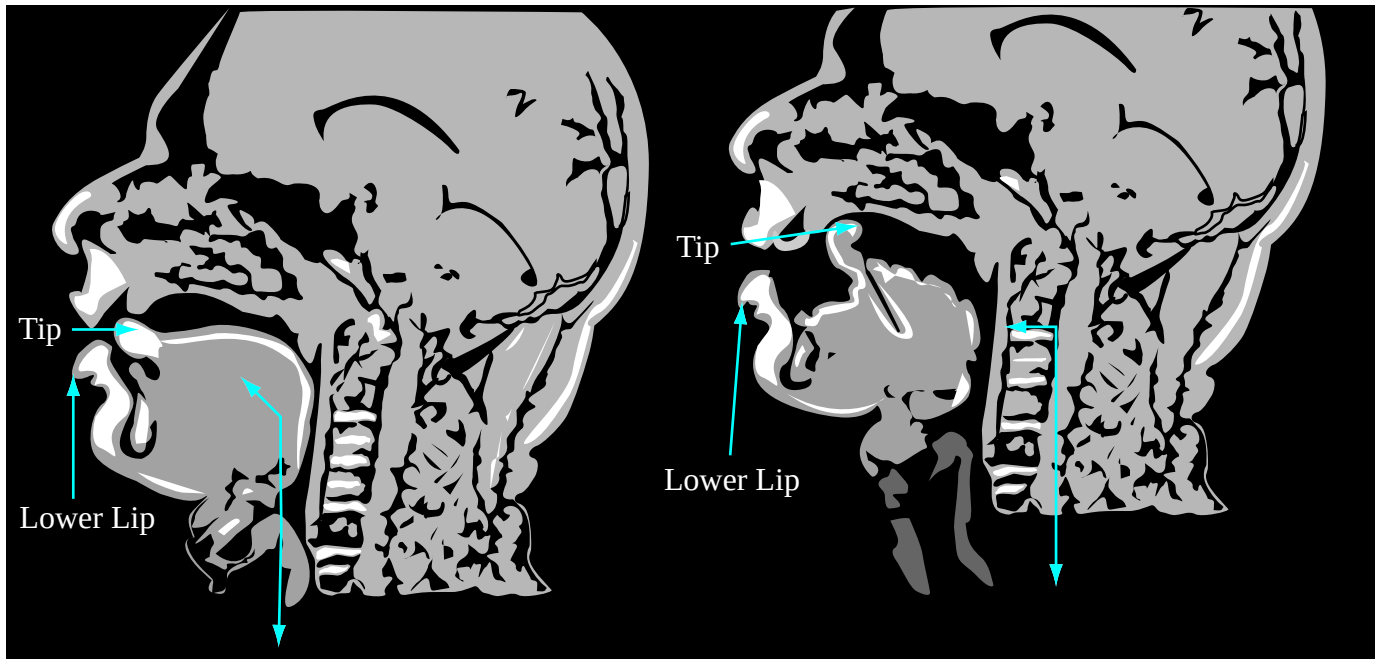
24.963 Linguistic Phonetics
Fall 2005

# 24.963
# Linguistic Phonetics

# The phonetics and phonology of retroflex consonants

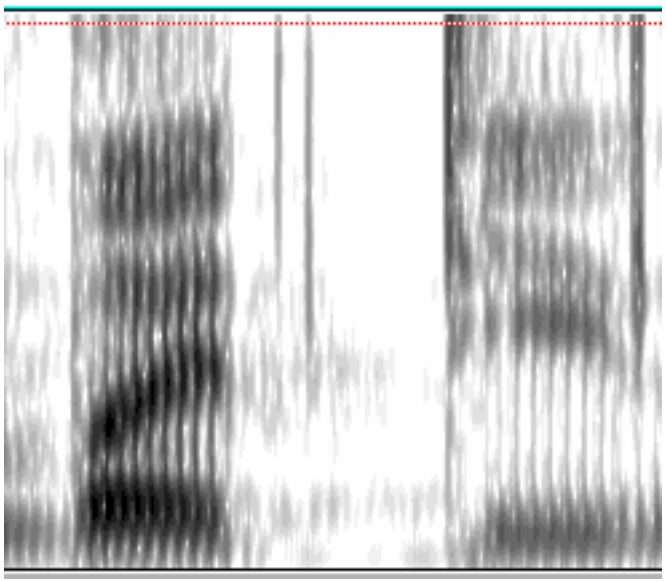



dental [l̪] retroflex [ɭ]

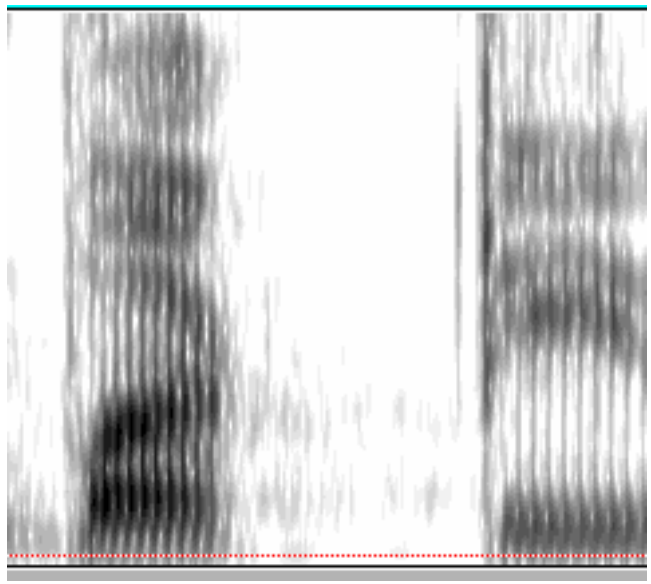
MRI images of Tamil laterals (Narayanan et al 1999)

Figure by MIT OpenCourseWare, adapted from Narayanan, Shrikanth, Dani Byrd, and Abigail Kaun.
"Geometry, Kinematics, and Acoustics of Tamil Liquid Consonants." *The Journal of the Acoustical Society of America* 106, no. 4 (October 1999): 1993-2007.

# The phonetics and phonology of retroflex consonants



apical alveolar [t]



retroflex [ʈ]

Malayalam

# Distribution of retroflexion contrasts in Gooniyandi (Steriade 1995)

Intervocalic: **contrast**

| | **apico-alveolar** | **retroflex** |
|---|---|---|
| oral stops | **ɟutu** 'straight' | **ɟuɖu** 'GLOSS' |
| nasals | **maniŋa** 'night time' | **maɳiŋga** 'sister' |
| laterals | **wila** 'ok, finish' | **wiɭa** 'back' |
| rhotics | **ɟari** 'if' | **ɟaːɽi** 'dry roots' |

Word final, post V apicals: **contrast**

| apico-alveolar | retroflex |
|---|---|
| **jawan** (subsection term) | **jilŋiɳ** 'dew' |

# Distribution of retroflexion contrasts in Gooniyandi

Preconsonantal, post V apicals: **contrast**

| | apico-alveolar | retroflex |
|---|---|---|
| oral stops | **dʃ** | **ɖb, ɖg** |
| nasals | **nʃ, ng, nɲ** | **ɳʃ, ɳg, ɳm, ɳɲ** |
| laterals | **lb, lʃ, lg, lm, lɲ, lw** | **ɭb, ɭj, ɭg, ɭm, ɭɲ, ɭw** |

e.g.: **ɟunɟunanaɟgu** 'pardalote' vs. **gambunɟuwa** (toponym)
**balŋaŋa** 'outside' vs. **wanbiŋa** 'I'll go'

Word-initial: **no contrast** (free variation):
**ʈu:wu: ~ tu:wu** 'cave'
**ŋɑ:gʌ ~ nɑ:gʌ** 'dress'

Postconsonantal: **no contrast**
Apical clusters: **nd, ɳɖ, ld, ɳɭ**
e.g.: **banɖi** 'spider' vs. **jambiyindi** (subsection name)
**banɭundi** 'I returned'

# Distribution of retroflexion contrasts in Gooniyandi

Summary:

- Contrast between retroflex and apical alveolar after vowels V_#, V_V
- No contrast elsewhere #_, V_C

- This pattern of distribution is common in Australian and Dravidian languages.
- An unusual pattern of distribution - major place contrasts, voicing contrasts occur preferentially before vowels.

# Distribution of retroflexion contrasts

Explanation (Steriade 1995, etc):

- The primary cues to the contrast between retroflex and apical alveolar are located in the VC transitions (unlike major place contrasts.
  - Most retroflex consonants are retroflexed at closure, but the tongue tip moves forward during closure.
  - At release tongue tip position is similar to an apical alveolar, consequently the release and CV transitions of the two consonant types are similar.
- Contrasts preferentially appear in environments where they are better cued.

# Warlpiri [ʈ] from onset of closure to post-release: Butcher 1993

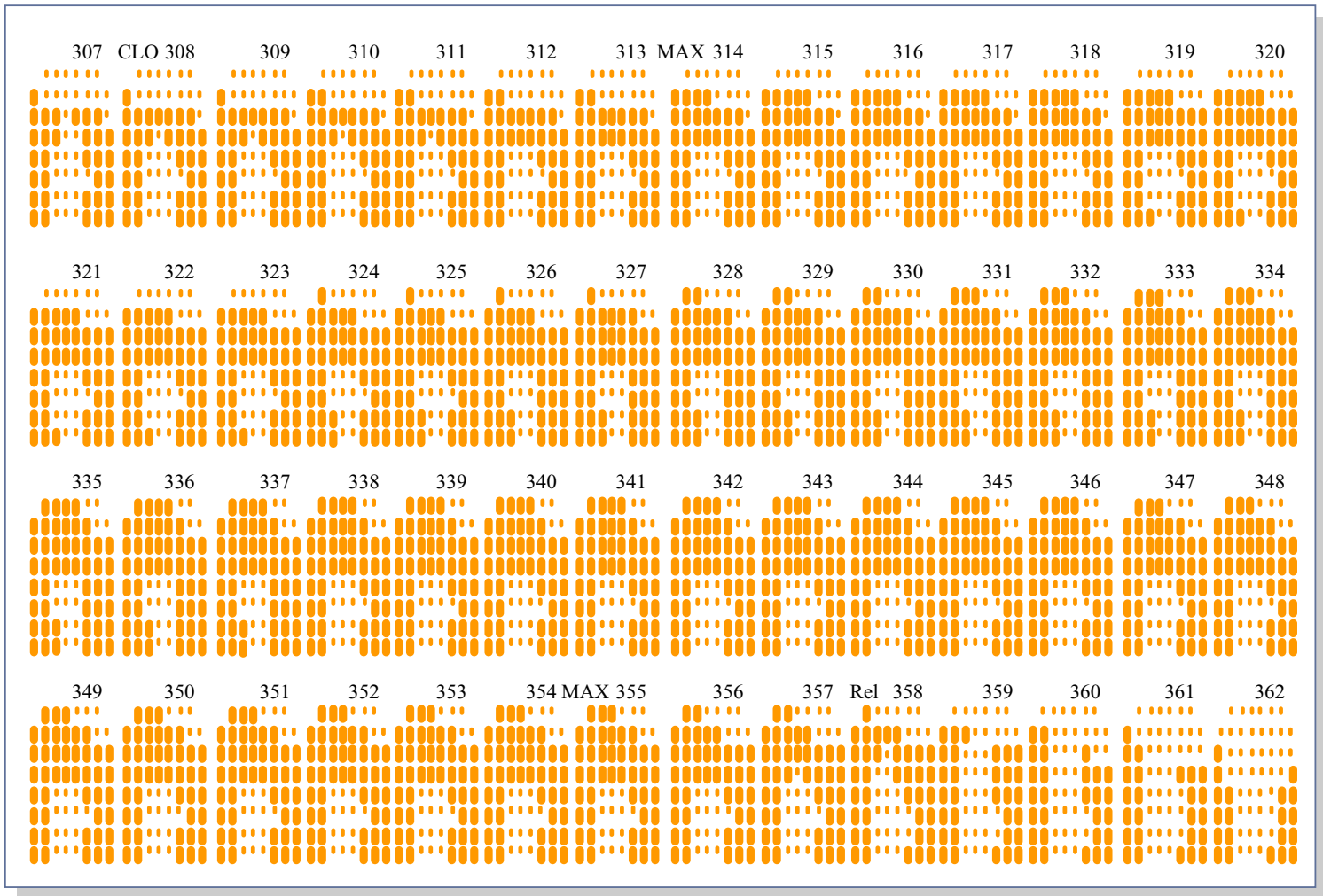



Figure by MIT OpenCourseWare. Adapted from Butcher, Andrew. "The Phonetics of Australian Languages." Flinder University, South Australia, 1993. Unpublished manuscript.

