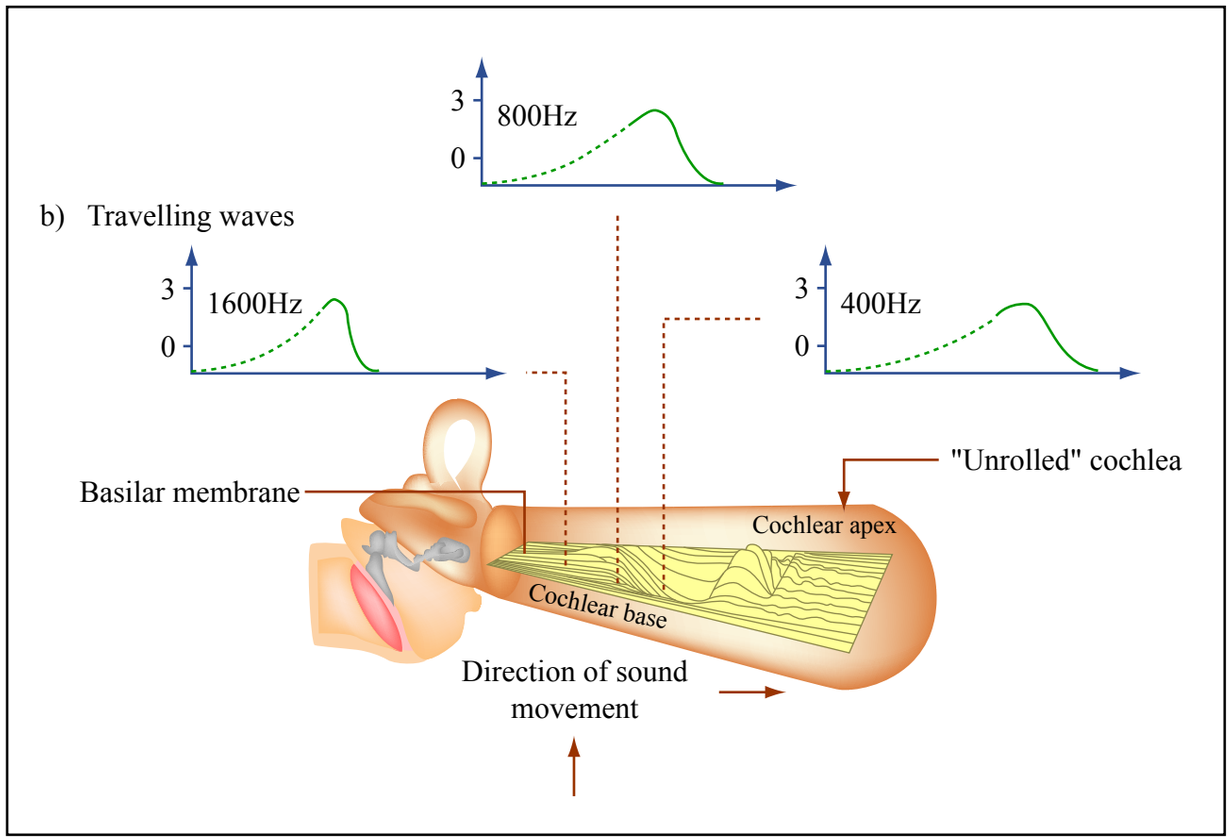


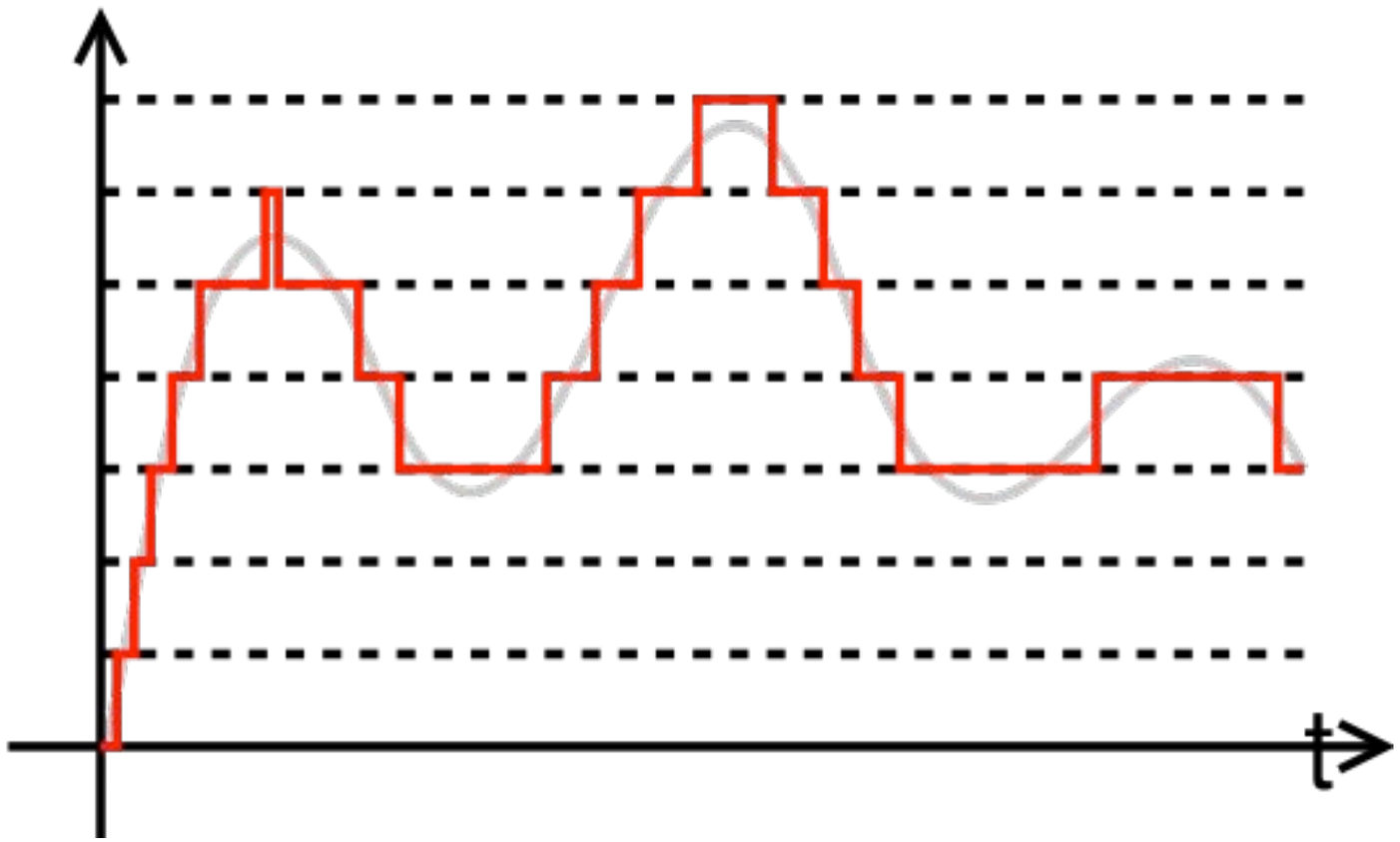
Figure by MIT OpenCourseWare.

MP3 Compression

- Perceptual coding
- ISO Standard 1991
- 10 : 1 compression
- Typical song size: 3.75 MB vs. 40 MB (CD