# Distribution of retroflexion contrasts

Moral:

- The details of the articulation and acoustics of retroflexes are crucial to understanding their phonological properties.

# Second Occurrence Focus

Focus sensitive particles:

1. Jan only gave BILL money.
2. Jan only gave Bill MONEY.

- The focus of ‘only’ is usually marked by a pitch accent (e.g. H*).

# Second Occurrence Focus

- It has been claimed that there are cases in which the focus of 'only' is not prosodically marked, e.g. SOF:

*Me*: Everyone already knew that Mary only eats $[\text{vegetables}]_{F}$.

*You*: If even $[\text{Paul}]_{F}$ knew that Mary only eats $[\text{vegetables}]_{SOF}$, then he should have suggested a different restaurant.

Beaver, David I. Brady Z. Clark, Edward Flemming, Florian Jaeger, and Maria Wolters. "When Semantics Meets Phonetics: Acoustical Studies of Second Occurrence Focus." *Language* 83, no. 2 (2007): 251-282.

- Others claim that SOF is longer/louder than a matched unfocused word.
- Beaver et al (2007) show that this is correct.

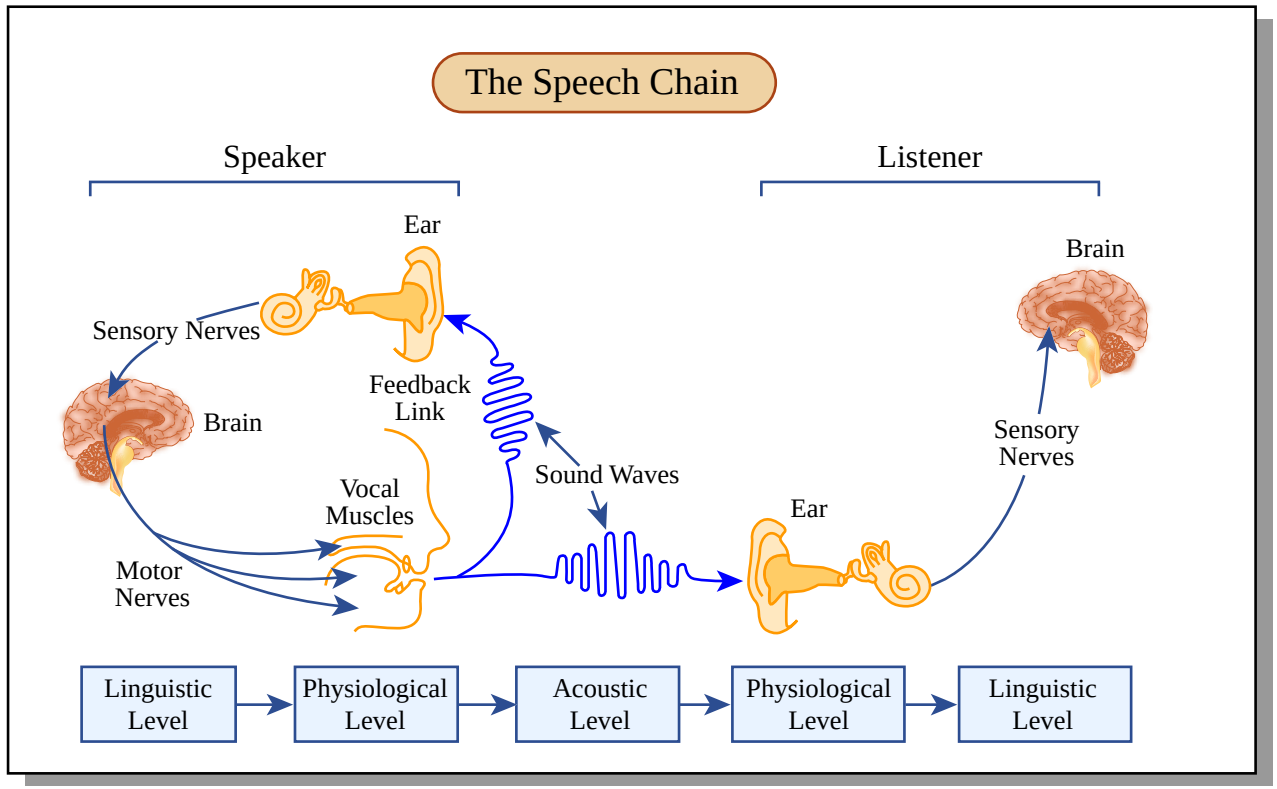
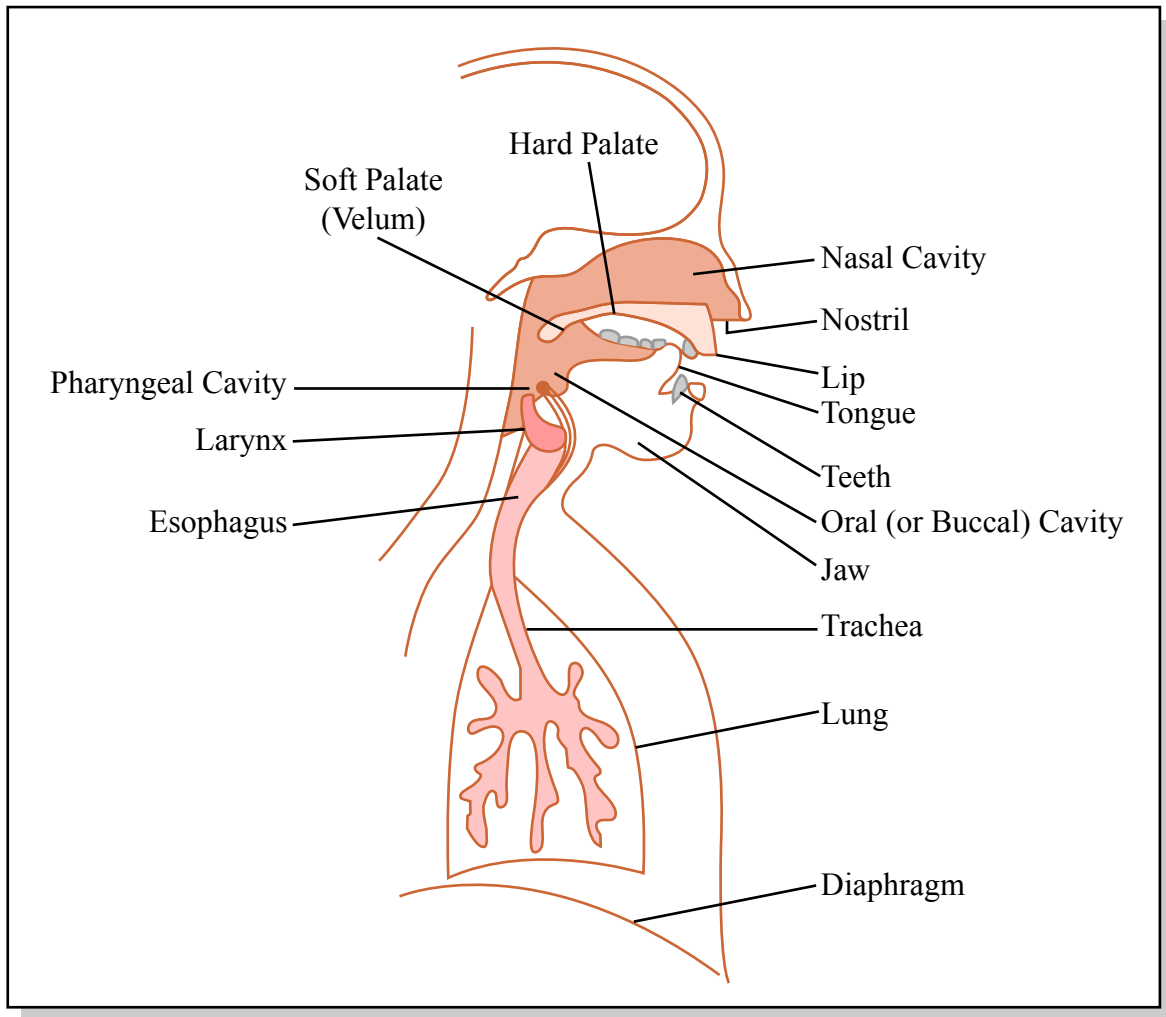
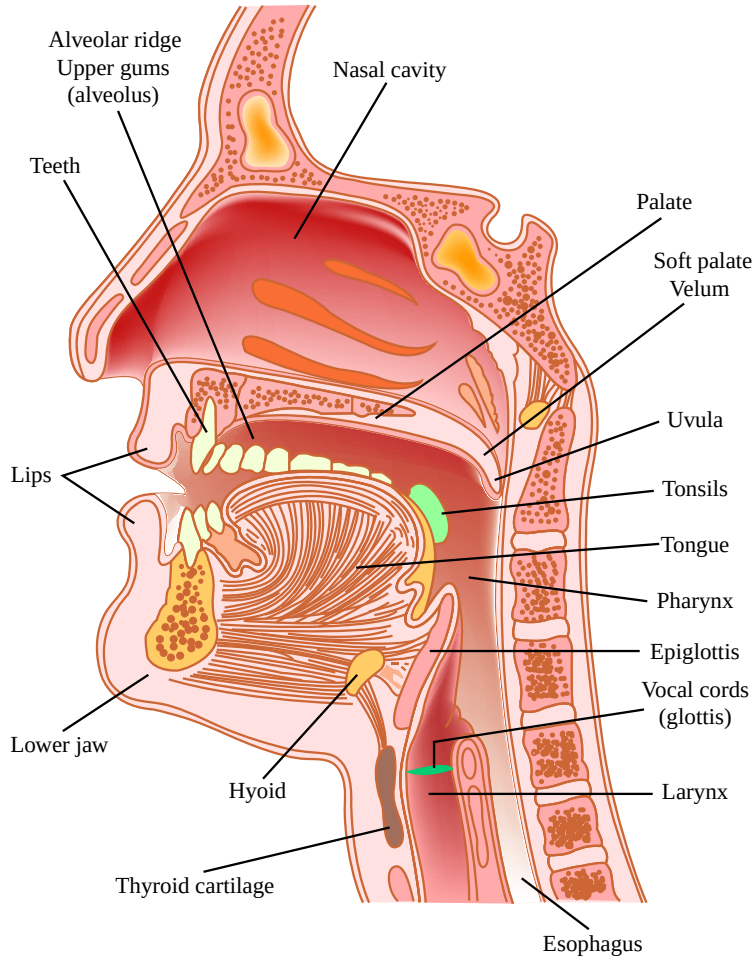



Image by MIT OpenCourseWare. Adapted from Denes, Peter B., and Elliot N. Pinson. *The Speech Chain: The Physics and Biology of Spoken Speech*. 2nd ed. New York, NY: W. H. Freeman, 1993. ISBN: 9780716723448.

# Articulation-
# The speech production system



# The vocal tract




Vocal tract configuration with raised soft palate for articulating non-nasal sounds.

# Articulatory description of speech sounds

Consonants:

- Voicing
- Place of articulation
- Manner
- Lateral/Central
- Nasal/Oral

- [s] voiceless alveolar central oral fricative

# Articulatory description of speech sounds

Vowels:

- High-low
- Front-back
- Rounded-unrounded

- [e] mid front unrounded vowel

Video removed due to copyright restrictions.

Please visit “Tongue video” in Peter Ladefoged’s *Vowels and Consonants*.

# Introduction to acoustics

- Sound consists of pressure fluctuations in a medium…

  …which displace the ear drum in such a way as to result in stimulation of the auditory nerve.

animation

# Speech acoustics

- Movements at a source produce a sound wave in the medium which carries energy to the perceiver.
- Pressure fluctuations move through space, but each air particle moves only a small distance.

Animated image of longitudinal pressure wave removed due to copyright restrictions.

# Representing sound waves

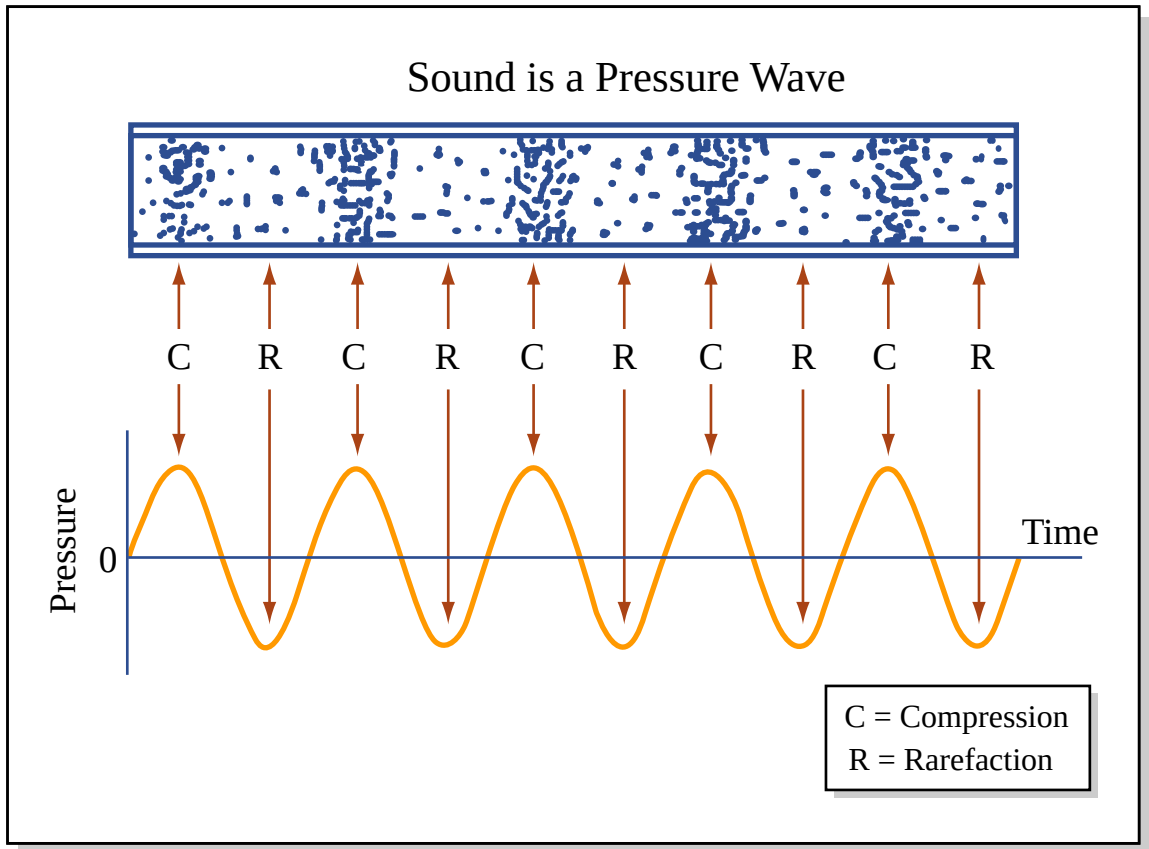
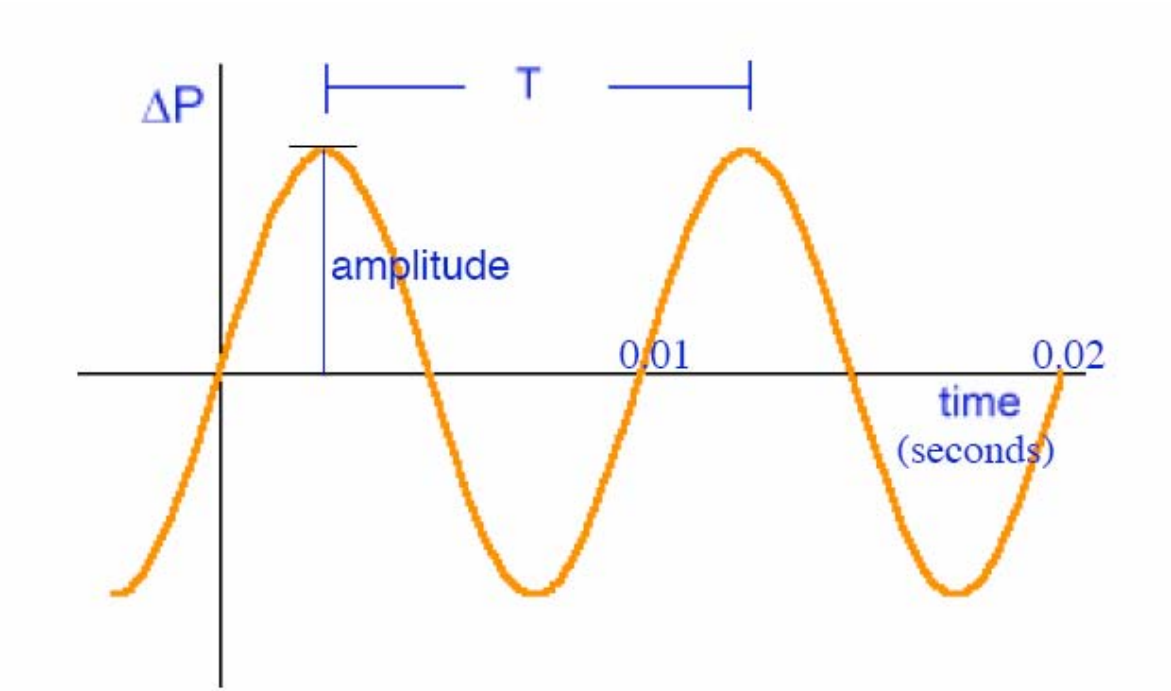



Image by MIT OpenCourseWare. Adapted from The Physics Classroom Tutorial.

# Periodic sounds

- A waveform is periodic if it repeats at regular intervals.
- Frequency of a wave is the number of cycles occurring per unit of time.
  - Units: 1 Hertz (Hz) is 1 cycle/second



# Periodic sounds

- Voiced sounds have complex (quasi-)periodic wave forms.
- The perceived pitch of a sound depends on its frequency.