Original iPod (2001)
5GB = 1000 songs

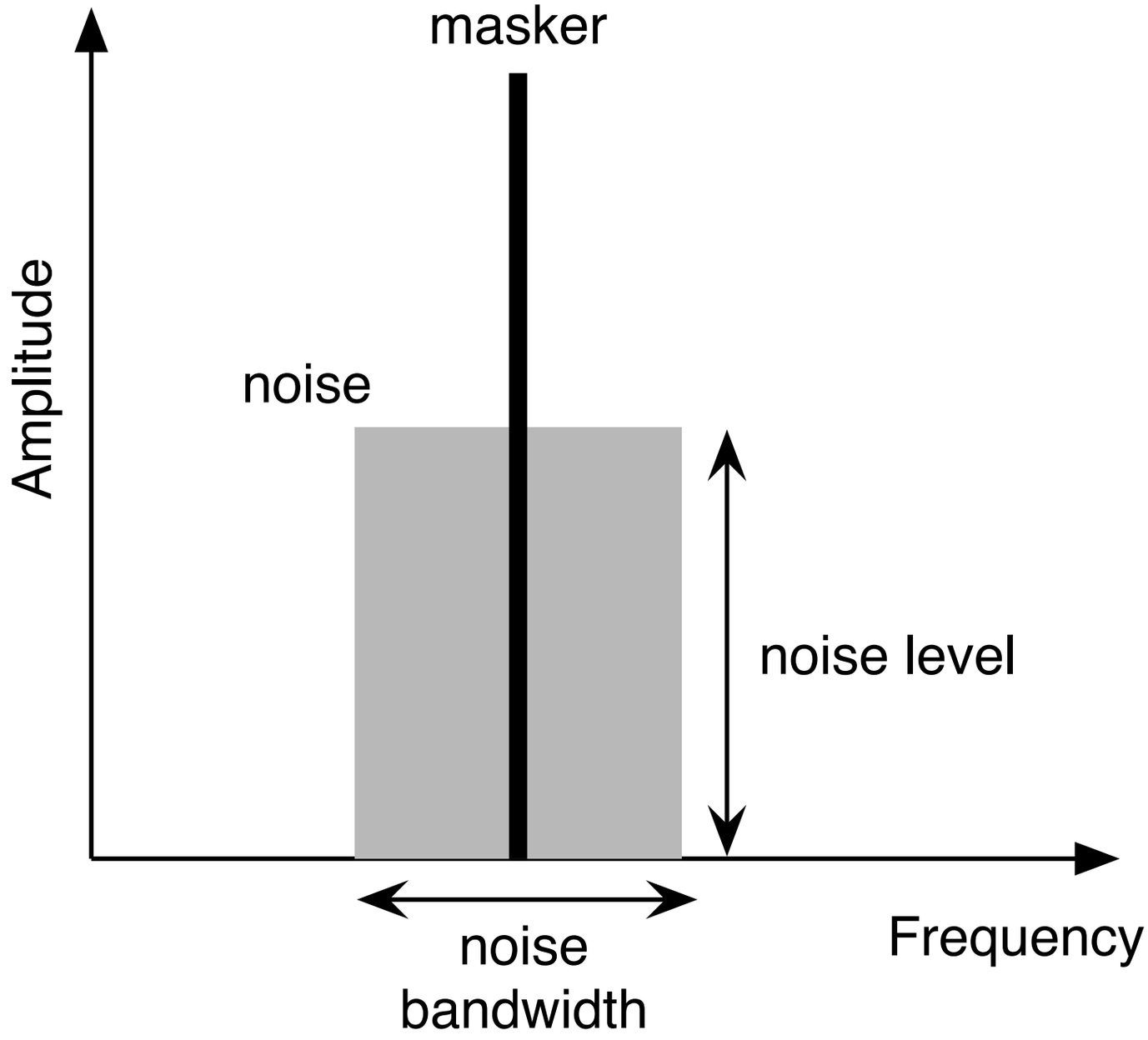
Quantization



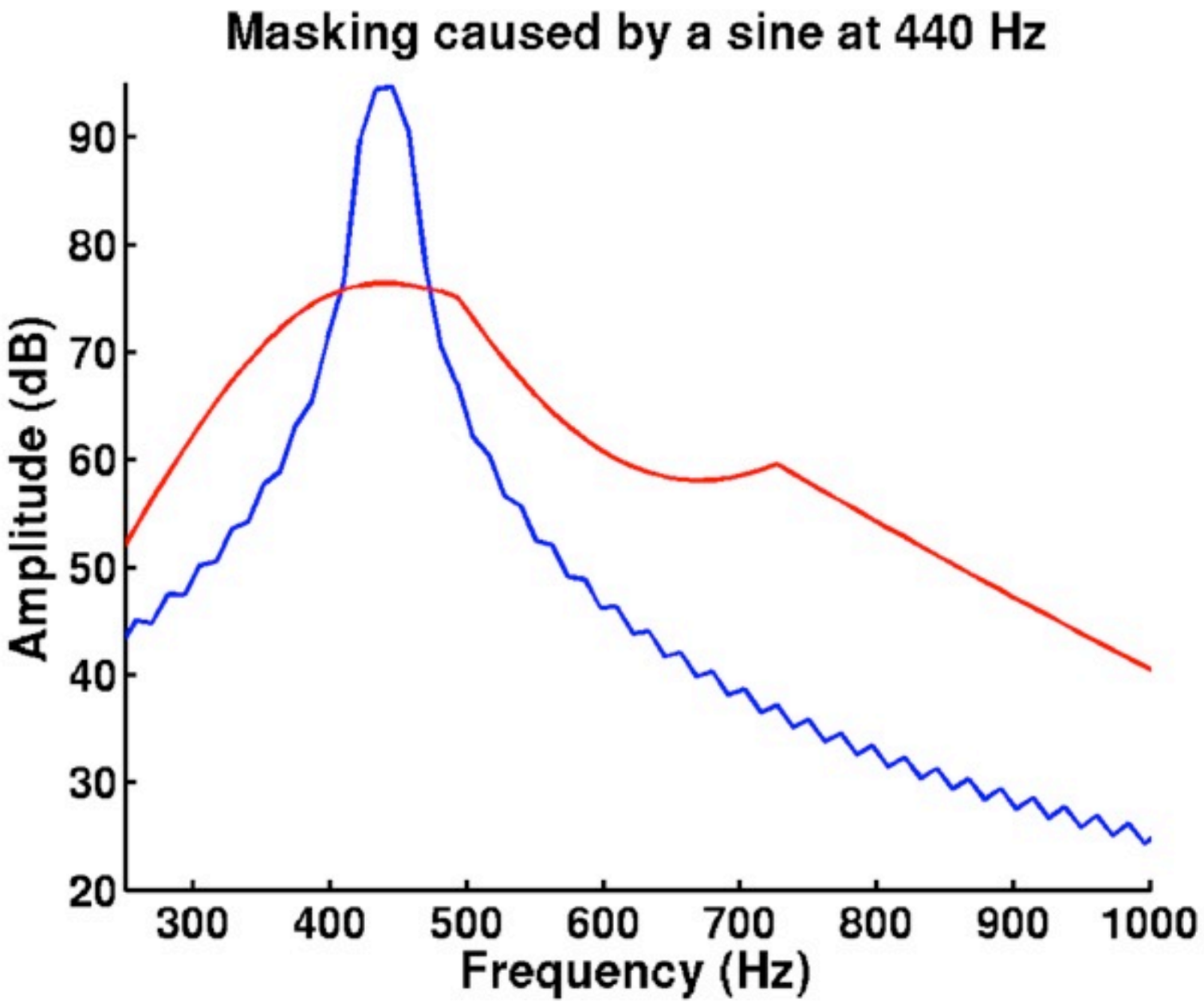
16 bits = 65536 levels

10 : 1 compression = 1.6 bits

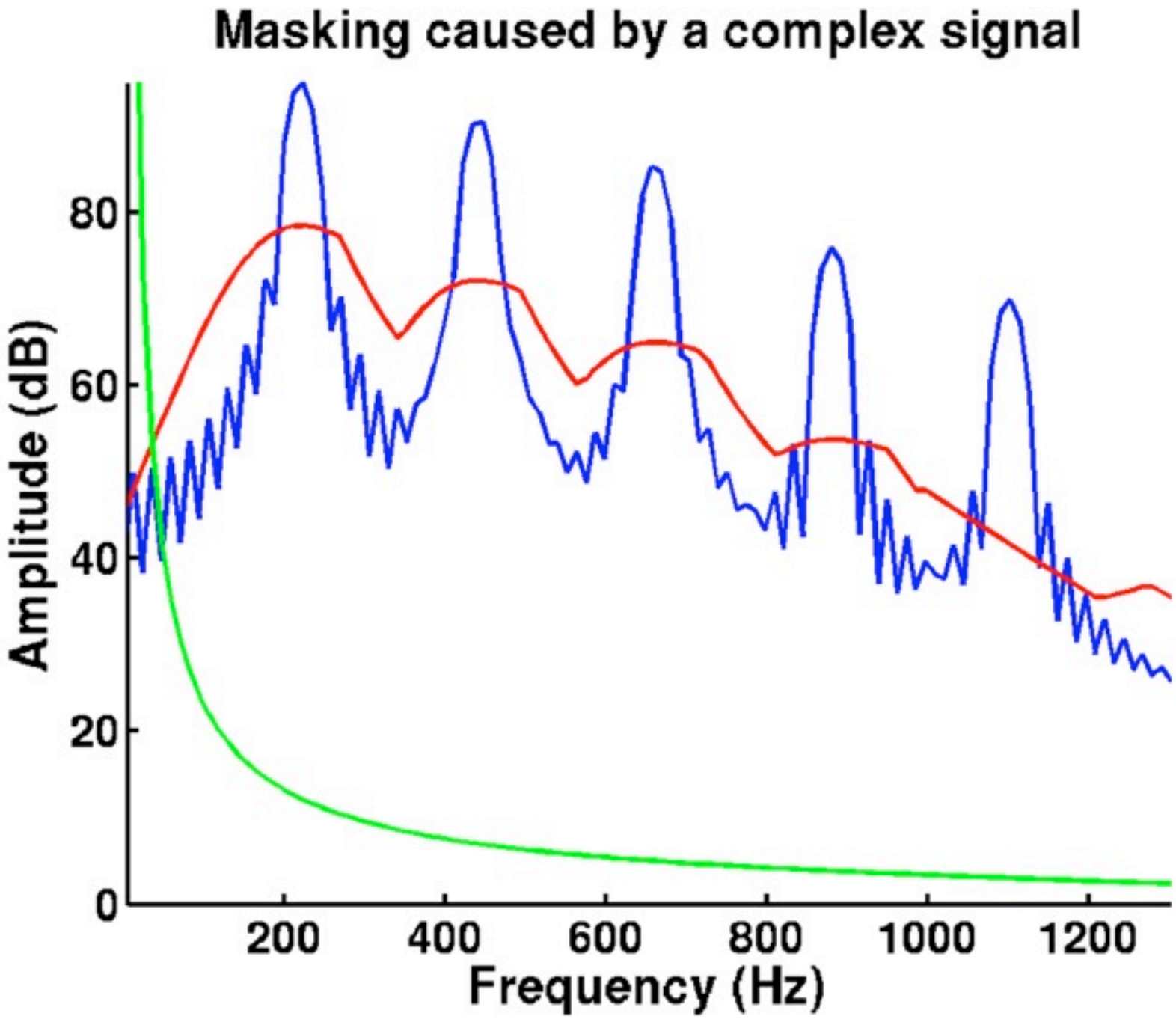
Tone masking noise



Tone masking noise



Complex tones



Hearing

- Sound localization
- Perception of complex periodic sounds
  - pitch
  - timbre
- Auditory scene analysis

Localization

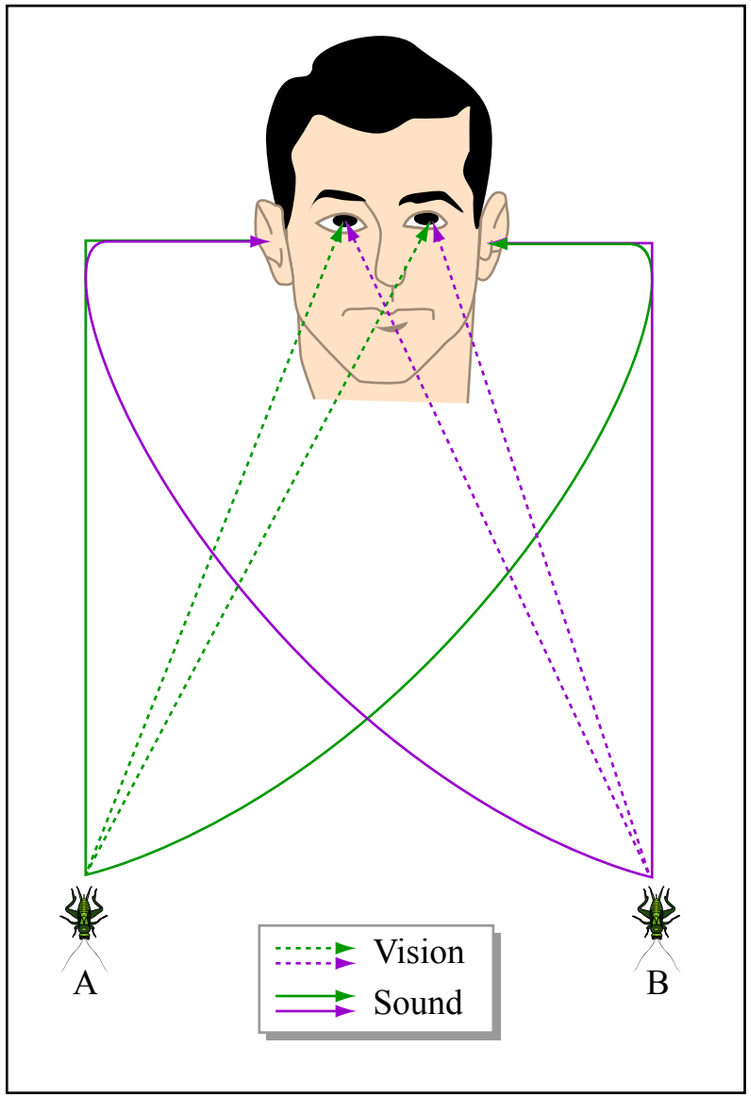


Figure by MIT OpenCourseWare.

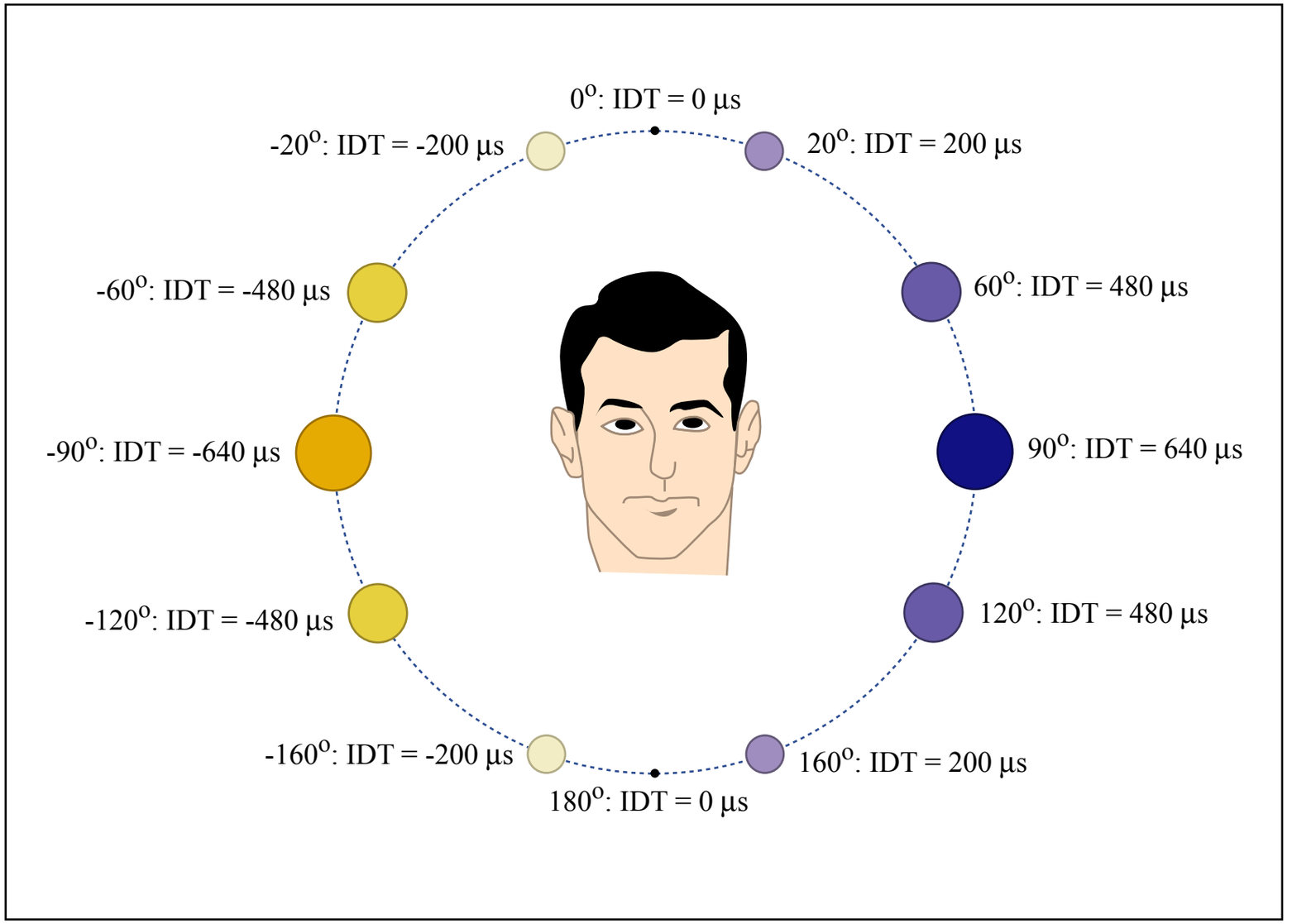


Figure by MIT OpenCourseWare.

Interaural time difference

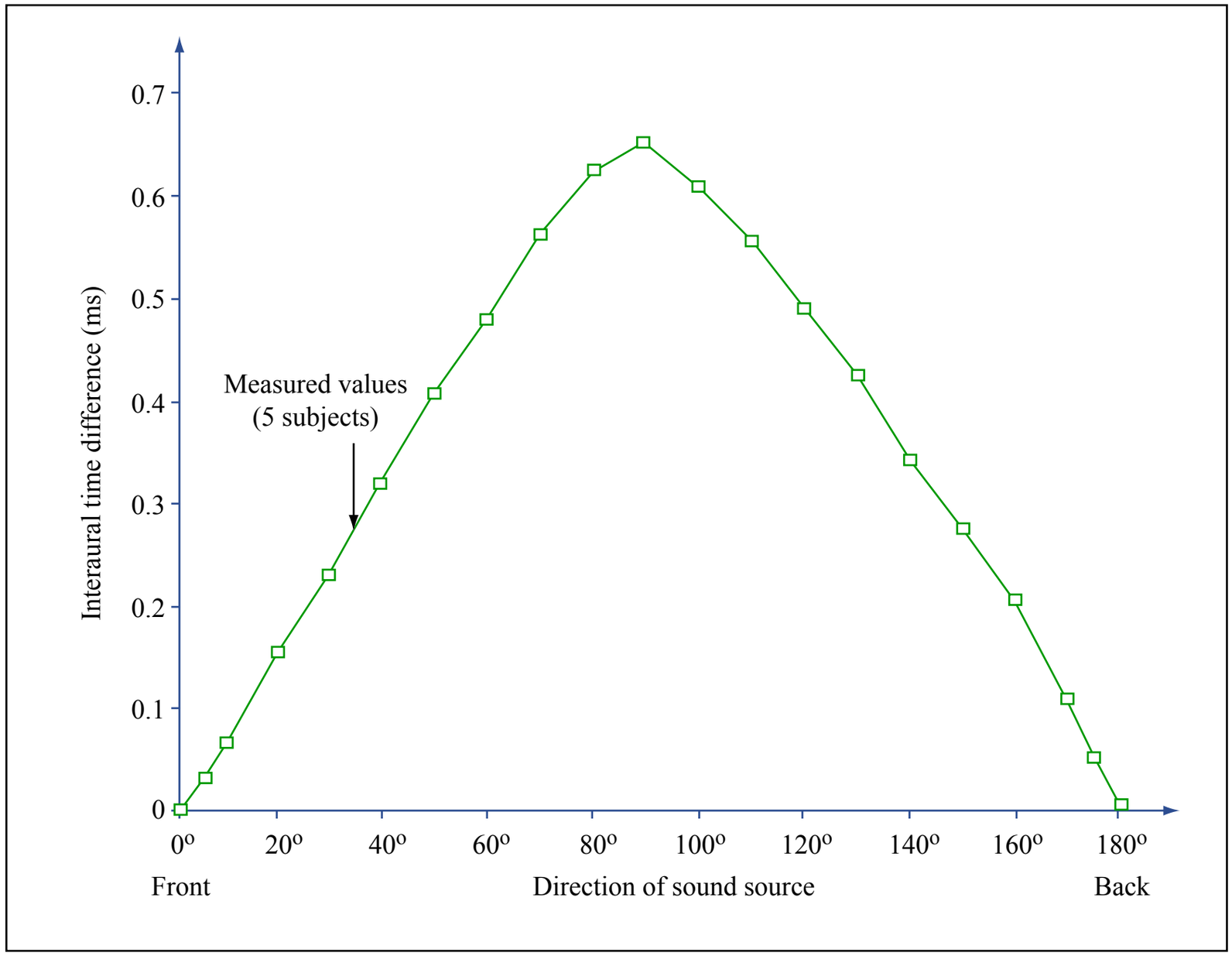


Figure by MIT OpenCourseWare.

Interaural level difference

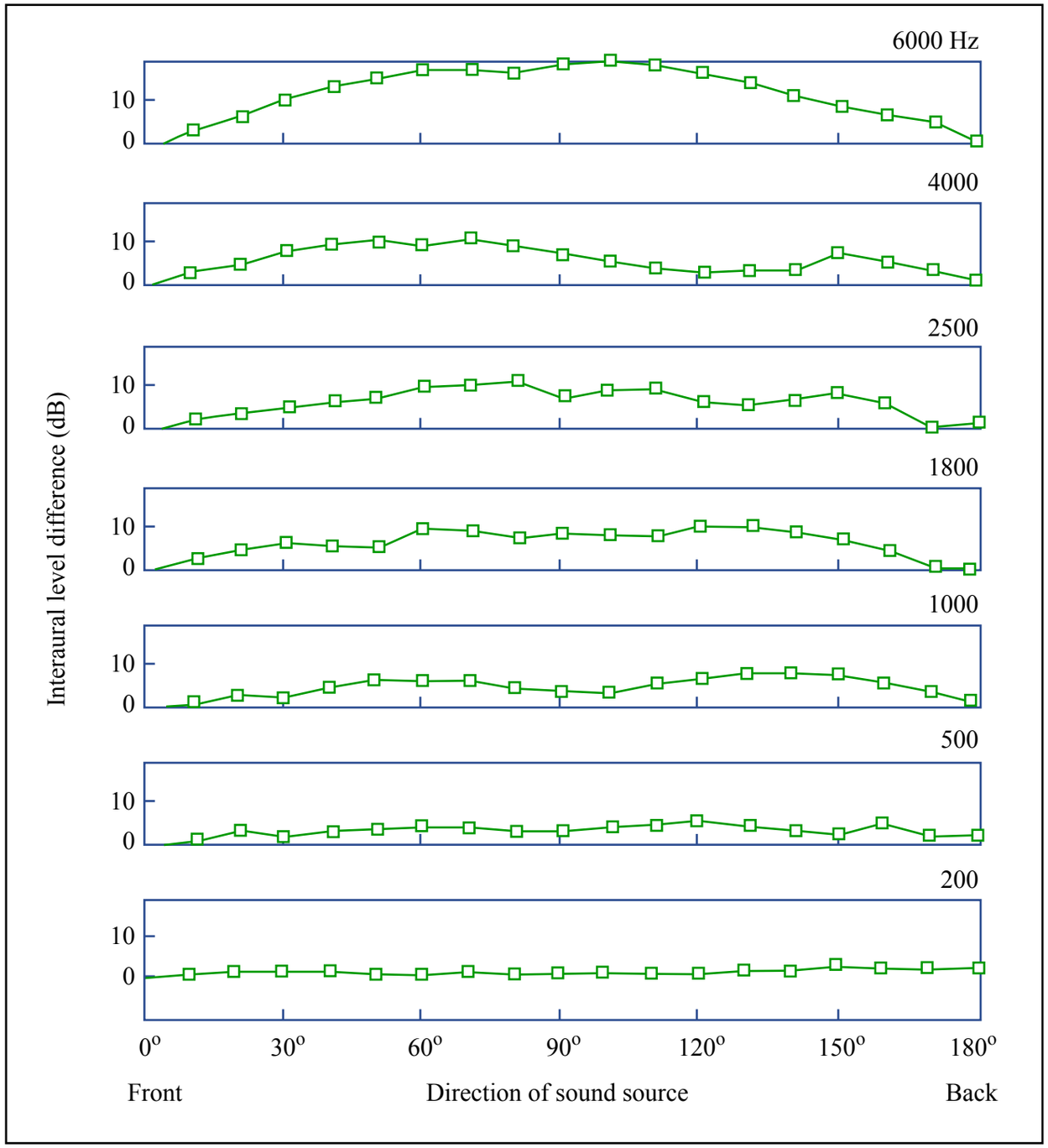


Figure by MIT OpenCourseWare.

Cones of confusion

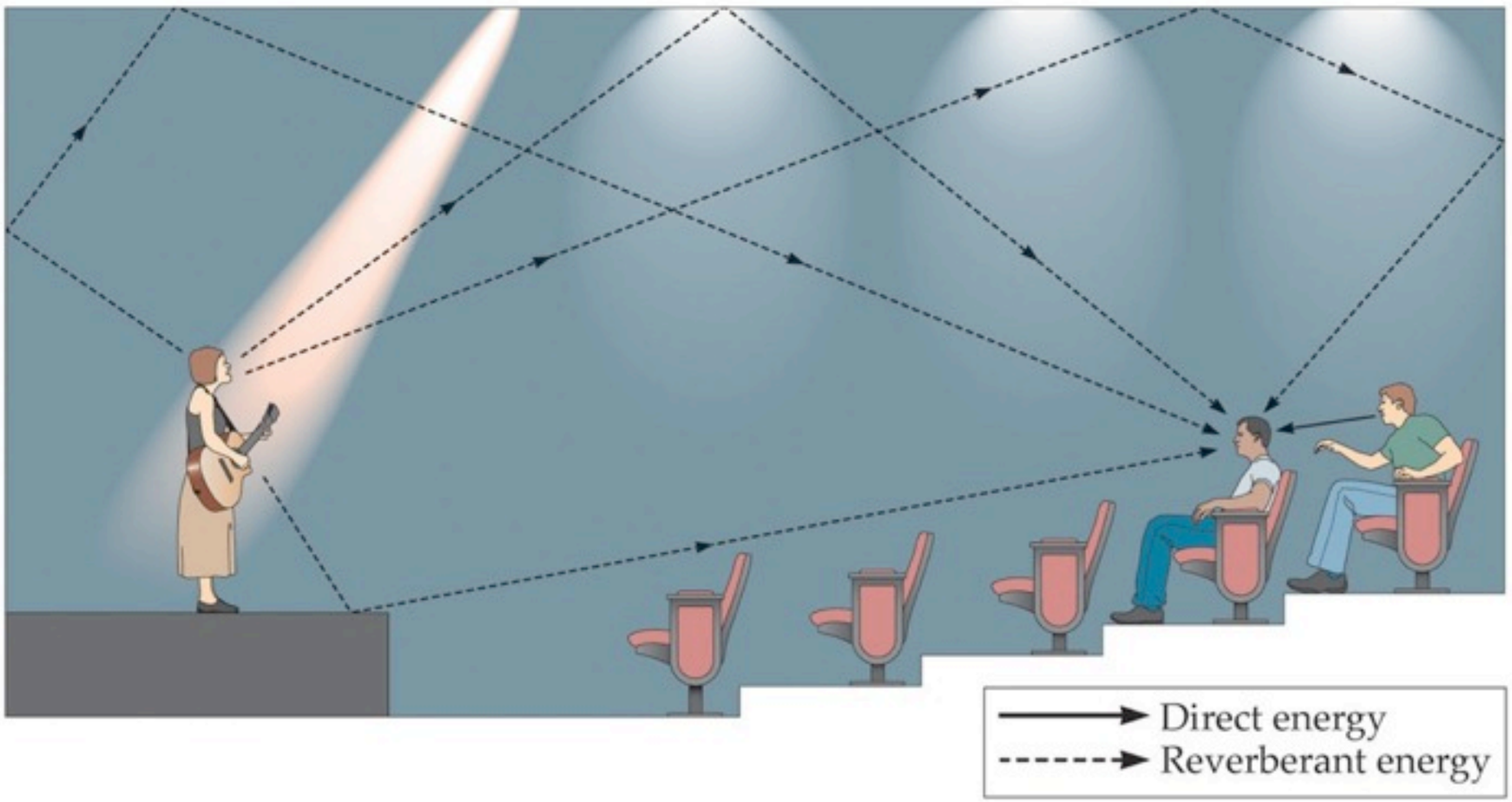
Figure by MIT OpenCourseWare.

Auditory distance perception

- Relative intensity
- Spectral composition

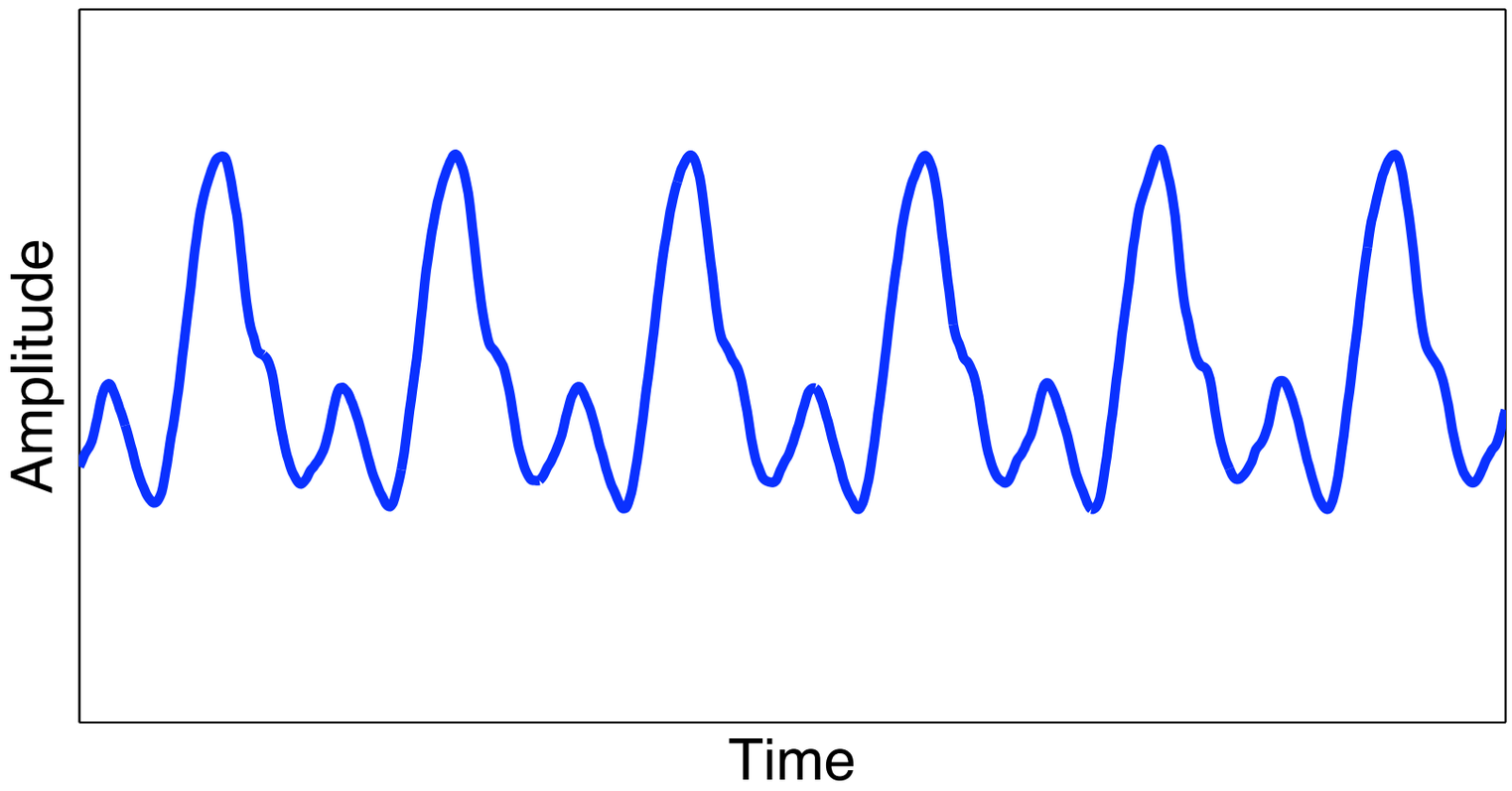
Auditory distance perception

- Relative intensity
- Spectral composition



Complex periodic sounds

- Pitch
- Timbre



Complex sounds: pitch

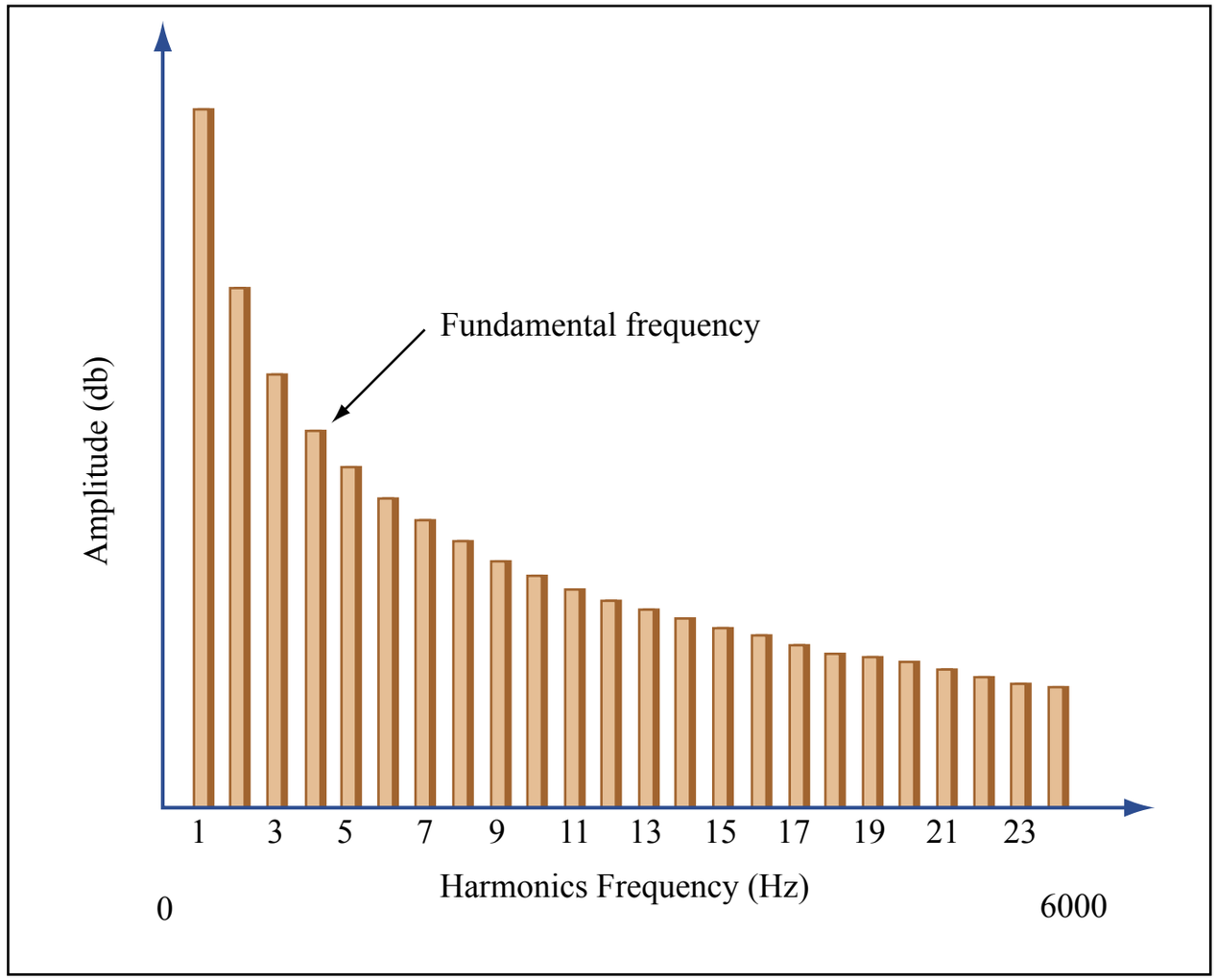


Figure by MIT OpenCourseWare.