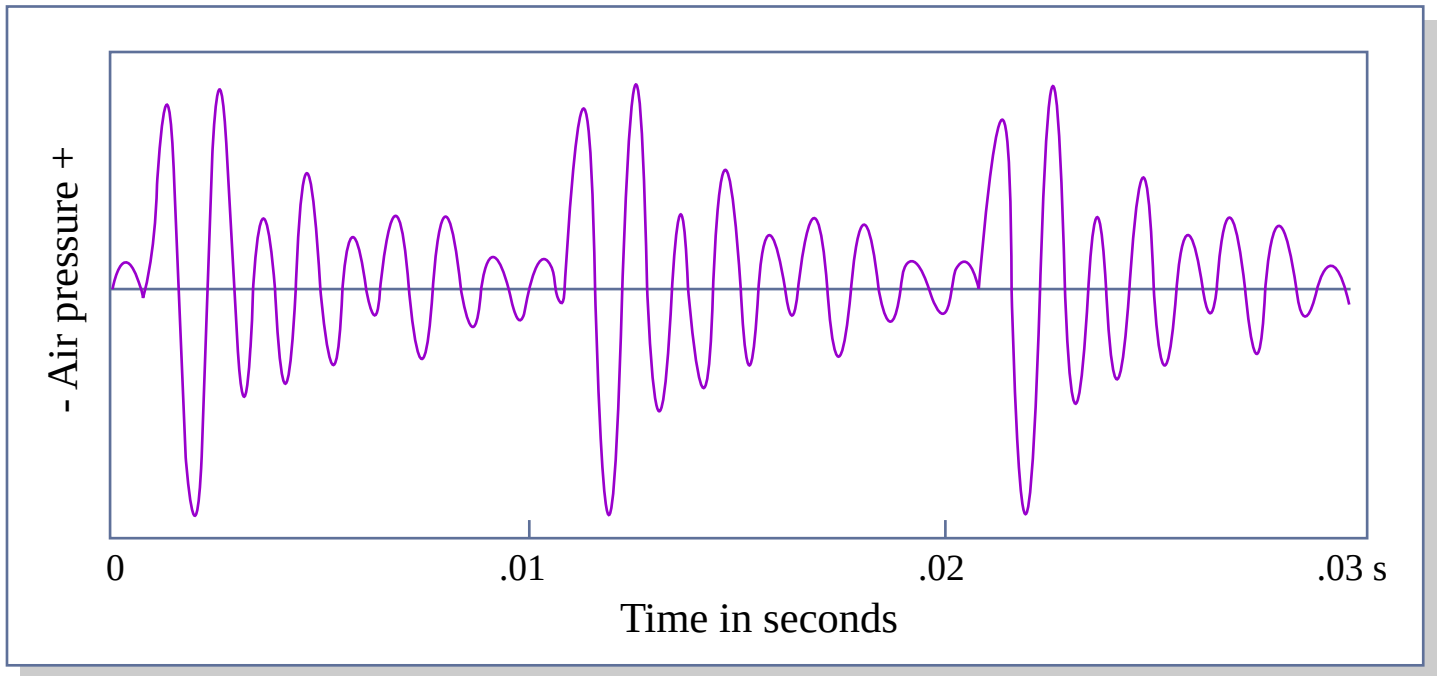
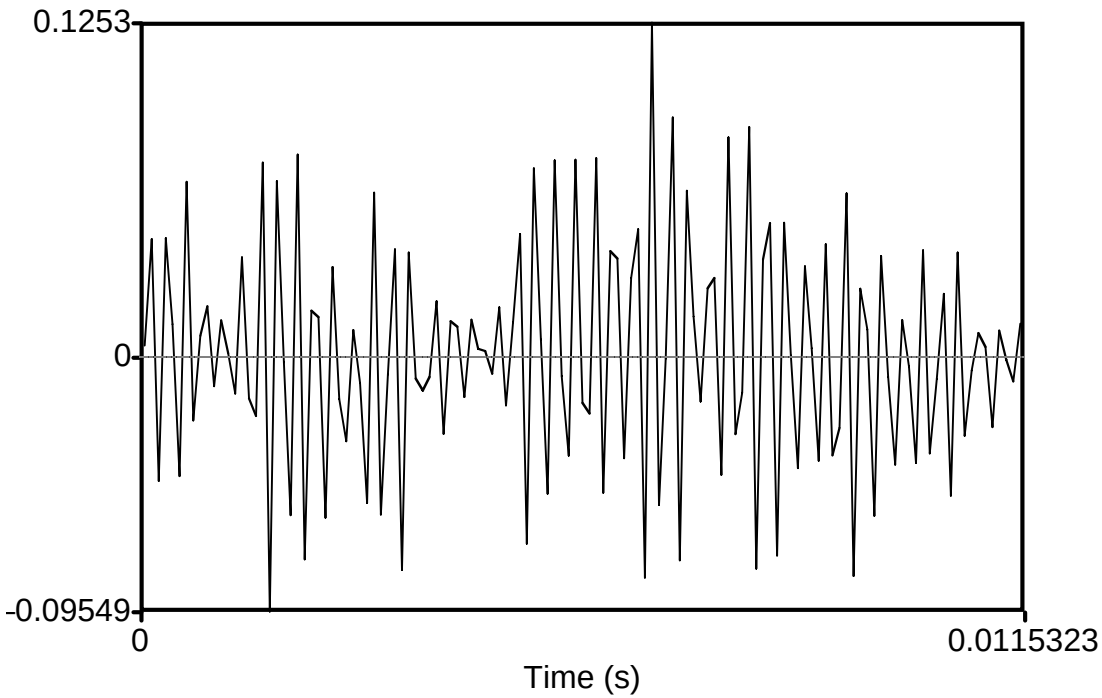



Image by MIT OpenCourseWare.

Segment of [ɔ]

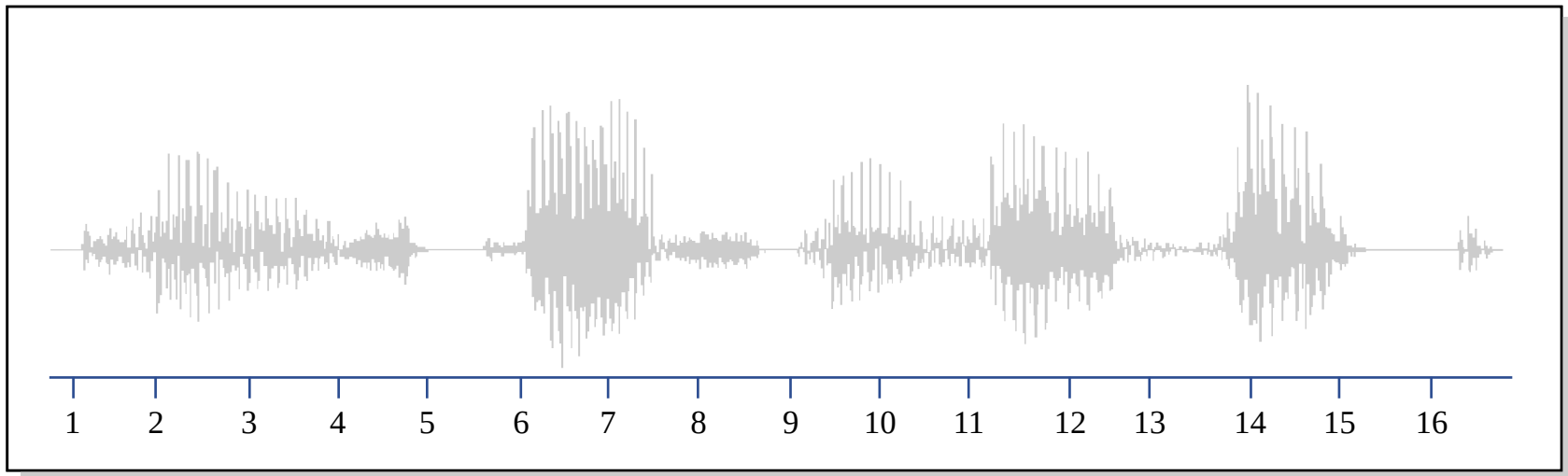
# Aperiodic sounds

- Aperiodic sounds have waveforms that do not repeat.
- Fricative noise is aperiodic.




Segment of [s]

# Waveform of a sentence






Please pass me my book

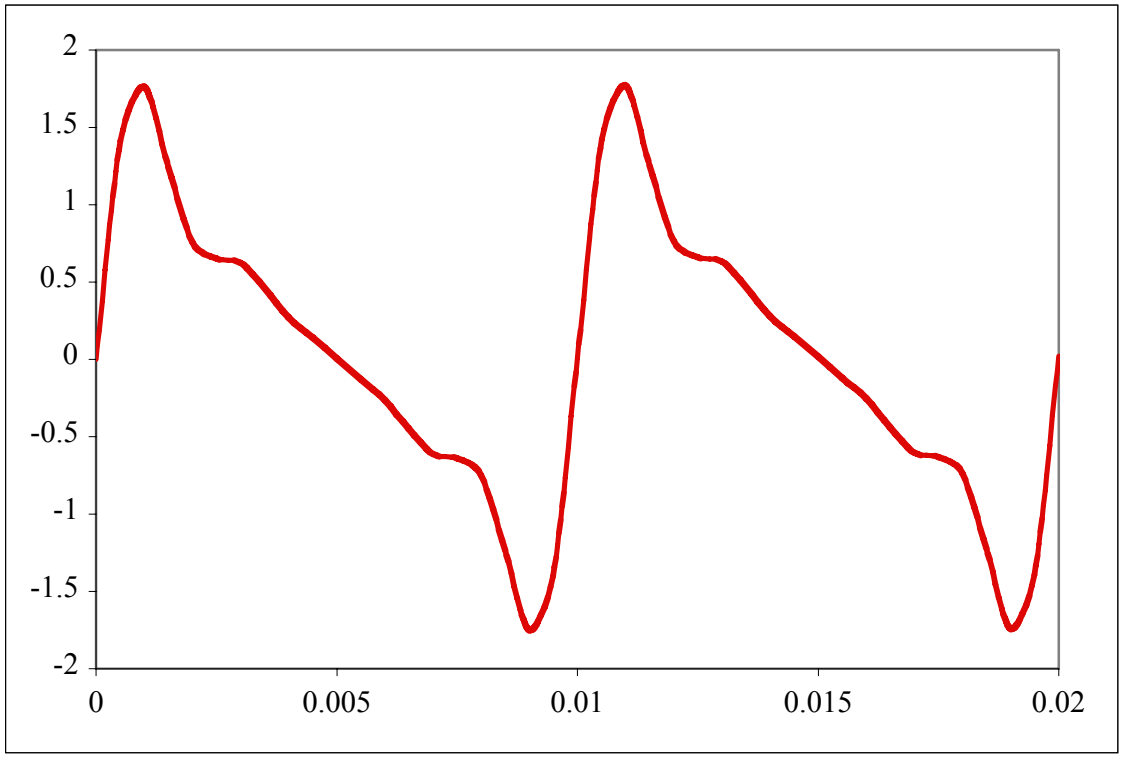
# Spectrums and spectrograms

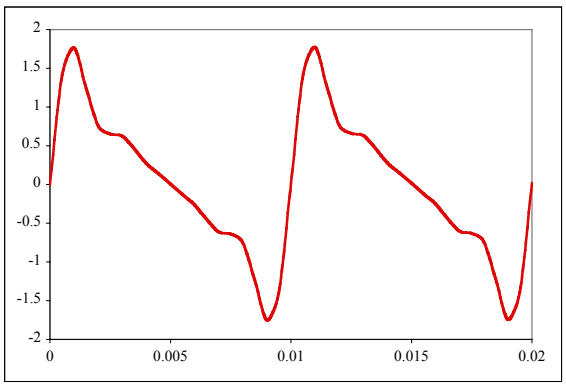
- The spectrum of a sound plays a central role in determining its quality or timbre.

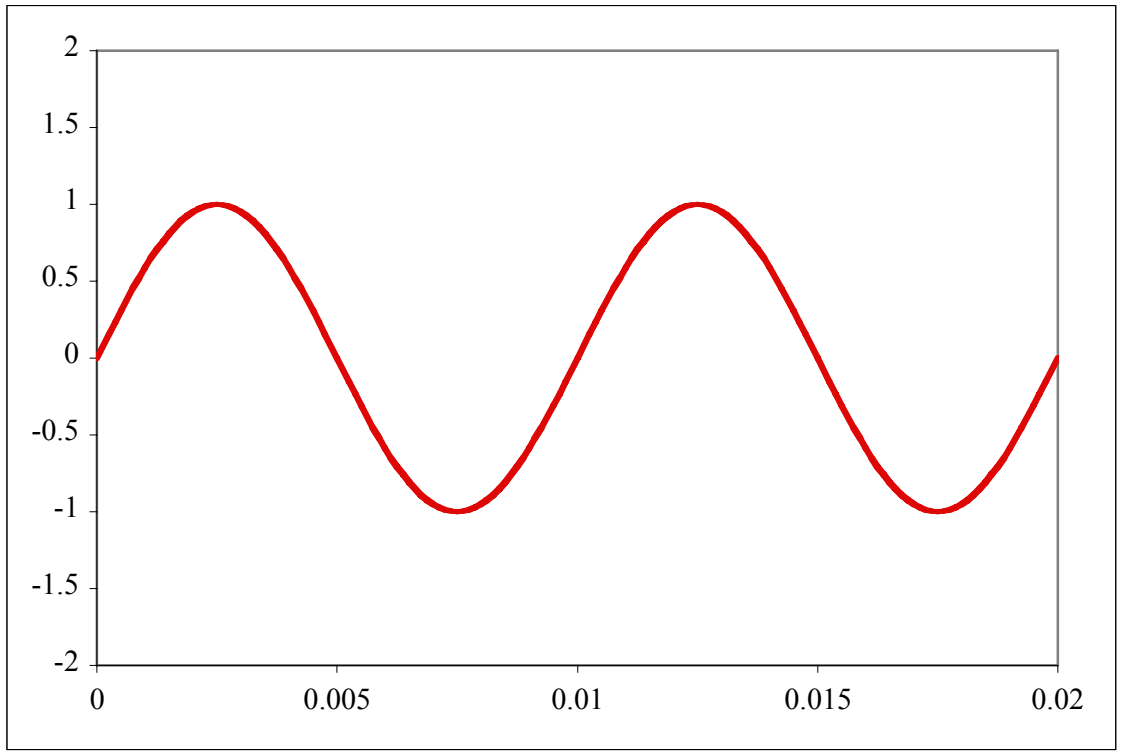
# Spectral representation

- Any complex wave can be analyzed as the combination of a number of sinusoidal waves of different frequencies and intensities (Fourier's theorem).
- In the case of a periodic sound like a vowel these will be
  - the fundamental frequency
  - multiples of the fundamental frequency (harmonics)
- The quality of a periodic sound depends on the relative amplitude of its harmonics.