Fundamental frequency

- Lowest harmonic usually perceived pitch
- Fundamental can be missing

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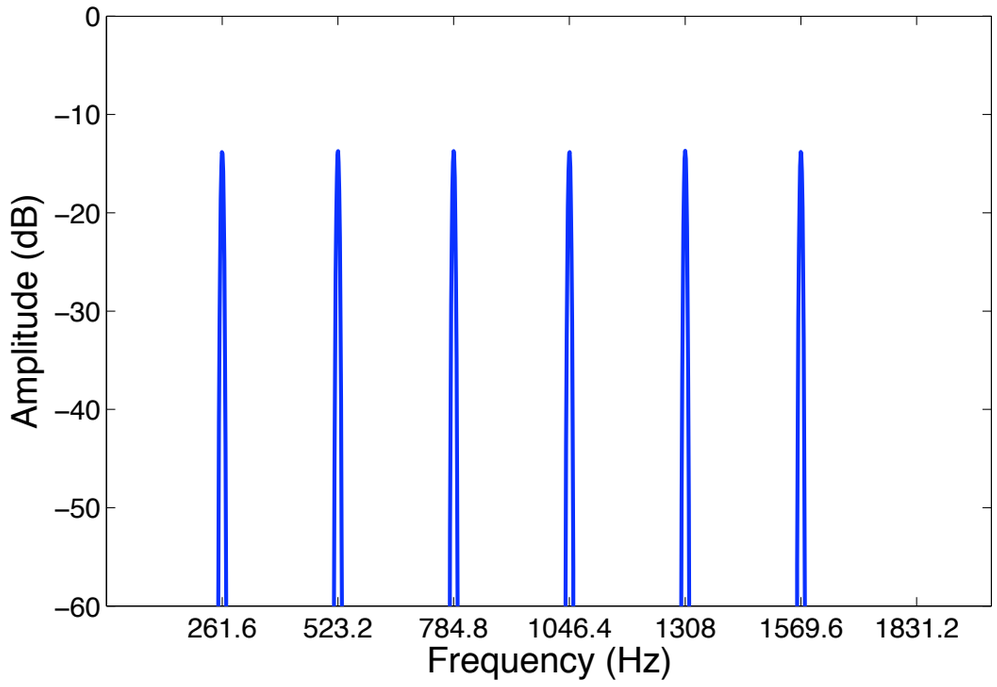

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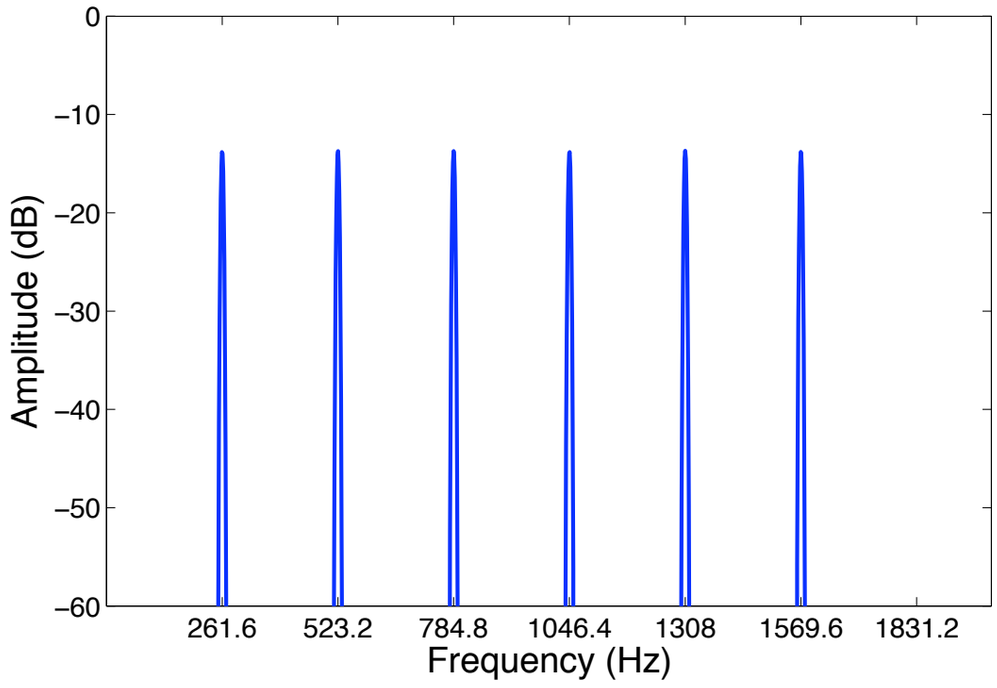
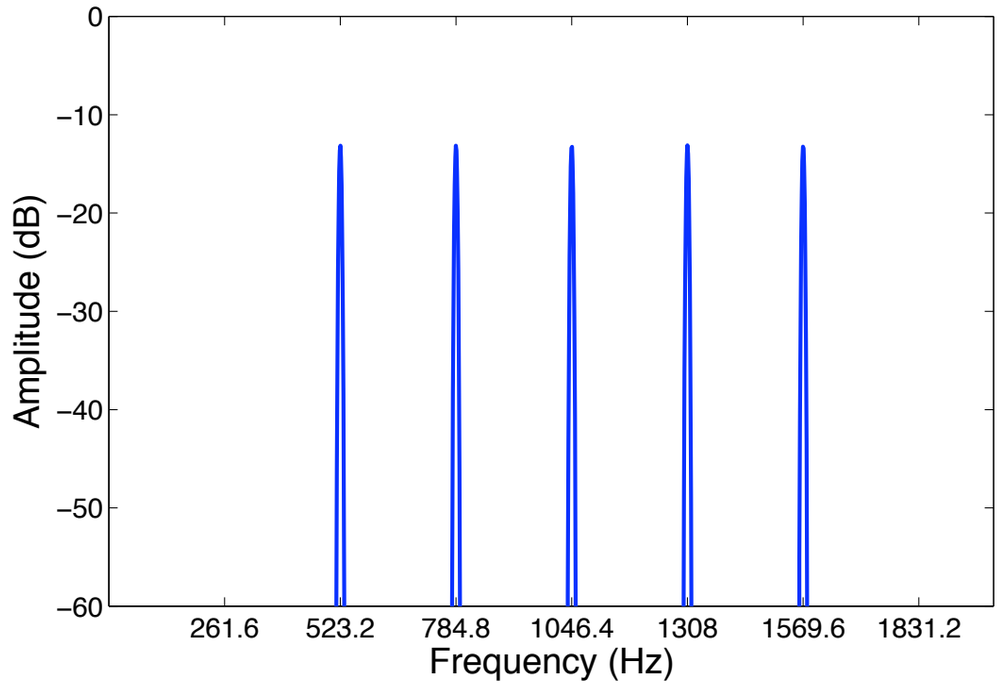




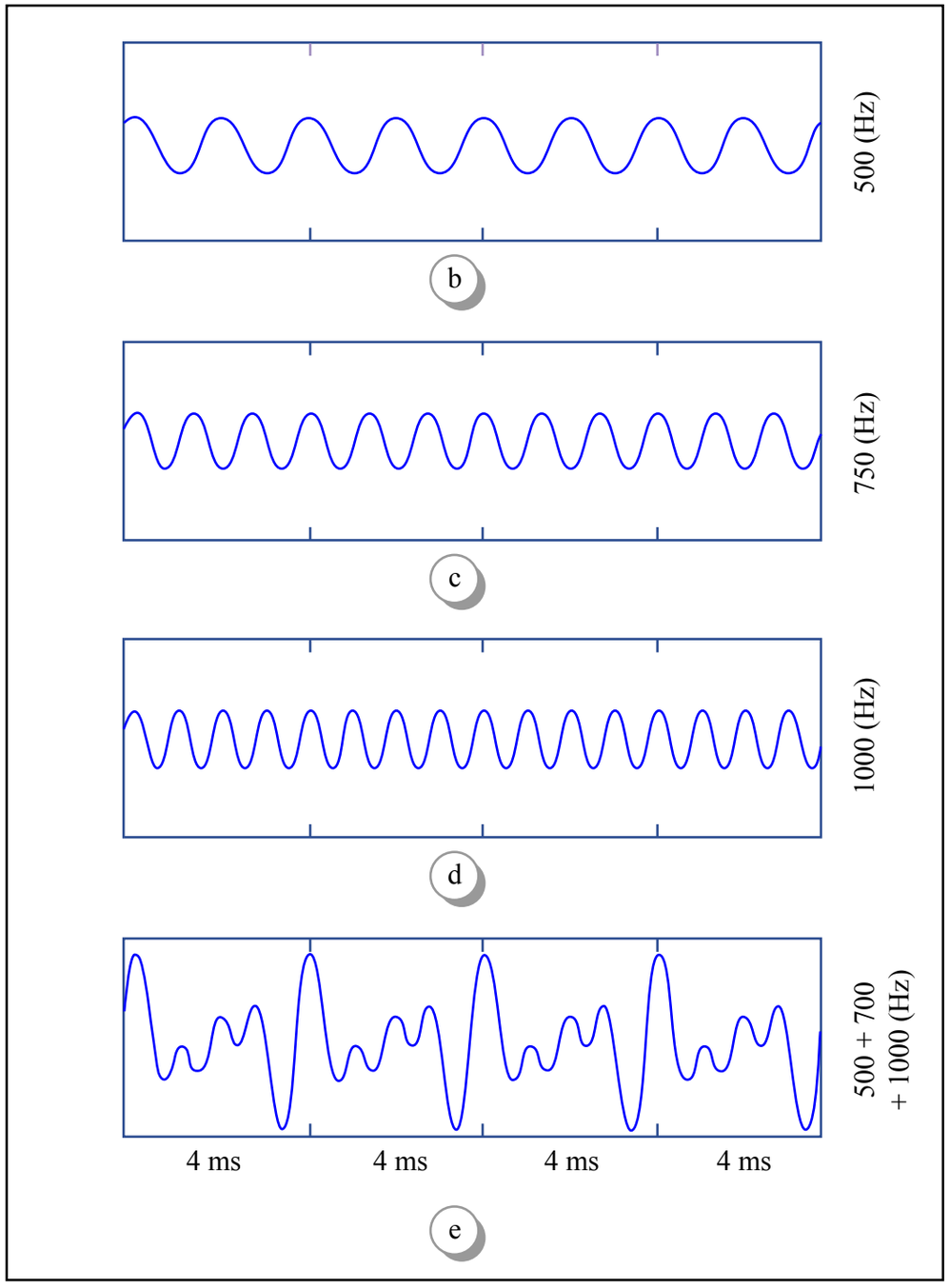
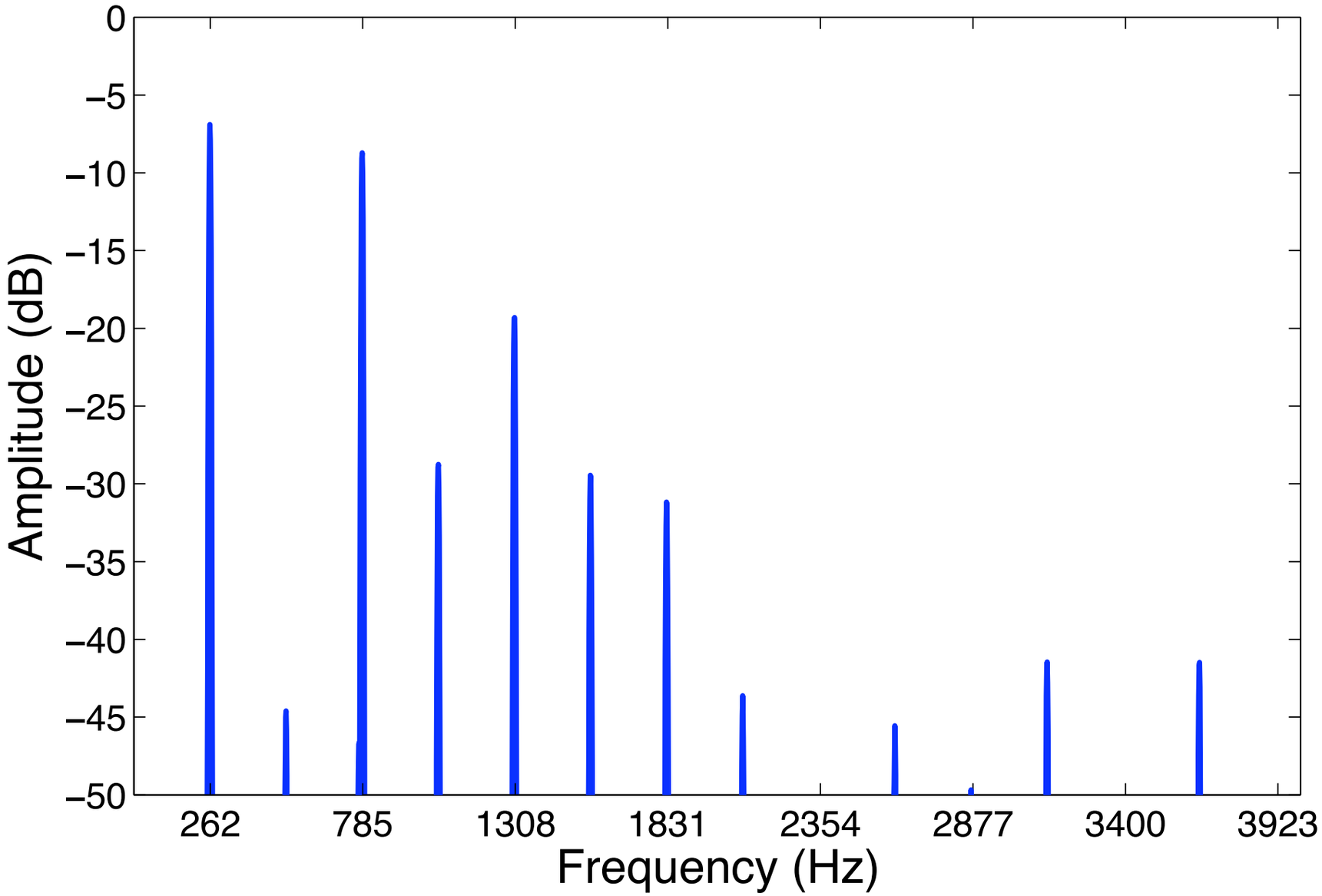


Figure by MIT OpenCourseWare.

Odd harmonics

- Clarinet
  - cylindrical bore, closed at one end



Pitch illusion

- Shepard tone

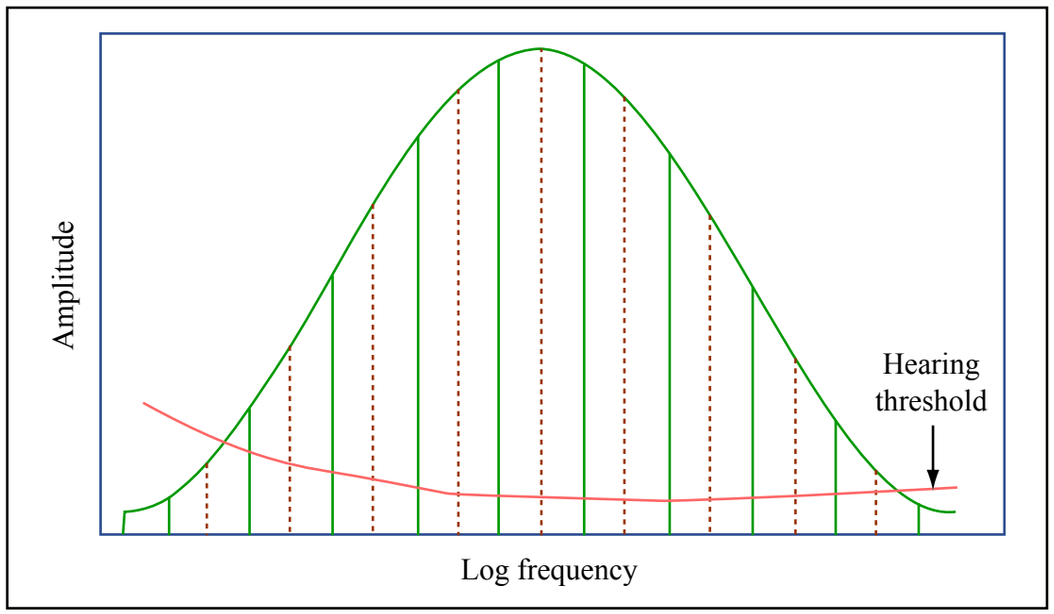
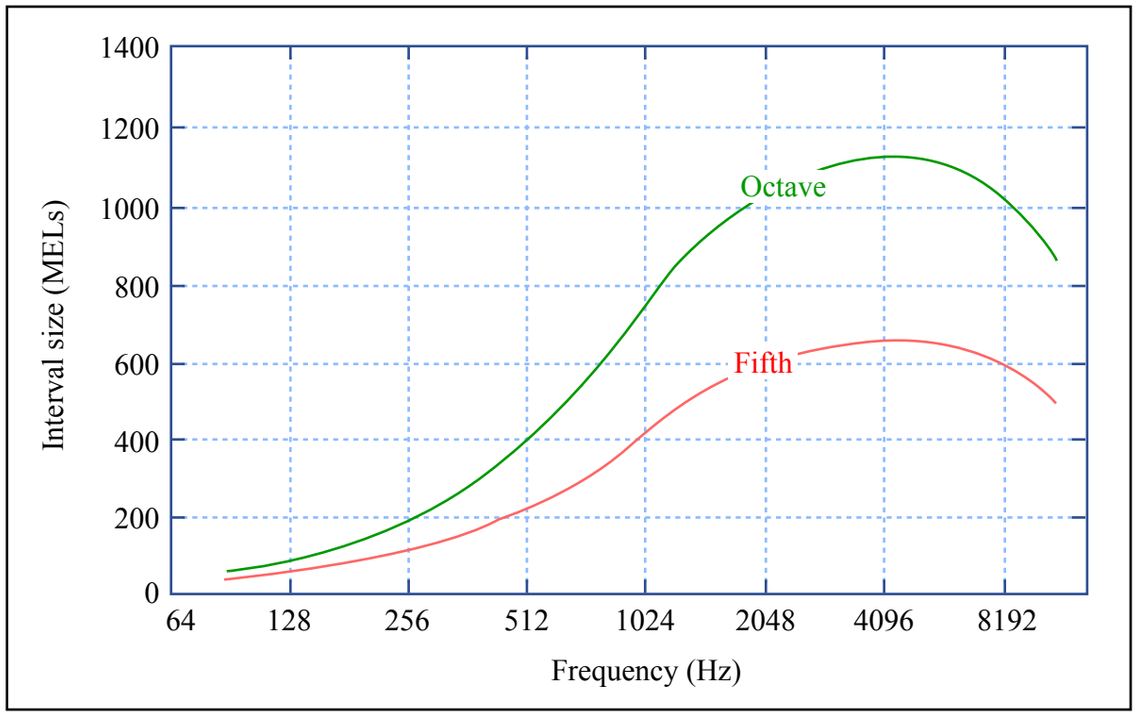


Figure by MIT OpenCourseWare.

from *Music, Cognition, and Computerized Sound*, ed. Perry Cook

Mel scale

- Stevens, Volkmann and Newman 1937
- Equal in distance



from *Music, Cognition, and Computerized Sound*, ed. Perry Cook

Pitch helix

- Drobish (1855)
- Shepard (1982)

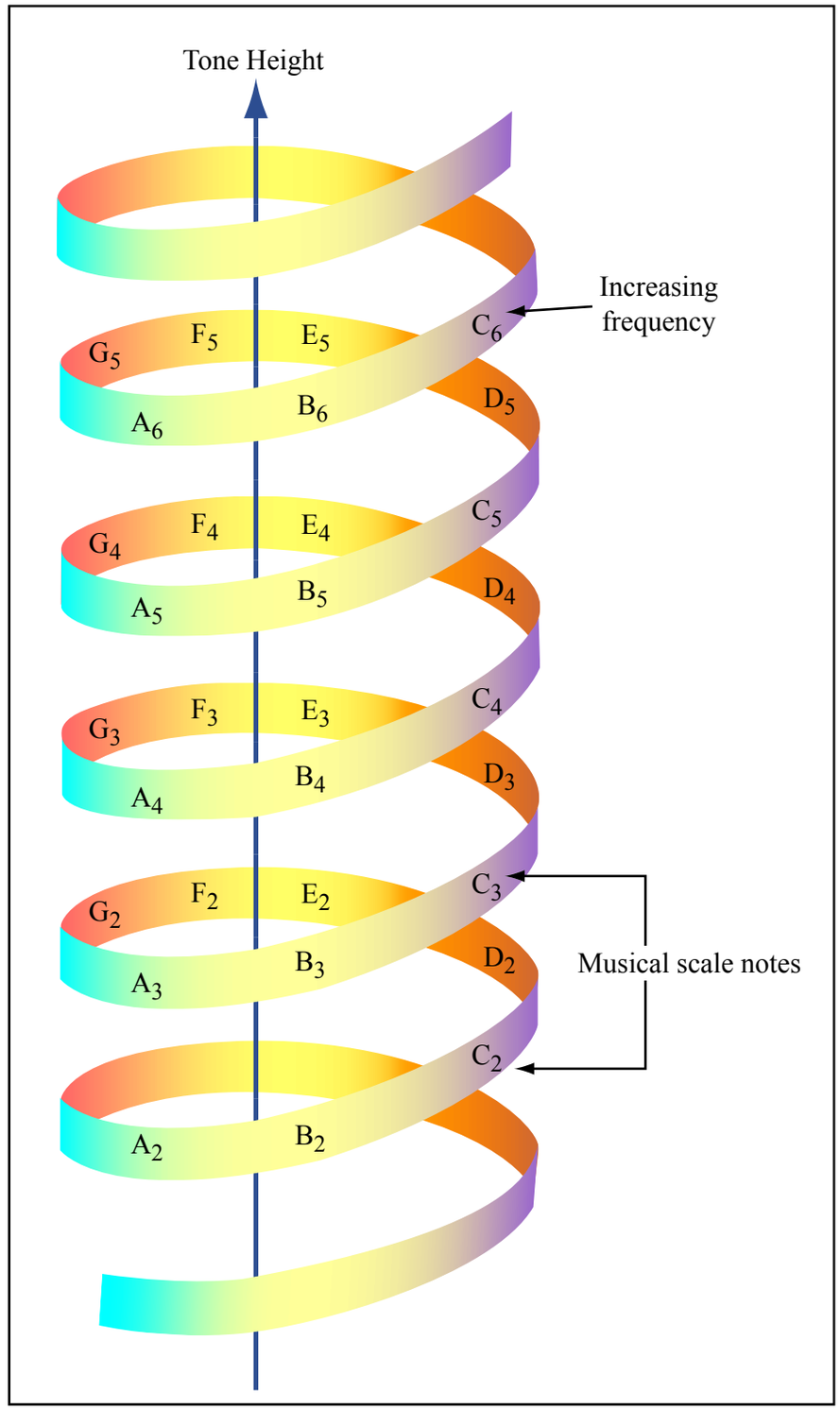


Figure by MIT OpenCourseWare.

Complex sounds: timbre

- Not well defined
- Overtones
- Formants
- Attack and decay
- Synchrony of microvariations

Harmonics fuse

- Energy in harmonics typically falls off
- Harmonics perceptible in unusual spectra

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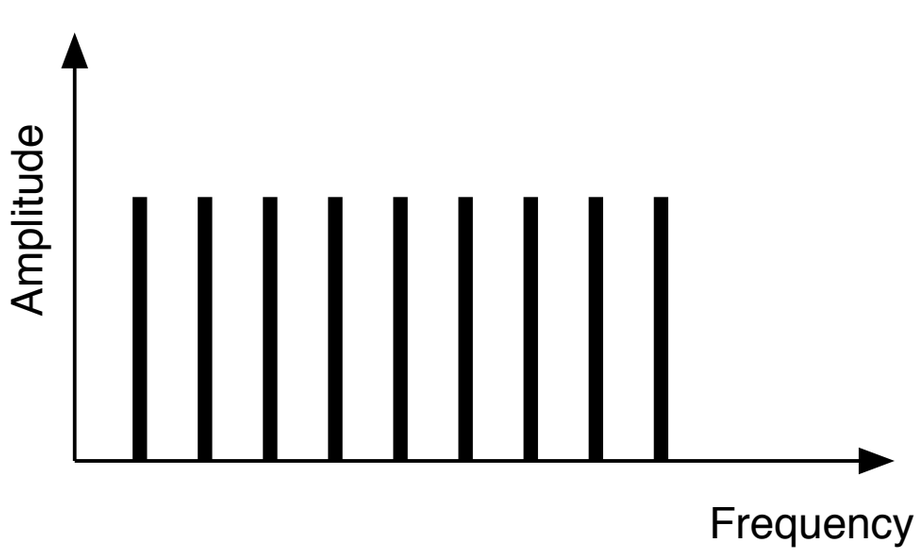

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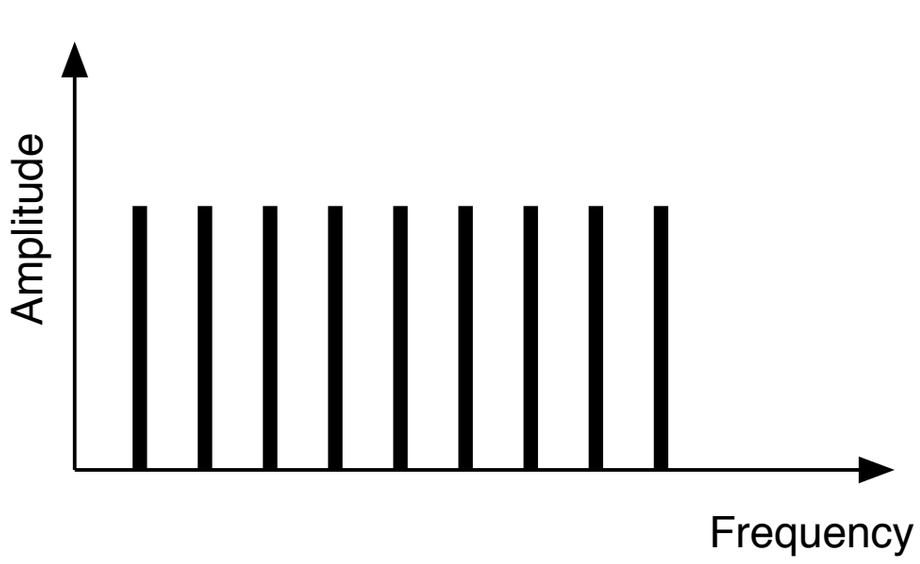

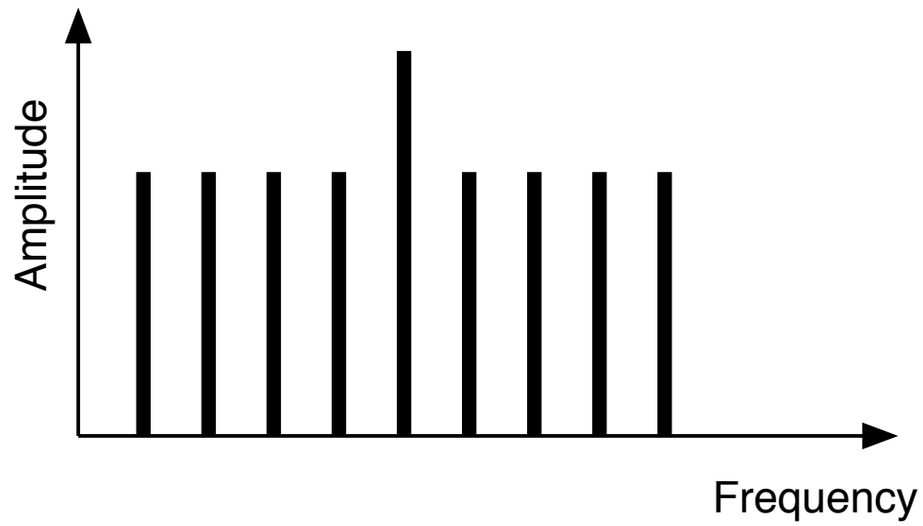

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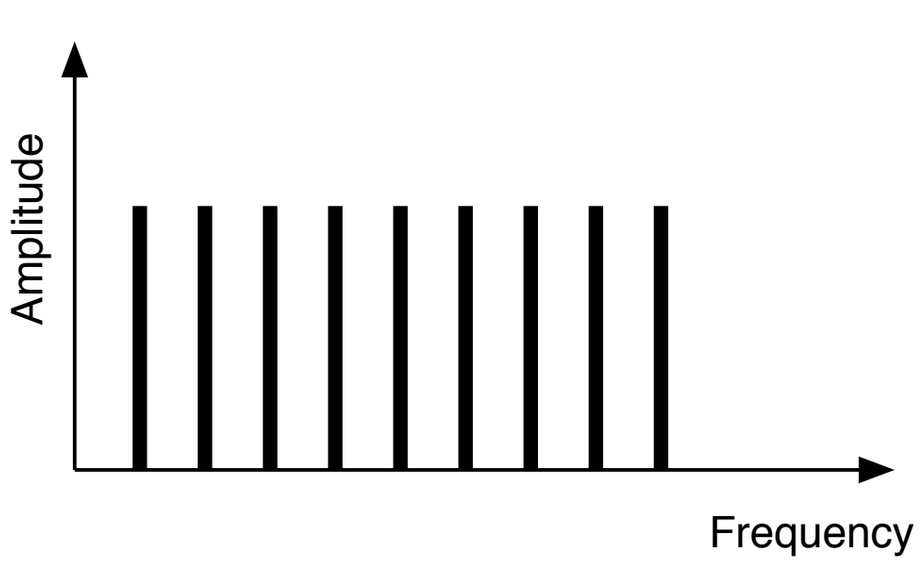