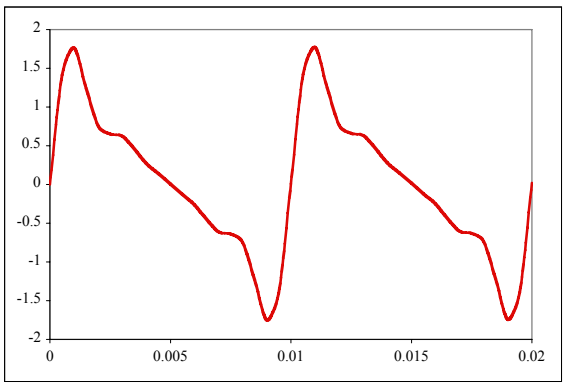
# Spectral representation

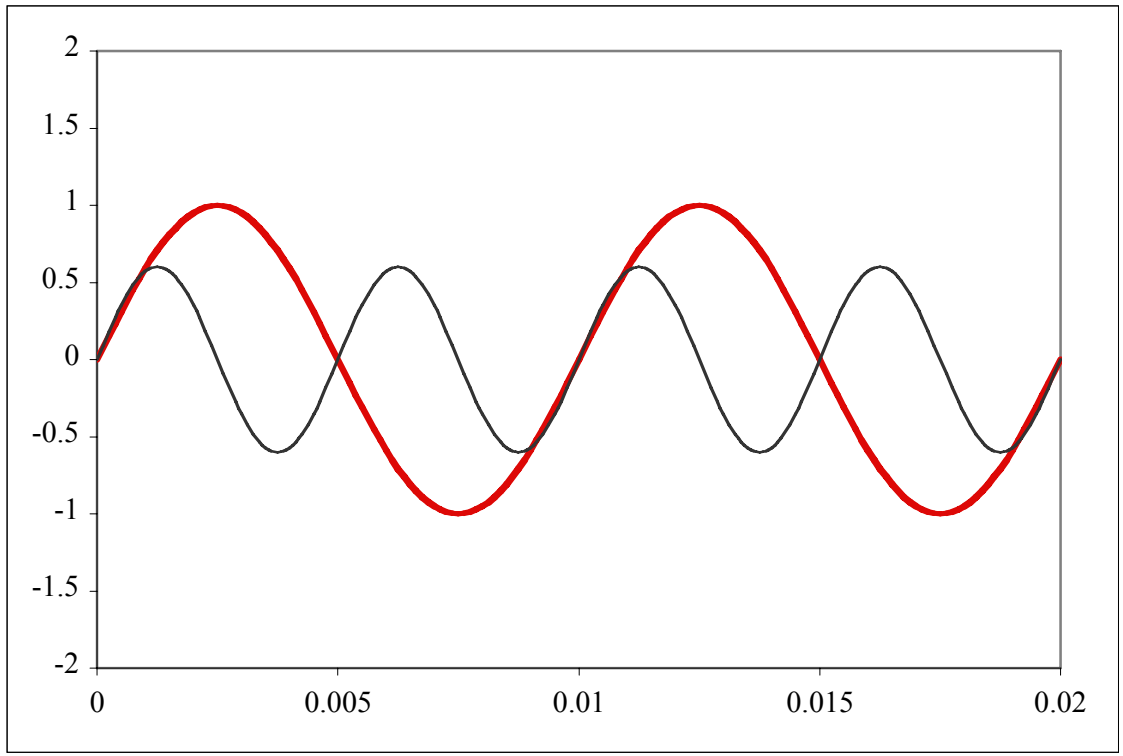




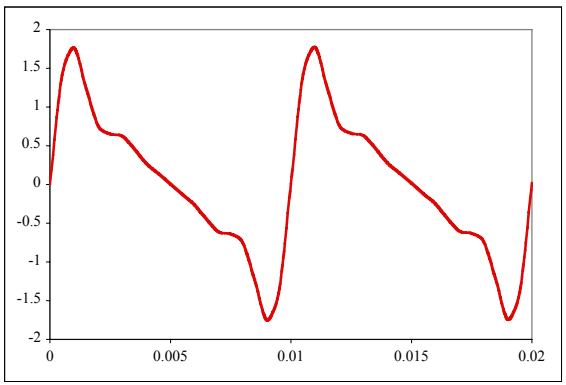




Fundamental frequency




2nd harmonic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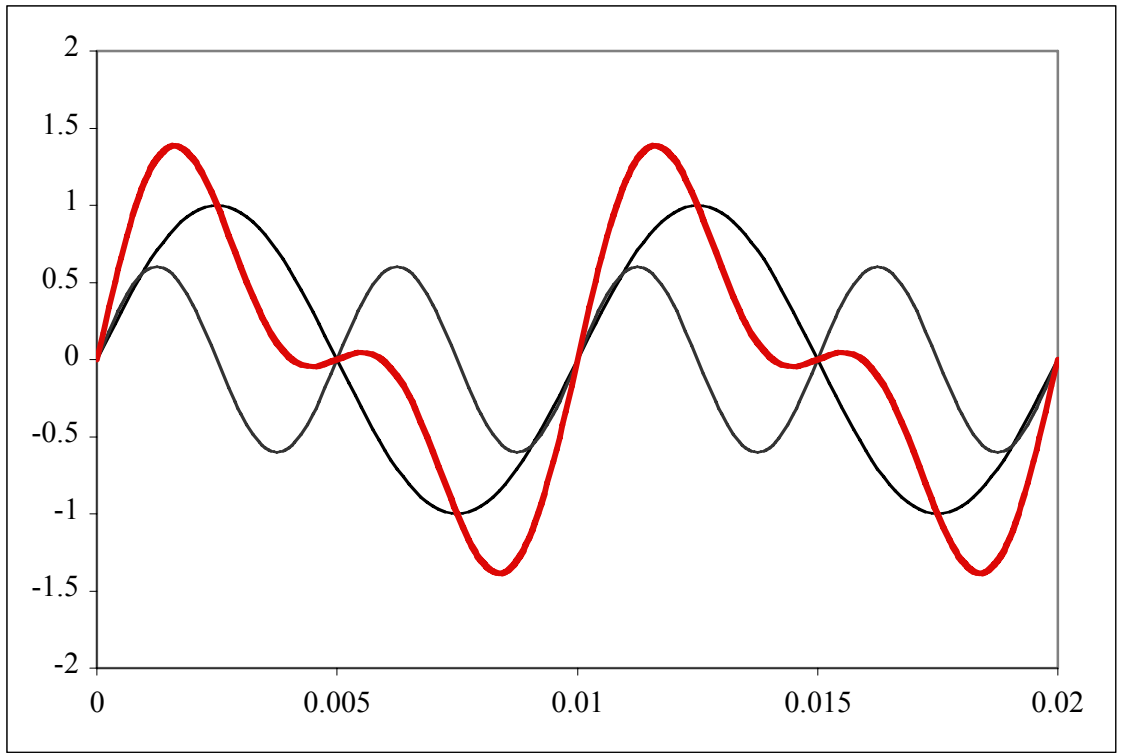
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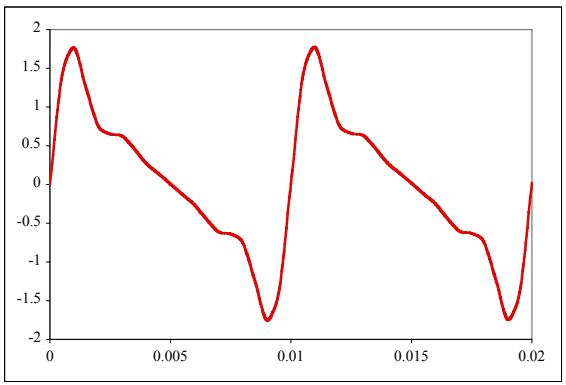
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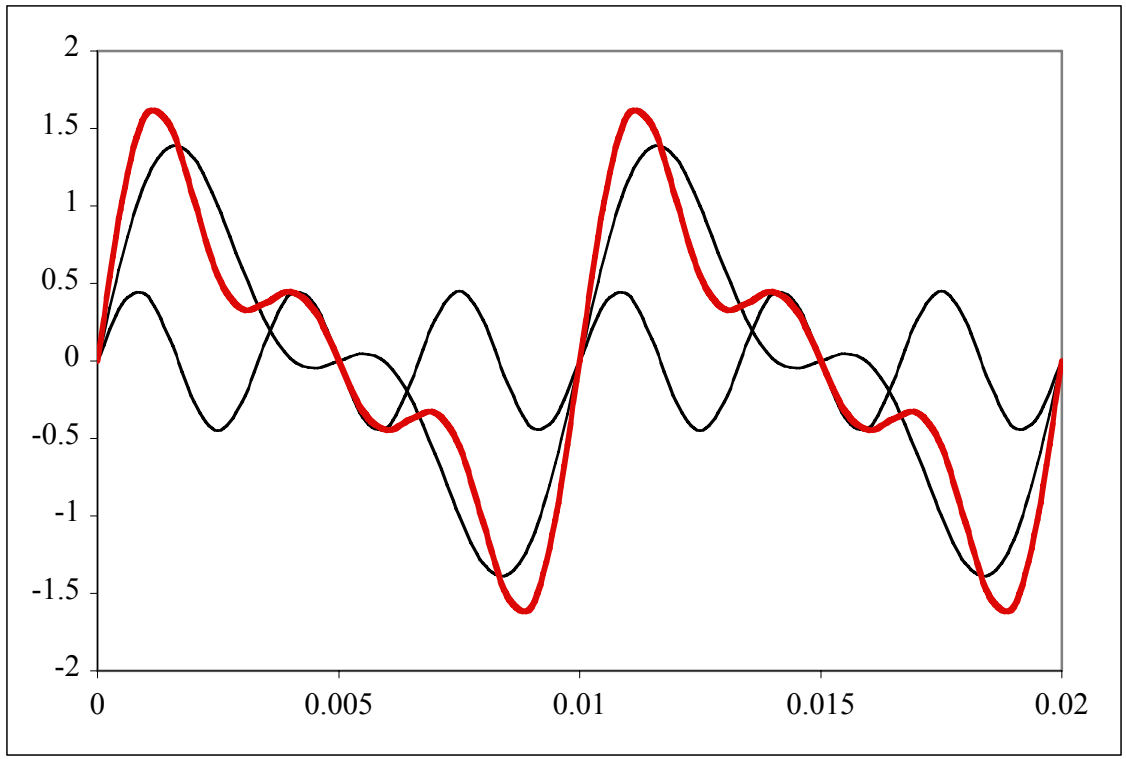
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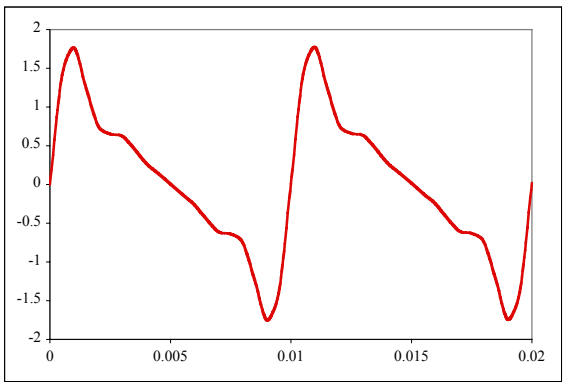
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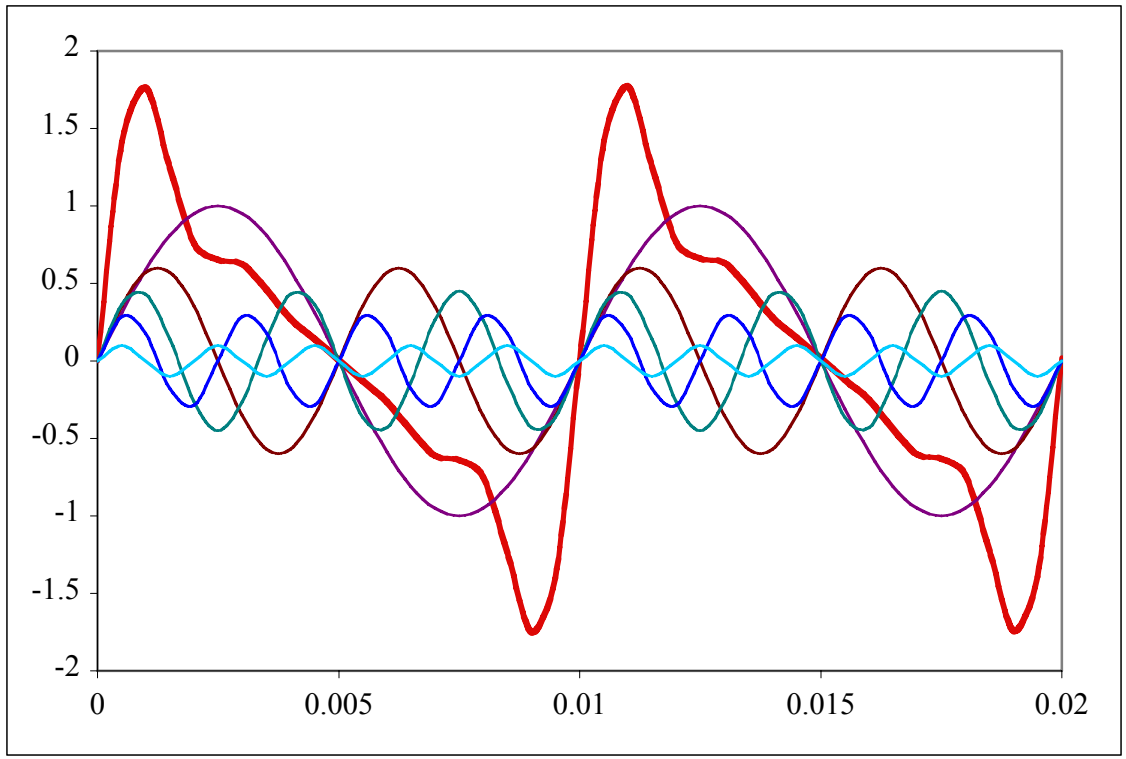