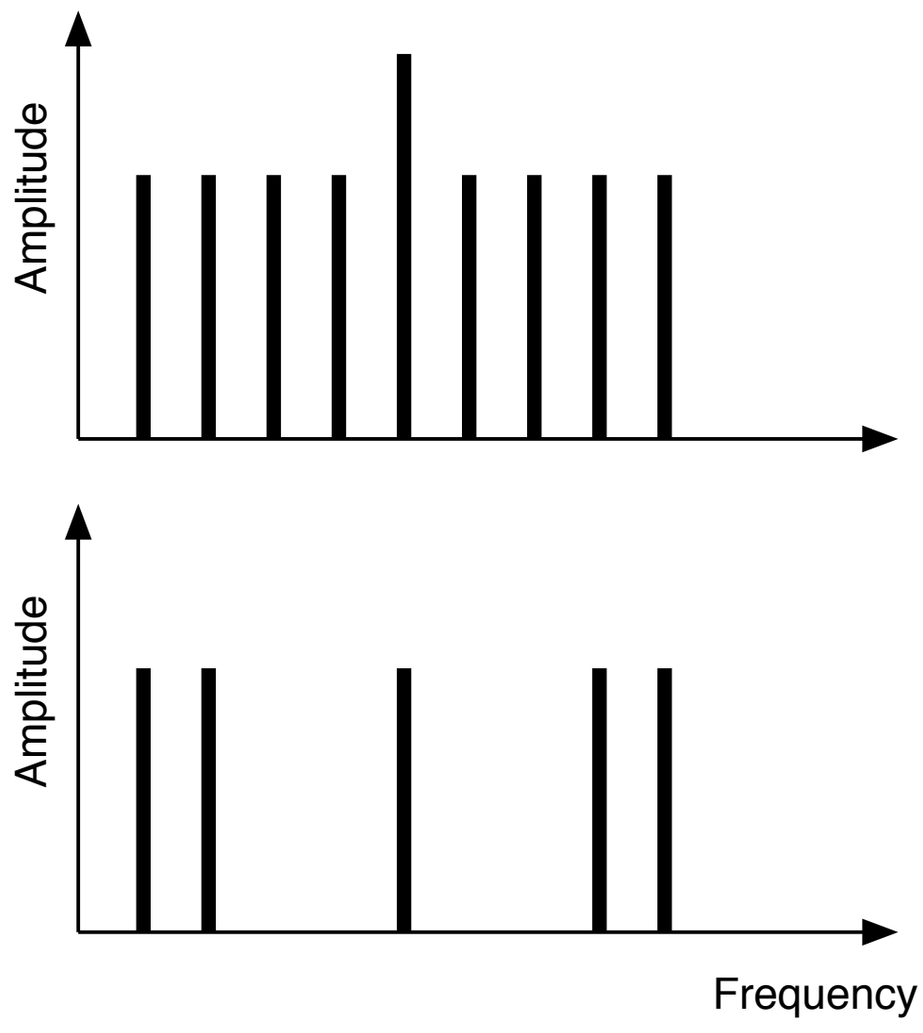

Throat Singing

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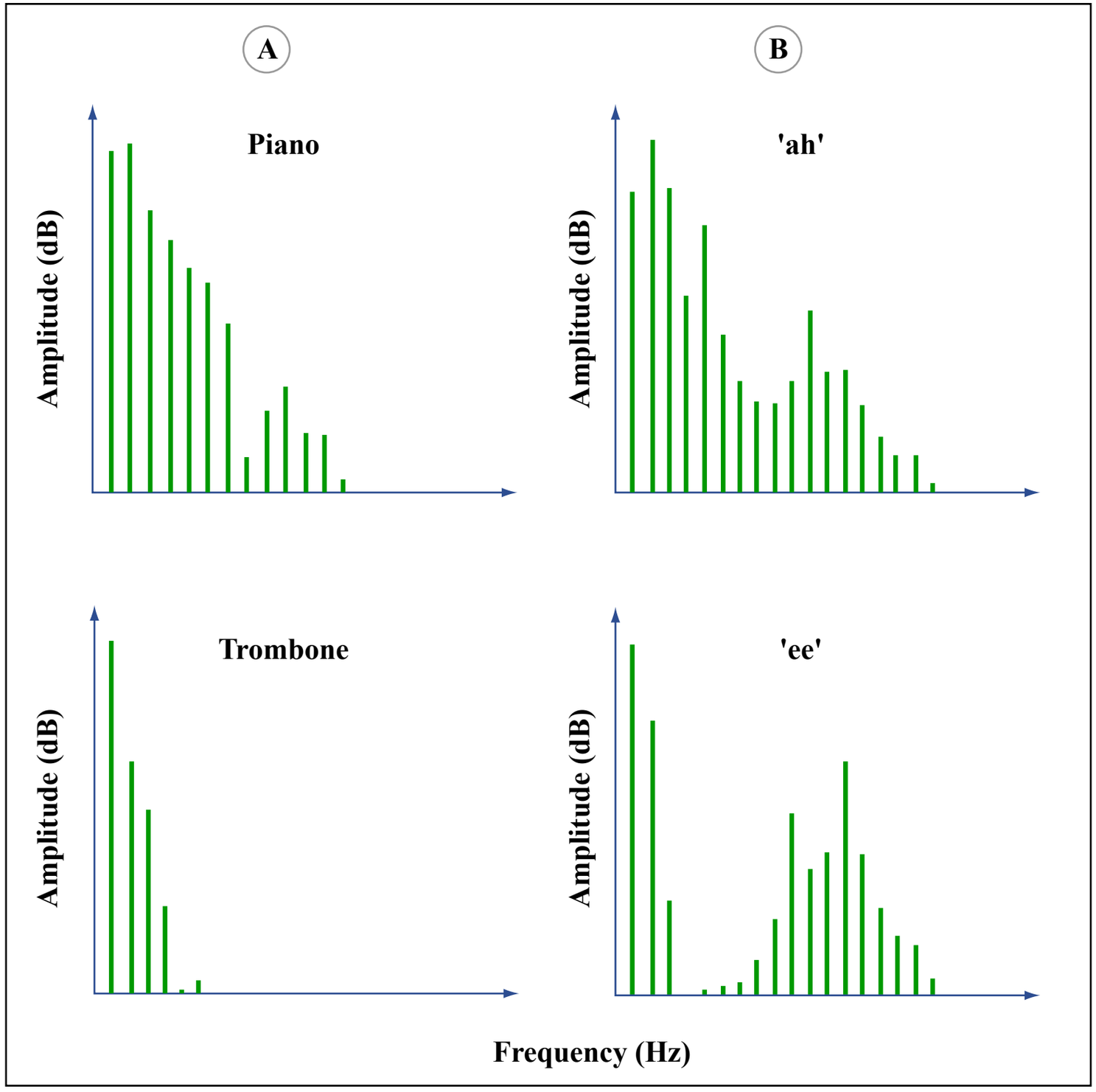
Formants