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0
0.005
0.01
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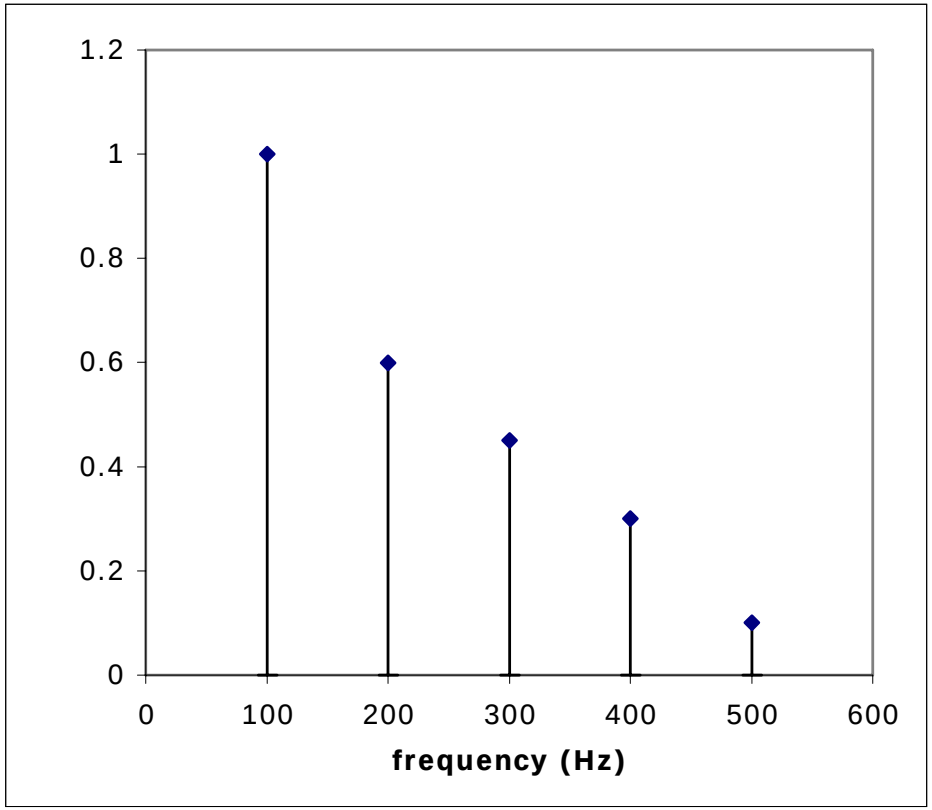
0.02

# Spectral representation

- Phase differences are relatively unimportant to sound quality, so key properties of a complex wave can be specified in terms of the frequencies and amplitudes of its sinusoidal components.

| Frequency (Hz) | Amplitude |
|---|---|
| 100 | 1 |
| 200 | 0.6 |
| 300 | 0.45 |
| 400 | 0.3 |
| 500 | 0.1 |




Power spectrum

# Idealized vowel spectrum

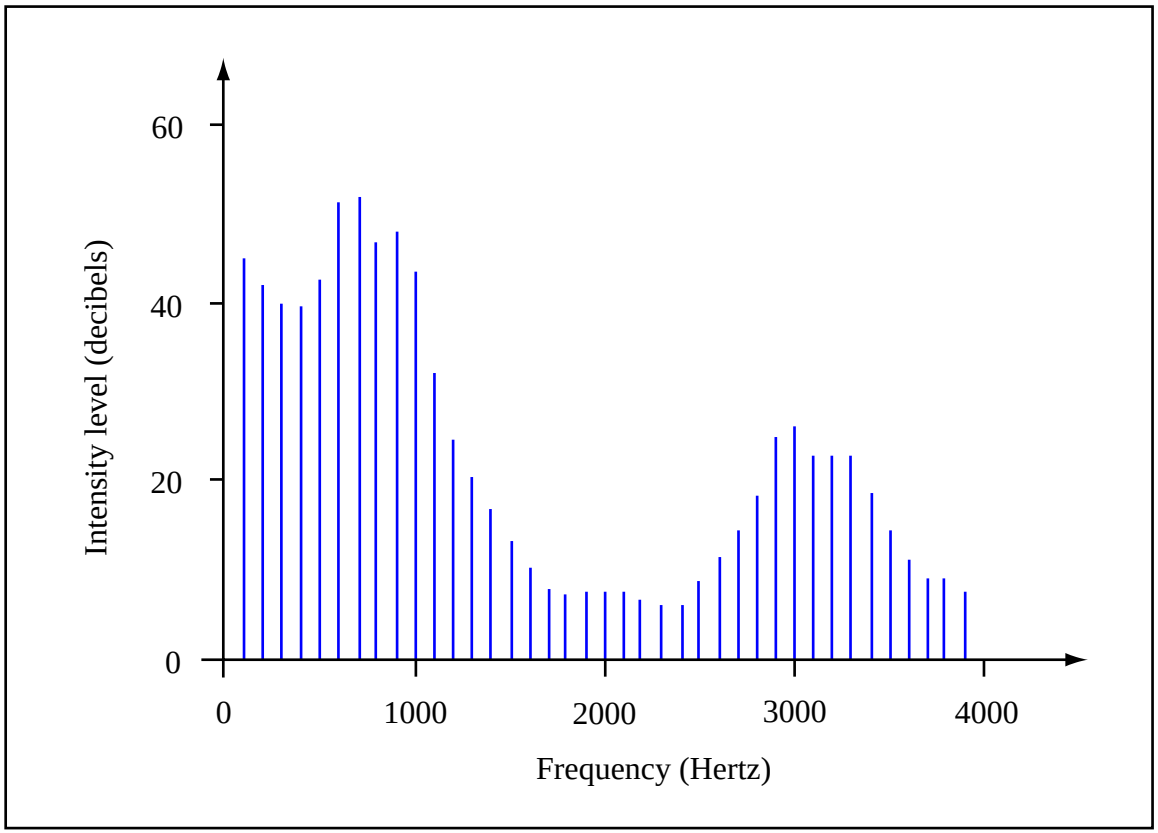
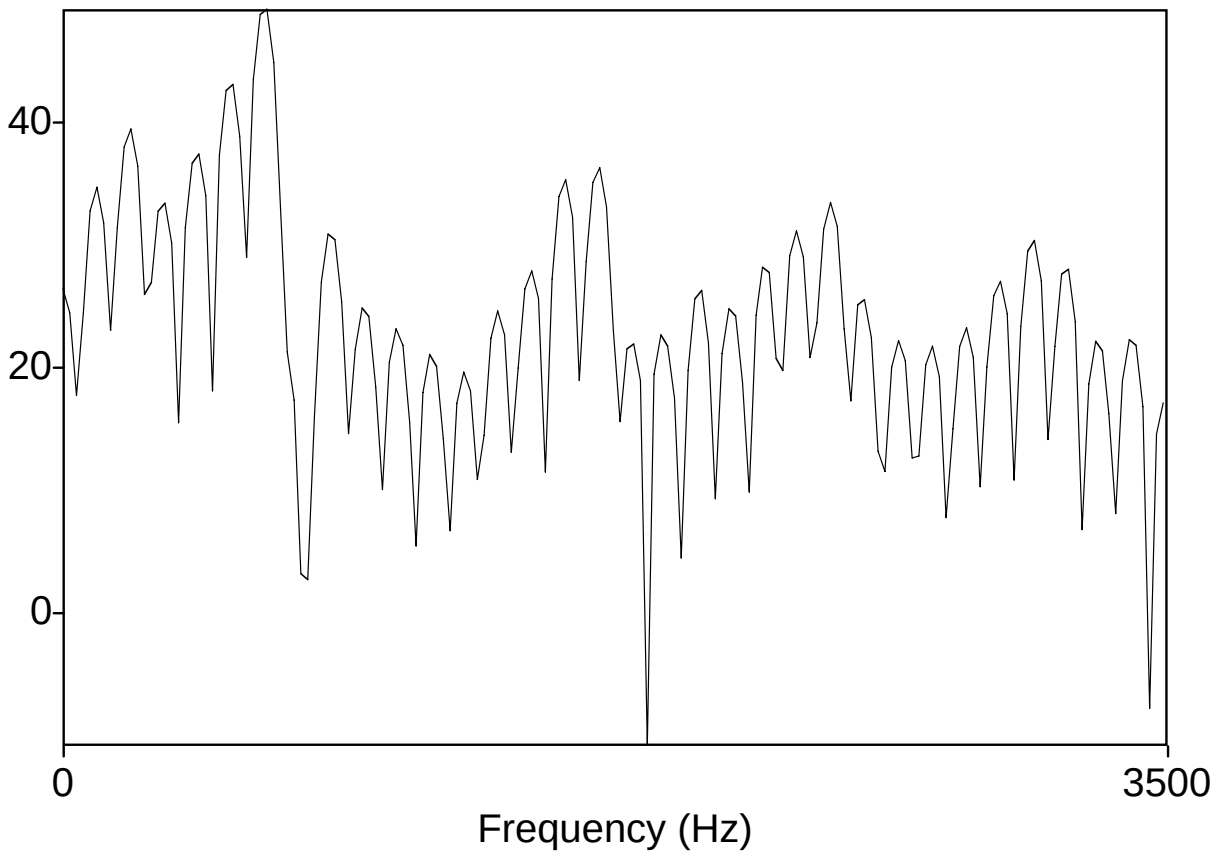



Image by MIT OpenCourseWare.

# vowel spectrum

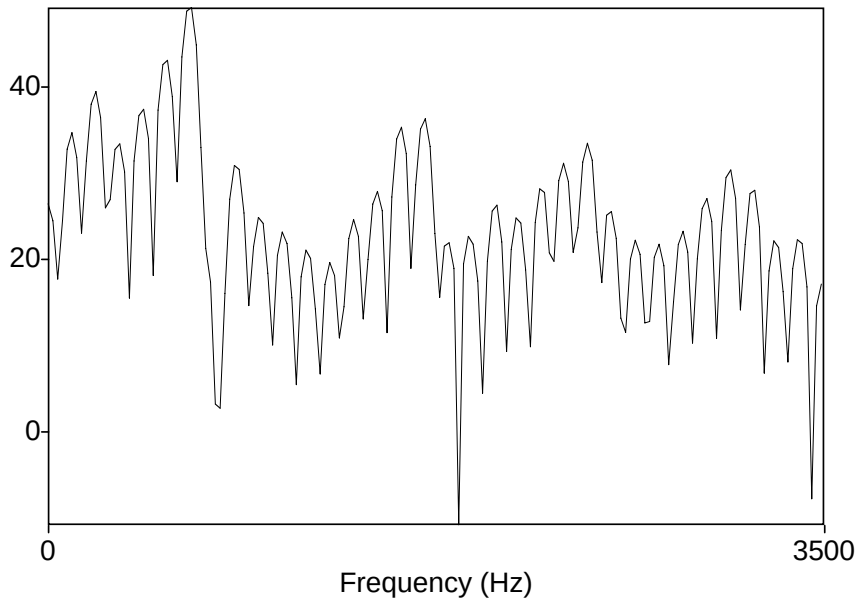



[æ]

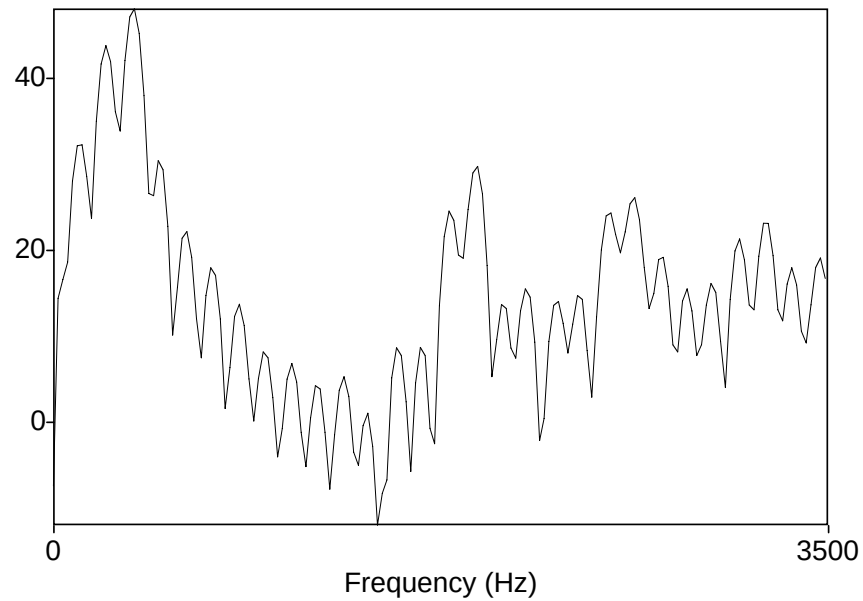
# Vowel quality

- The quality of a vowel depends on the shape of its spectrum.
- The shape of the spectrum depends on the shape of the vocal tract.

[æ]



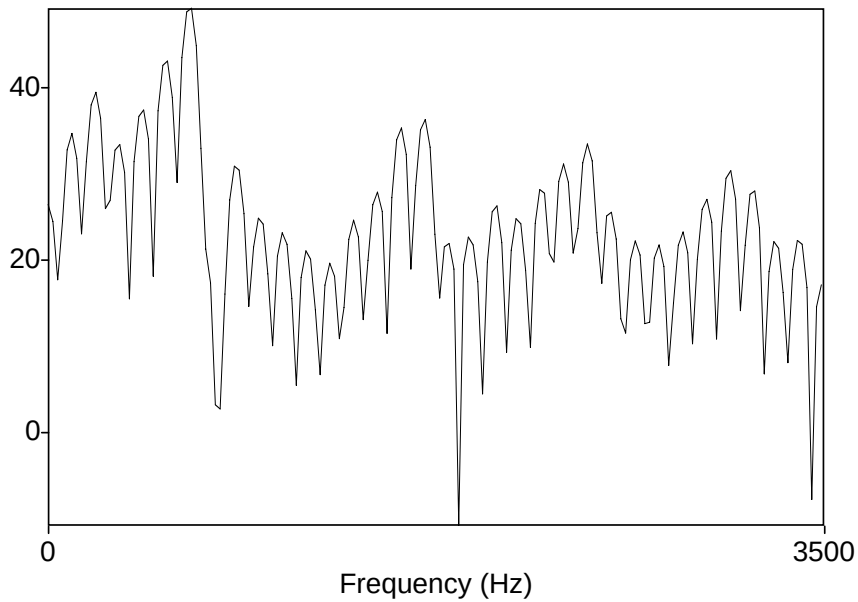

[ɪ]



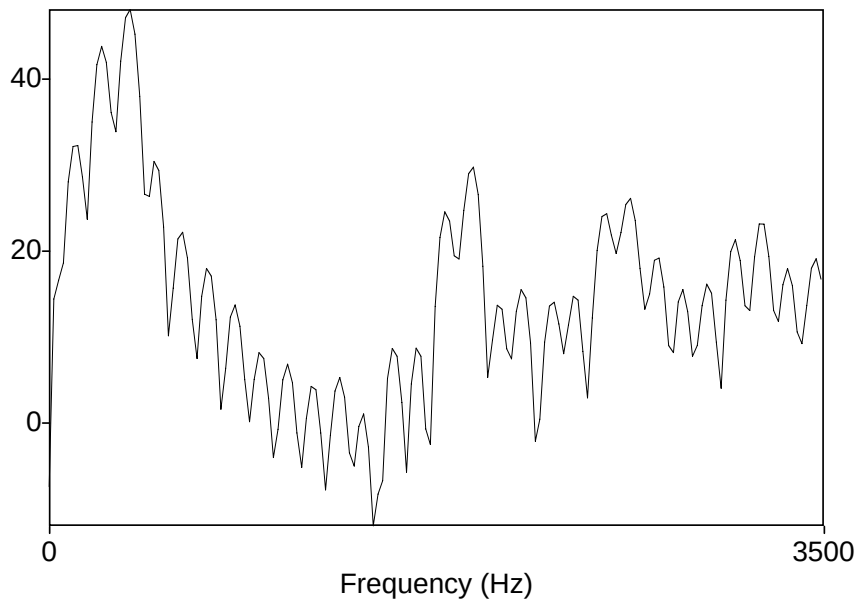
# Vowel quality

- The peaks in the spectrum of a vowel are called **formants**.
- Perceived vowel quality depends primarily on the frequencies of the first three formants.

[æ]




[ɪ]