- Fixed resonances



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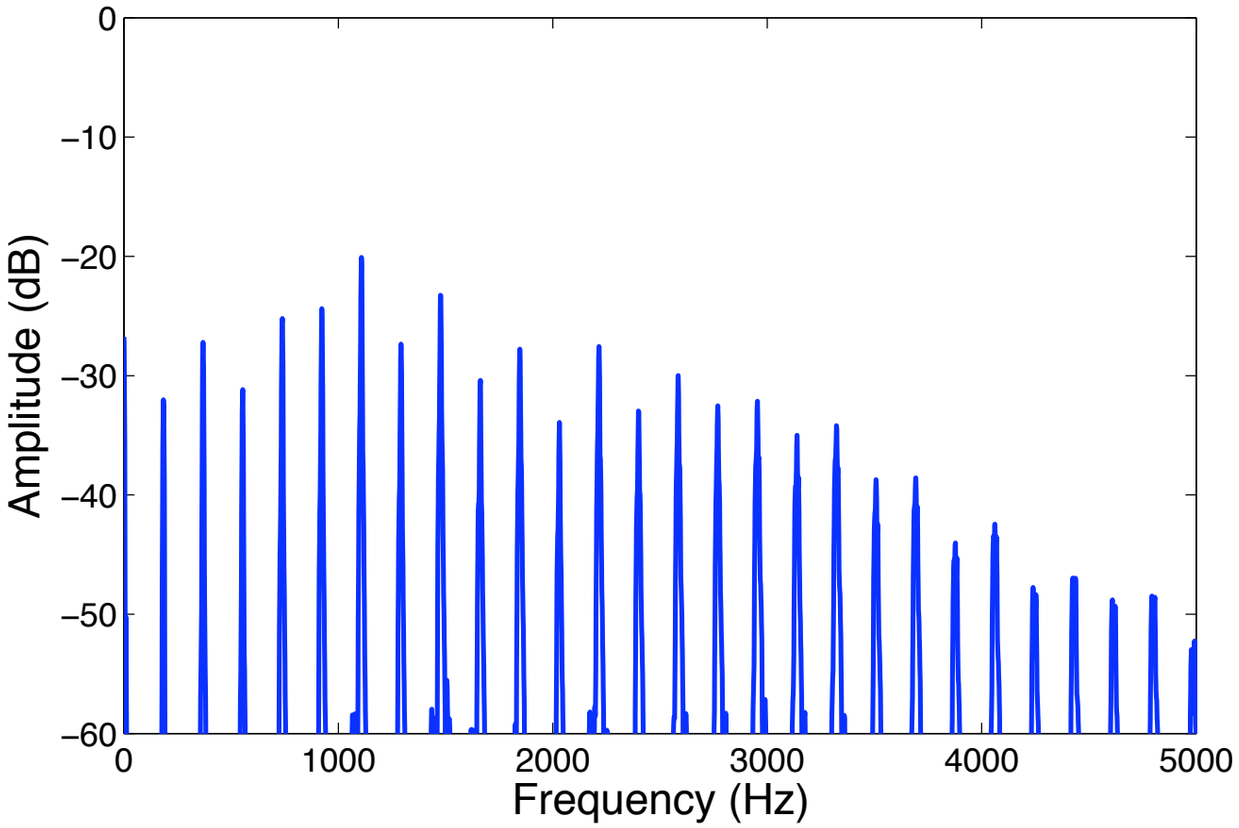
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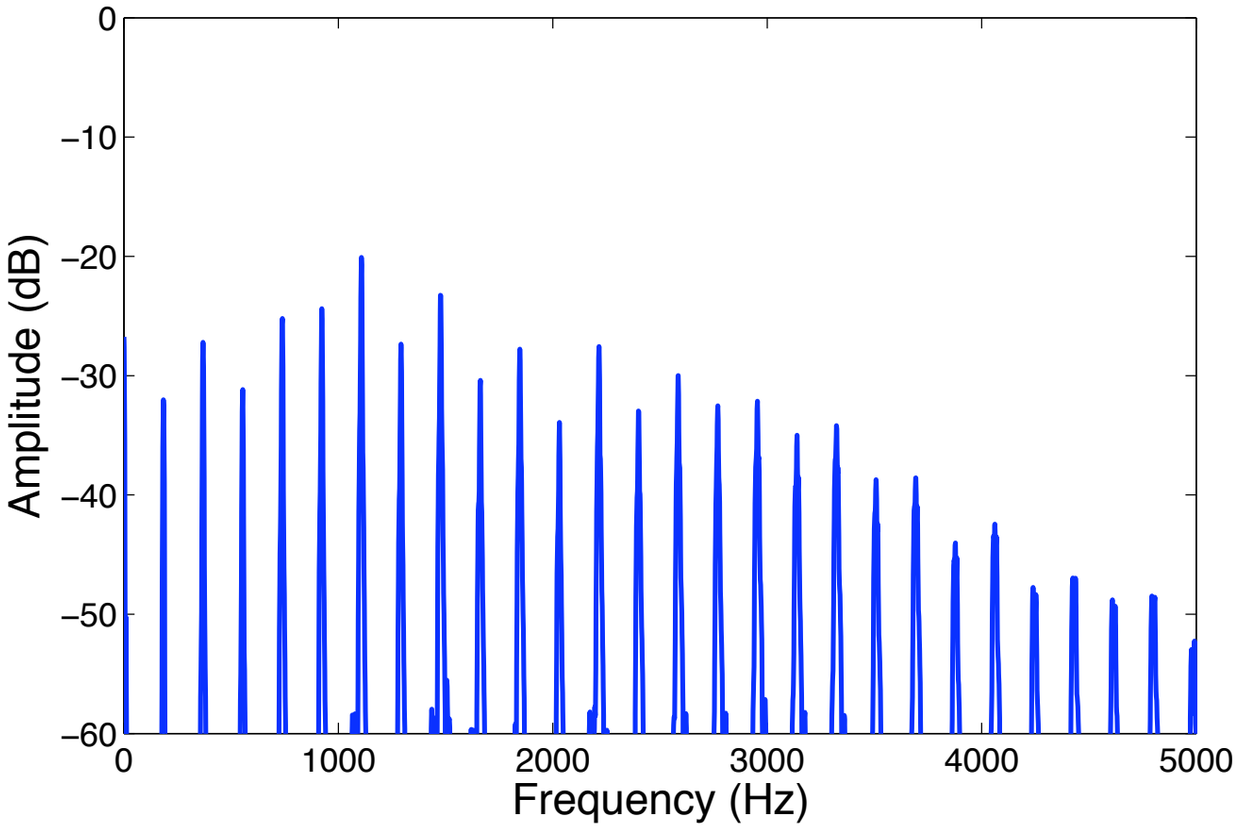
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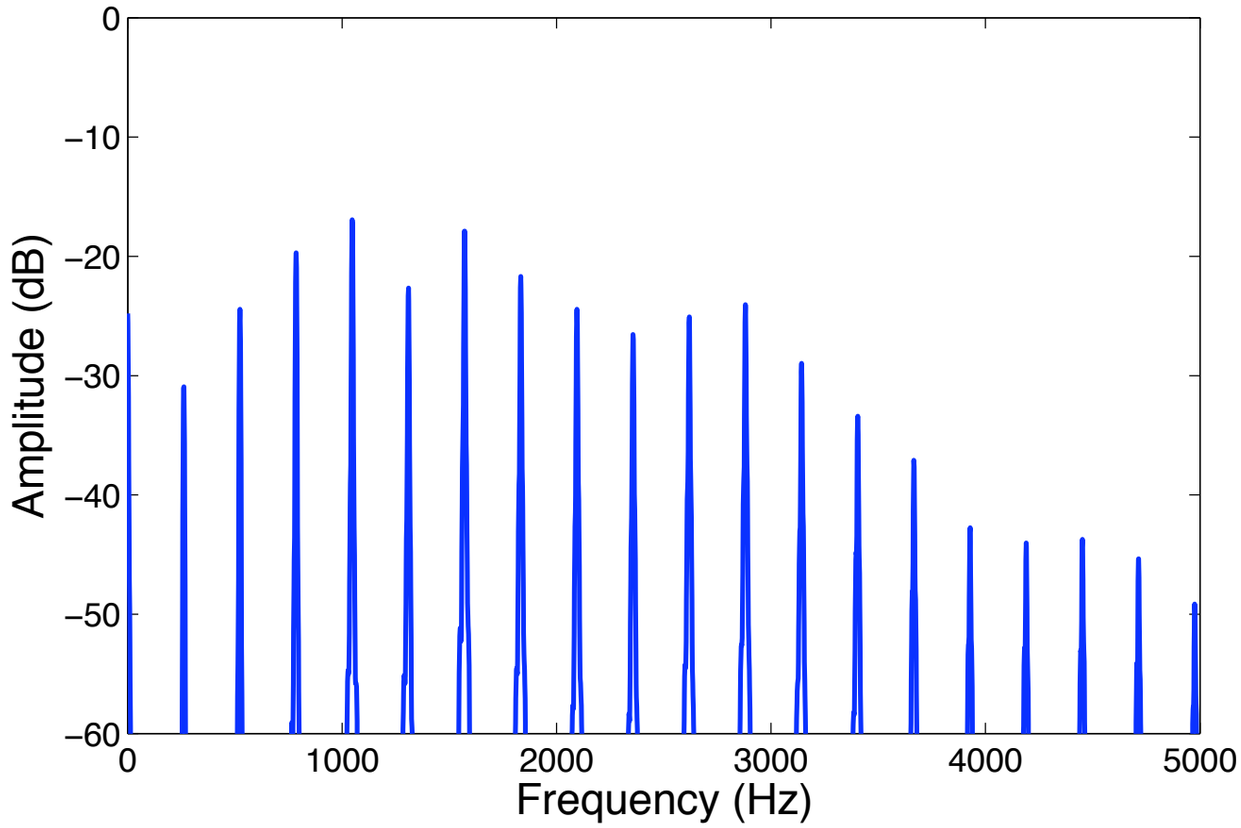
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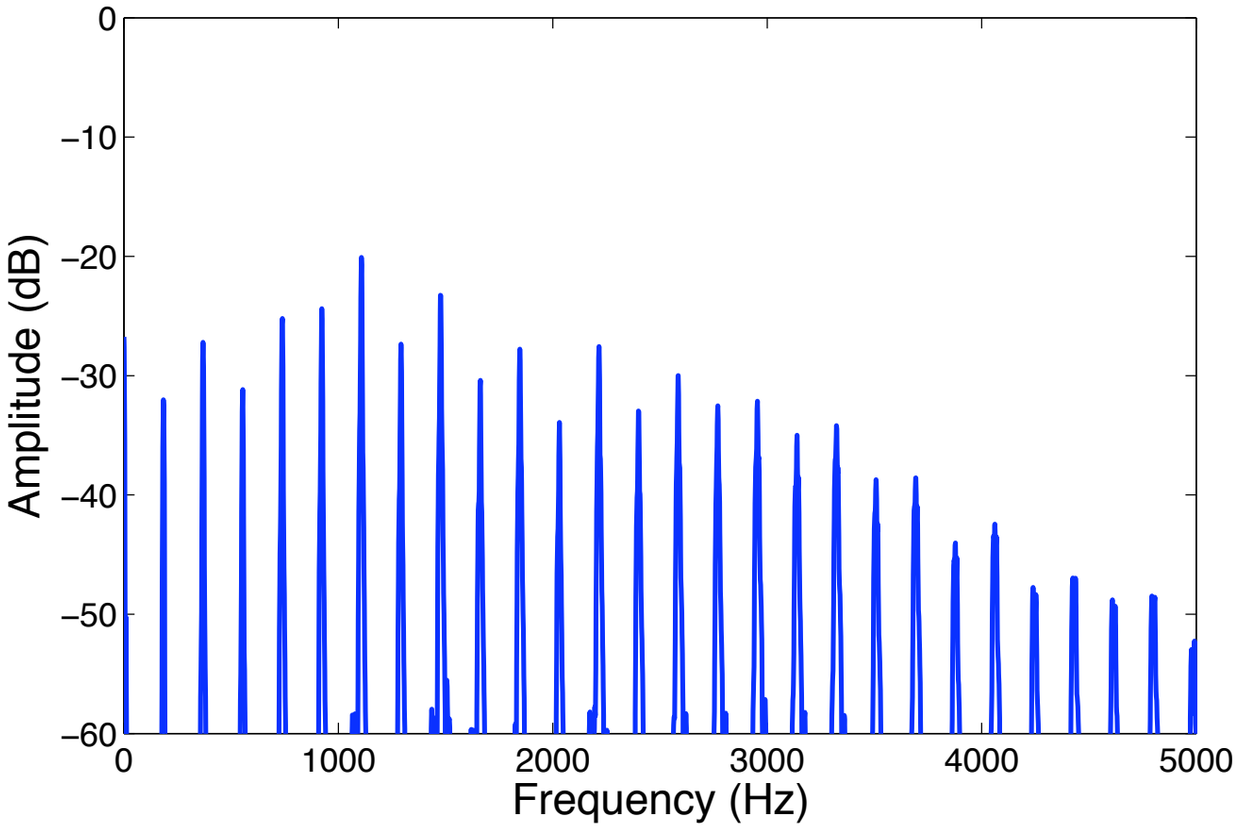
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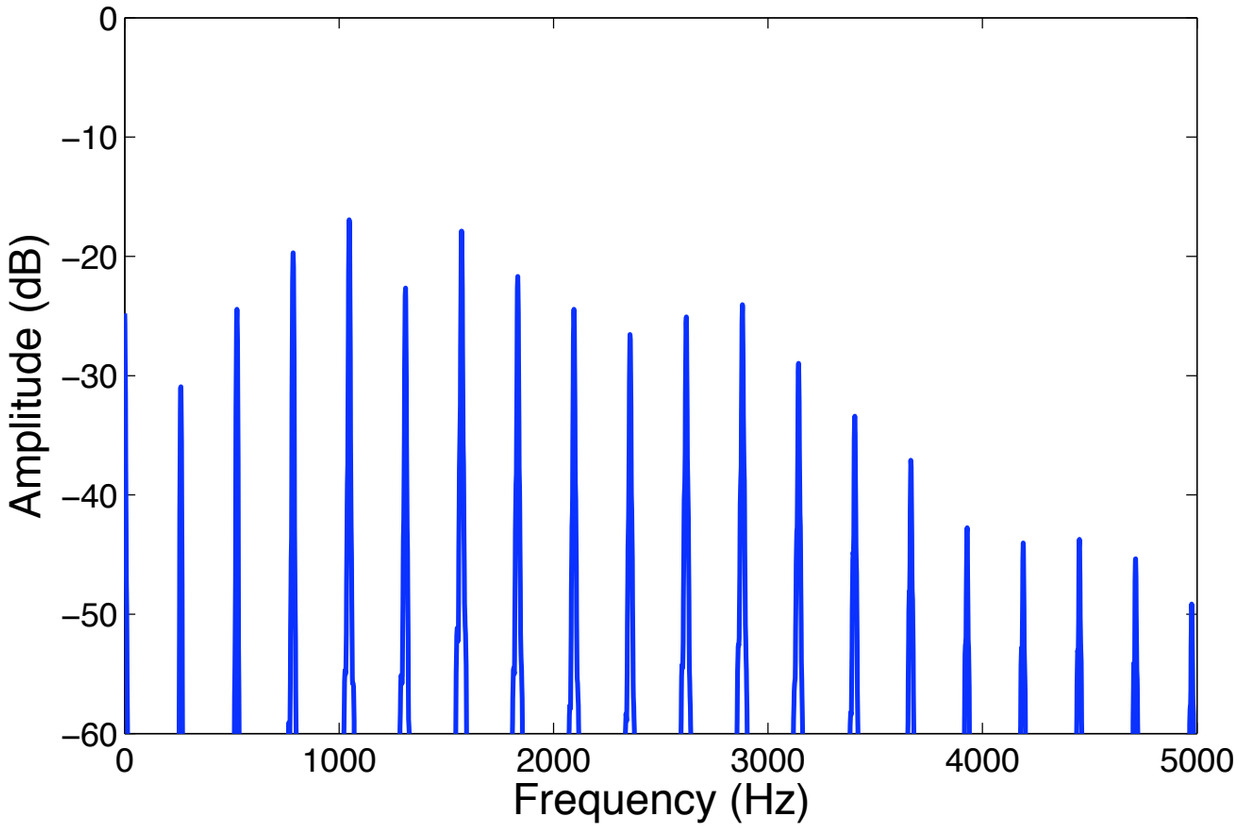
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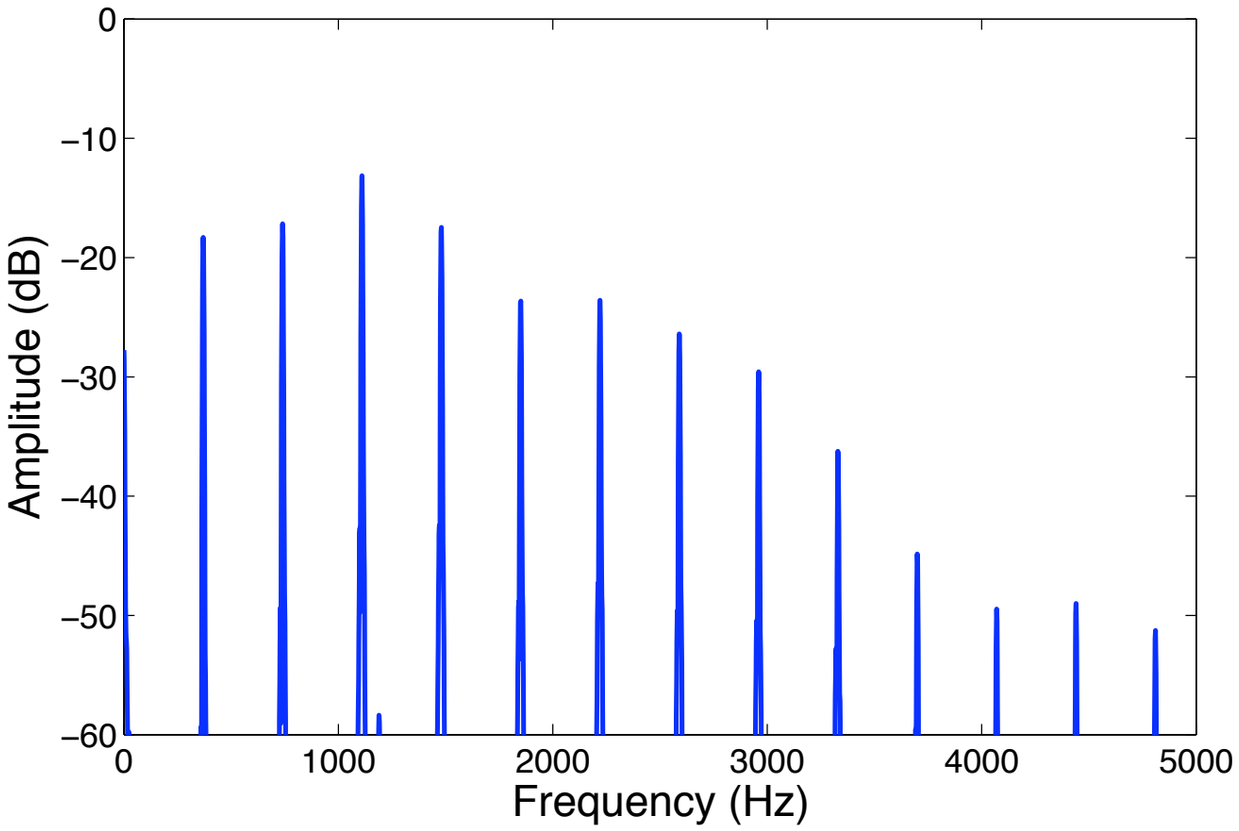
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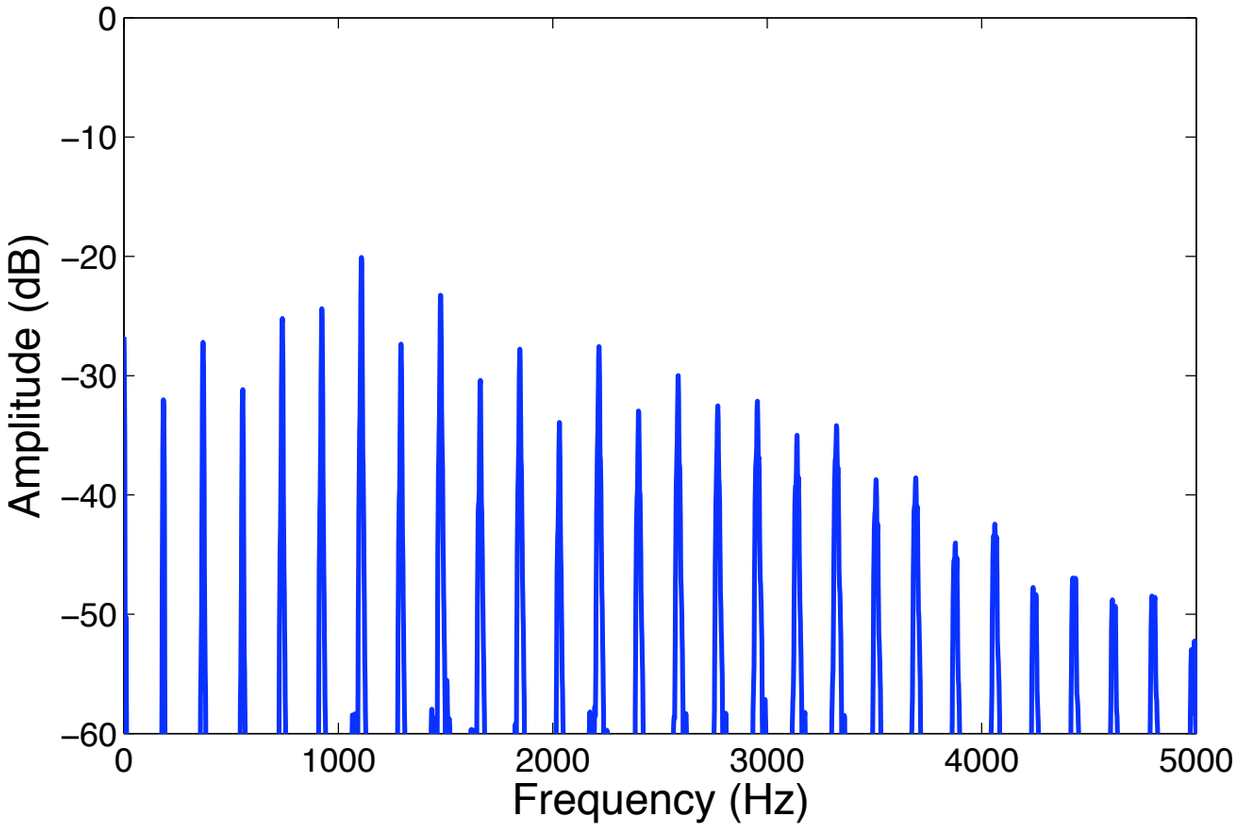
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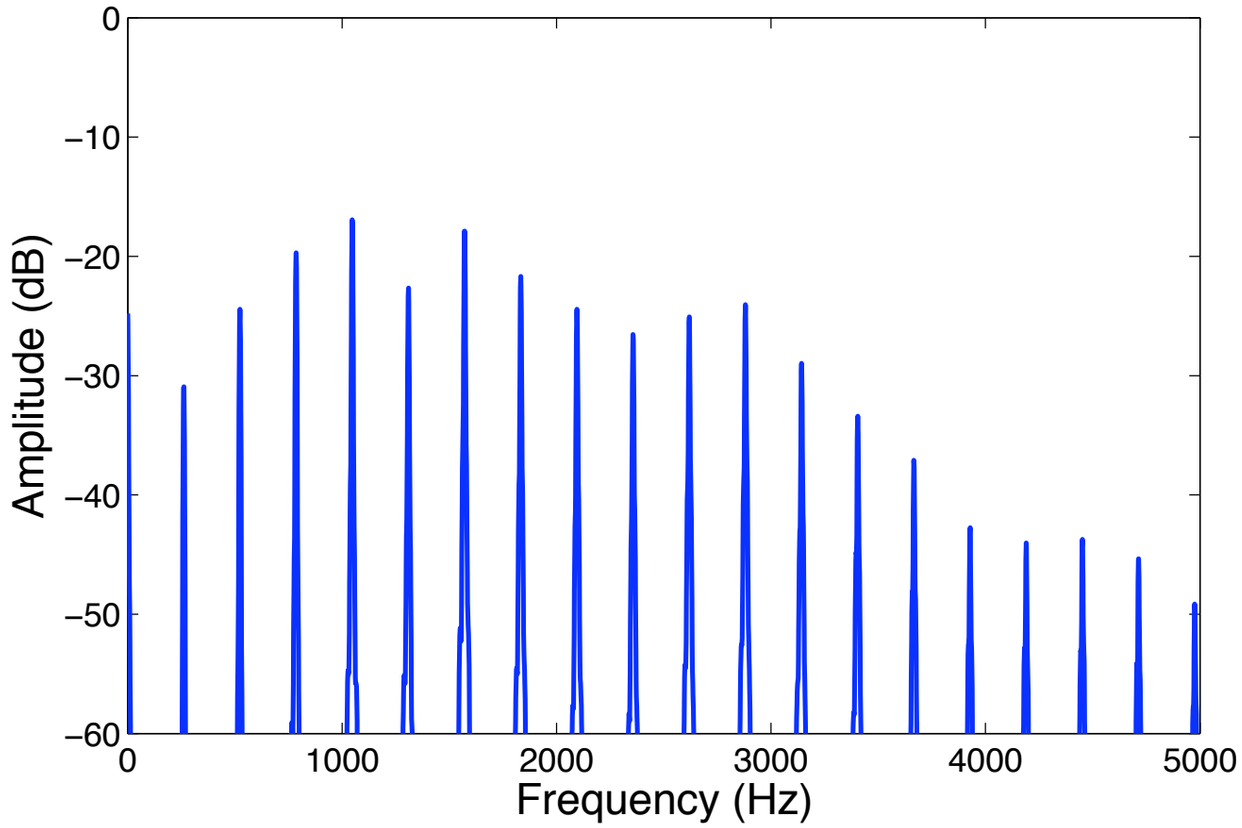
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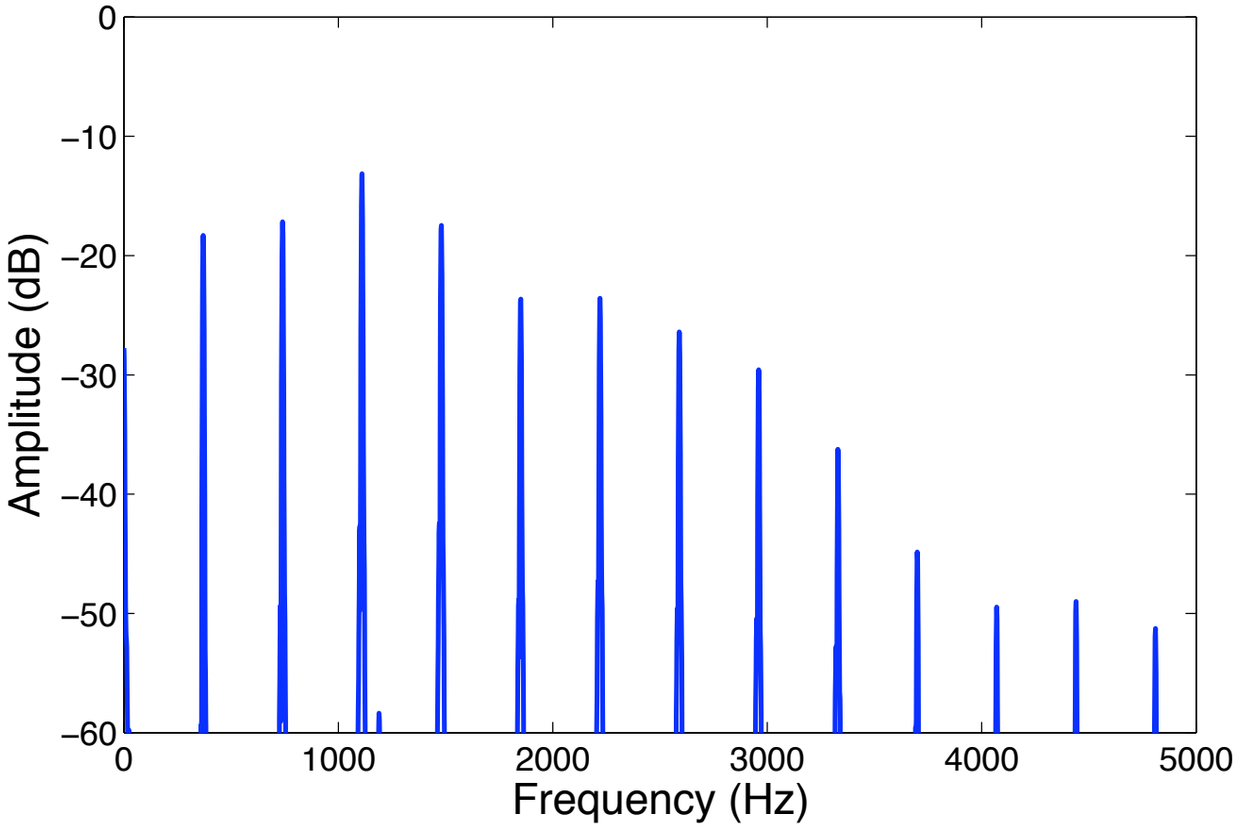
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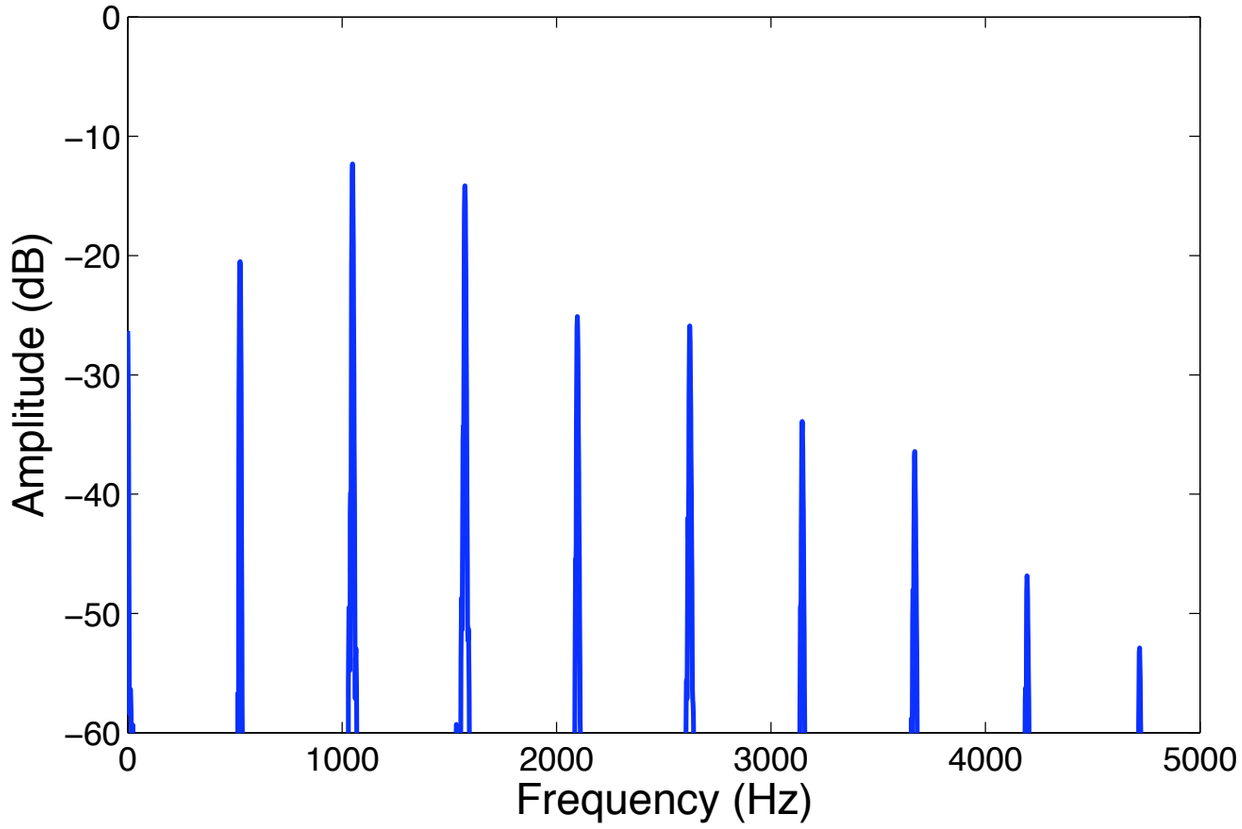
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Microvariations

- modulations of harmonics can affect fusion

Microvariations

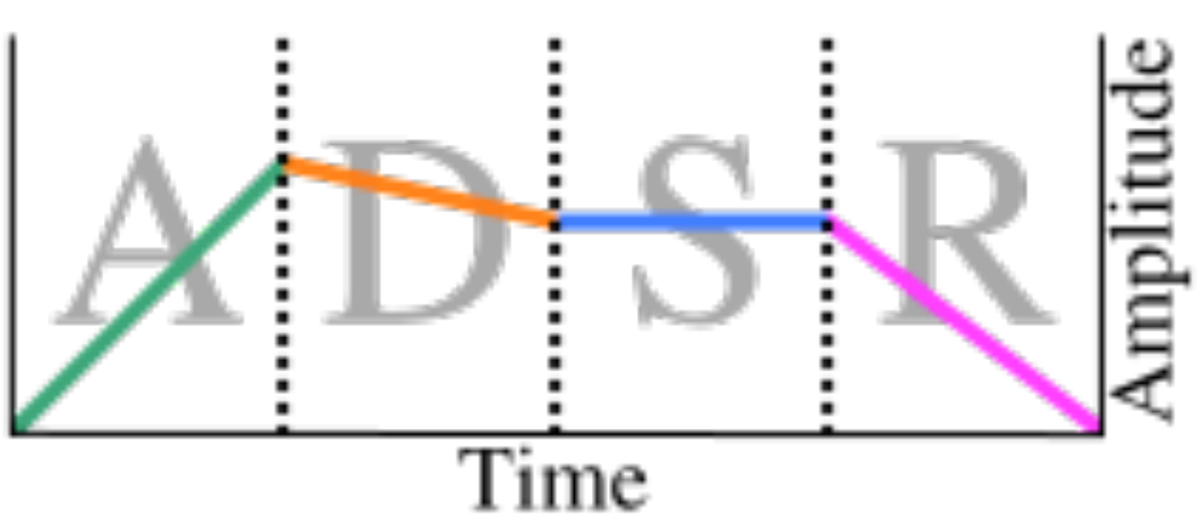
- modulations of harmonics can affect fusion

Example

from *Music, Cognition, and Computerized Sound*, ed. Perry Cook

Attacks and decays

- Basic transitions
  - attack, sustain, decay, release (ADSR)



http://en.wikipedia.org/wiki/ADSR_envelope

Instrument quiz

bassoon,
clarinet,
horn,
oboe,
piano,
sax,
synth,
trumpet

Instrument quiz

bassoon,
clarinet,
horn,
oboe,
piano,
sax,
synth,
trumpet

Instrument 1

Instrument quiz

bassoon,
clarinet,
horn,
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Instrument 1

Instrument 2

Instrument quiz

bassoon,
clarinet,
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piano,
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synth,
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Instrument 1

Instrument 2

Instrument 3

Instrument quiz

bassoon,
clarinet,
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sax,
synth,
trumpet

Instrument 1

Instrument 2

Instrument 3

Instrument 4

Instrument quiz 2

bassoon,
clarinet,
horn,
oboe,
piano,
sax,
synth,
trumpet

Instrument quiz 2

bassoon,
clarinet,
horn,
oboe,
piano,
sax,
synth,
trumpet

Instrument 1

Instrument quiz 2

bassoon,
clarinet,
horn,
oboe,
piano,
sax,
synth,
trumpet

Instrument 1

Instrument 2

Instrument quiz 2

bassoon,
clarinet,
horn,
oboe,
piano,
sax,
synth,
trumpet

Instrument 1

Instrument 2

Instrument 3

Instrument quiz 2

bassoon,
clarinet,
horn,
oboe,
piano,
sax,
synth,
trumpet

Instrument 1

Instrument 2

Instrument 3

Instrument 4

Attacks

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