# Spectrograms

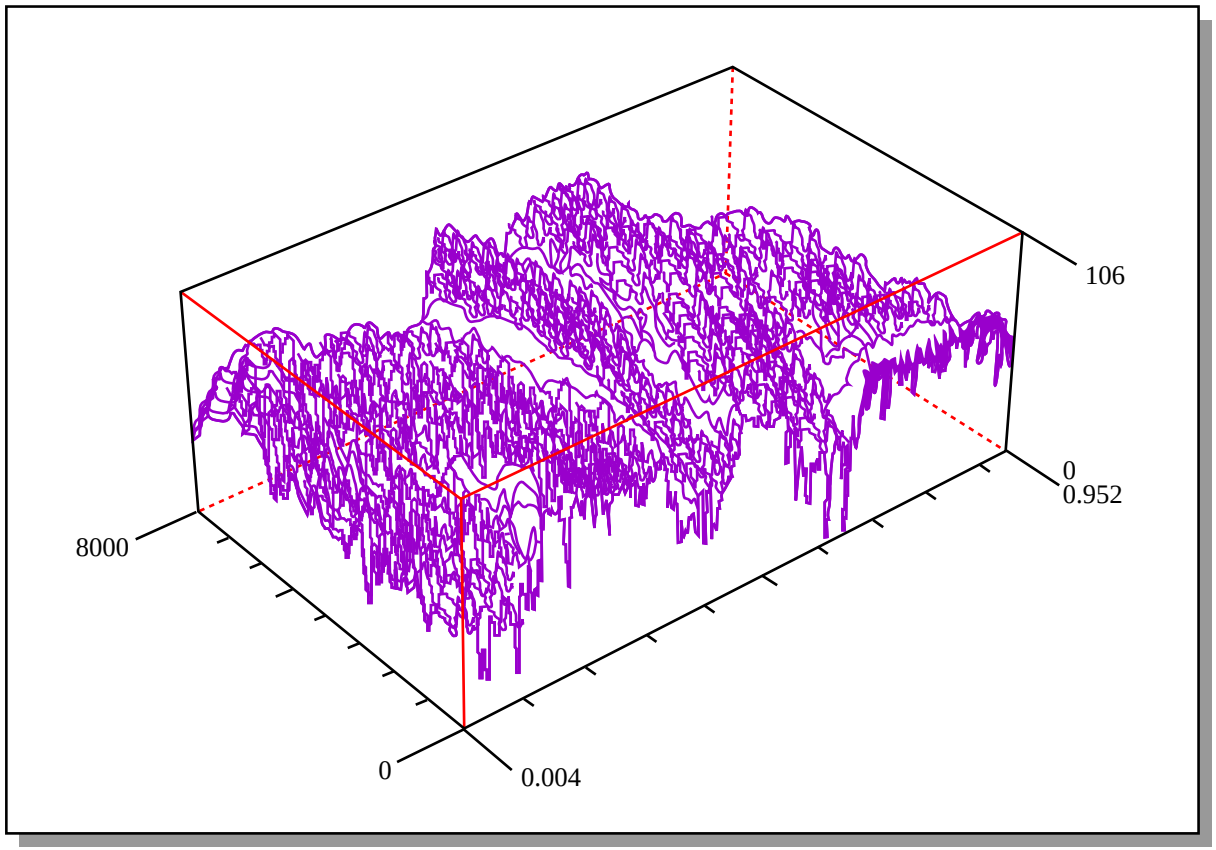
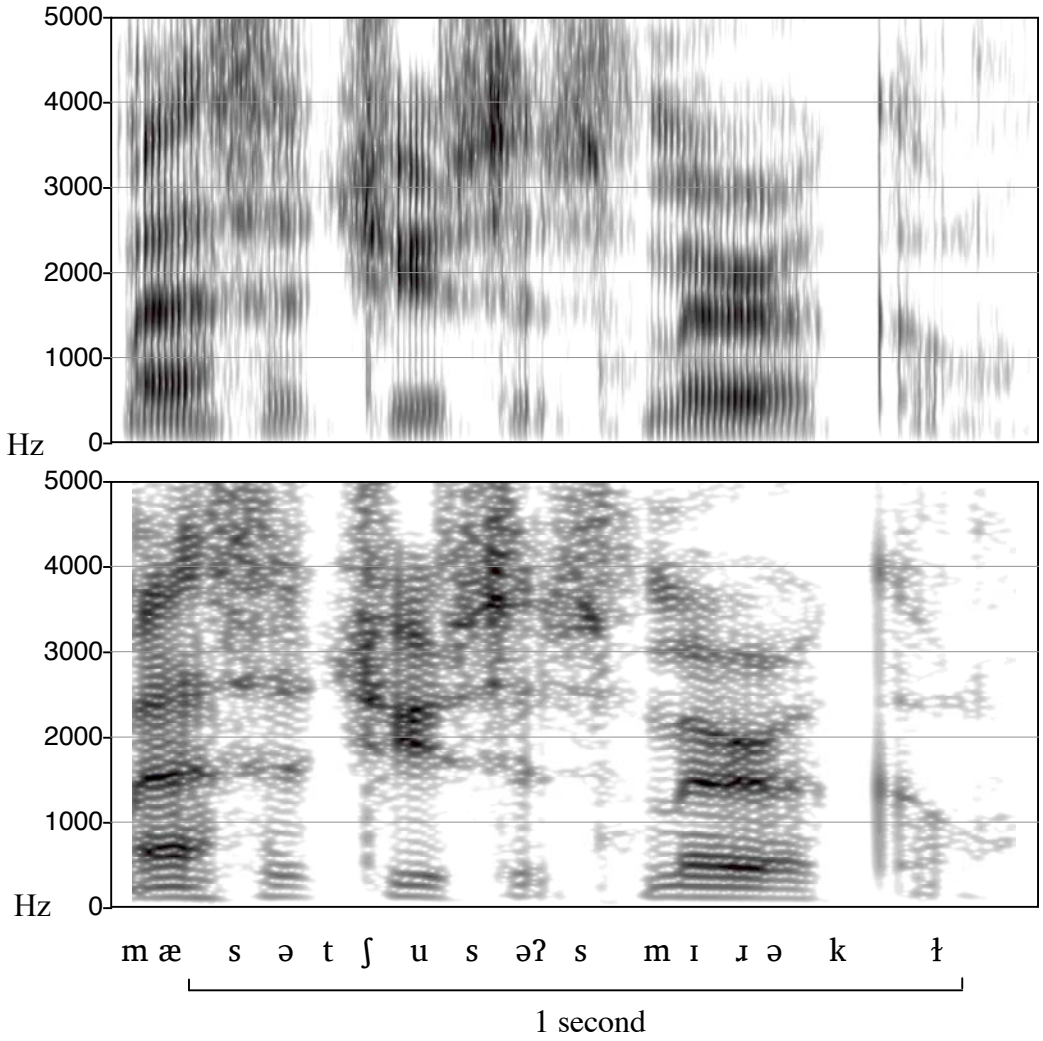



Image by MIT OpenCourseWare.

A spectrum represents important properties of a sound during an interval of time, but we are often interested in how the spectrum of a sound changes over time.


5000
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2000
1000
Hz
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5000
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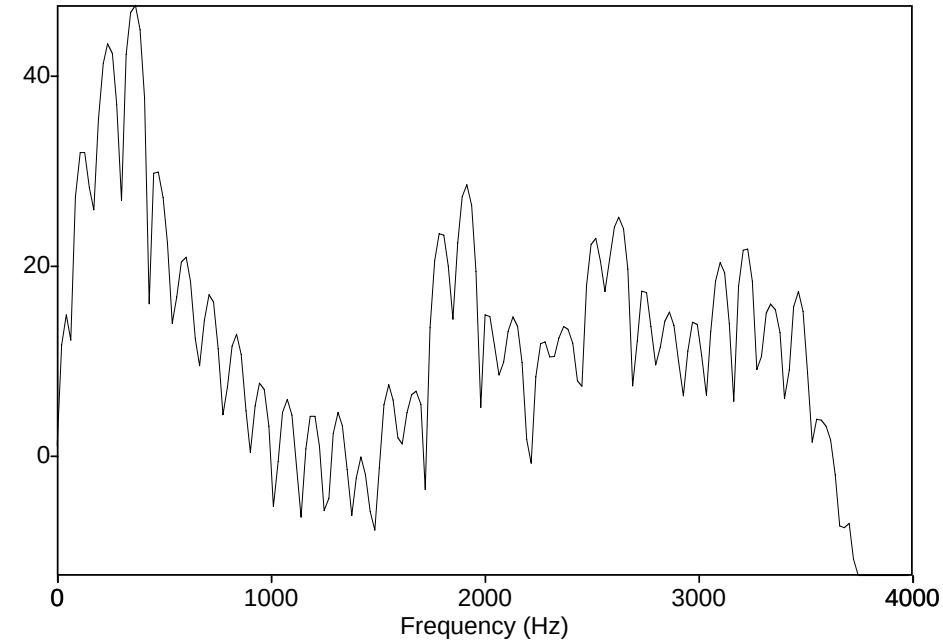
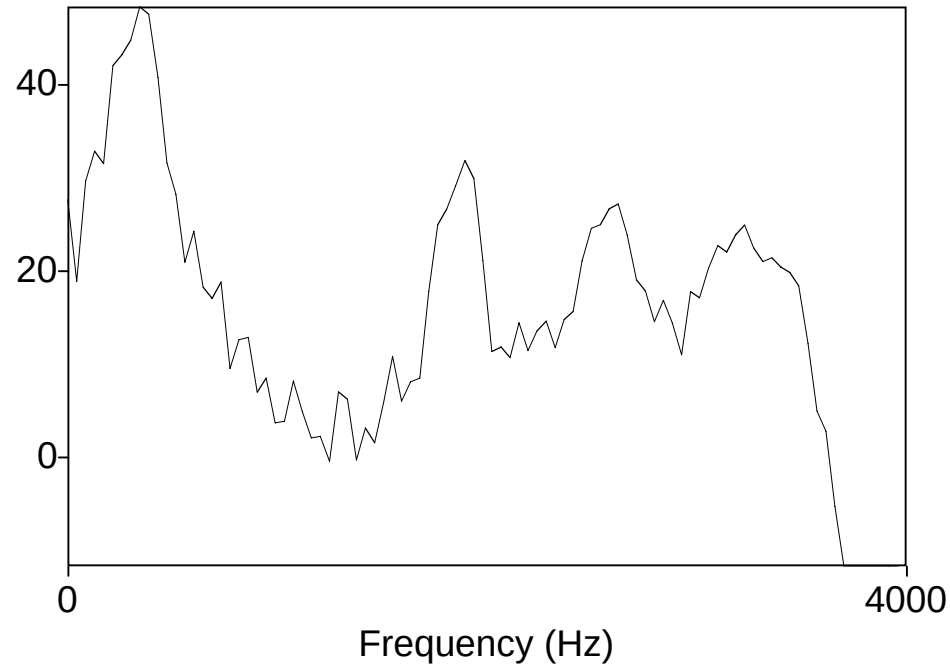
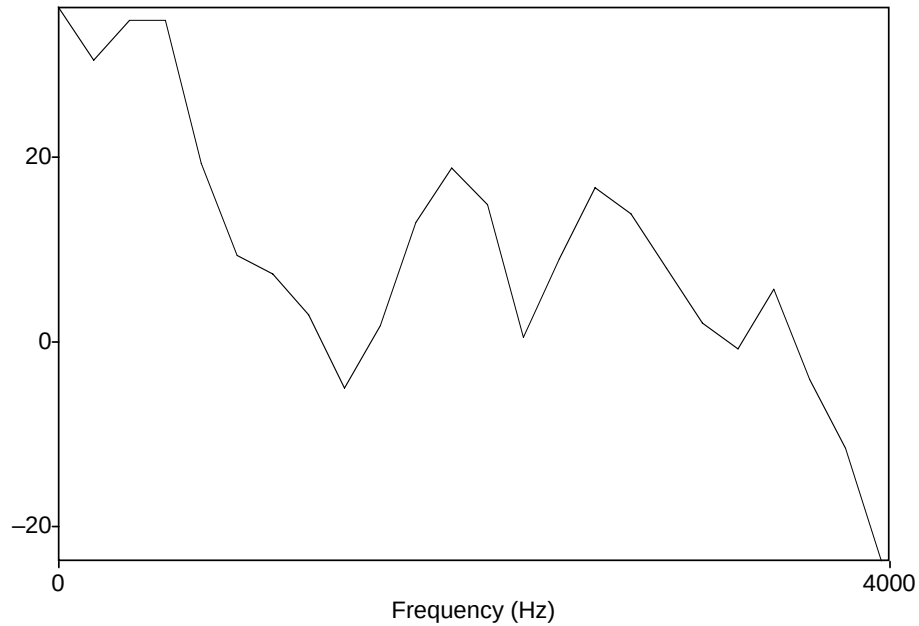
m æ s ə t ʃ u s əʔ s m ɪ ɹ ə k ɬ
1 second

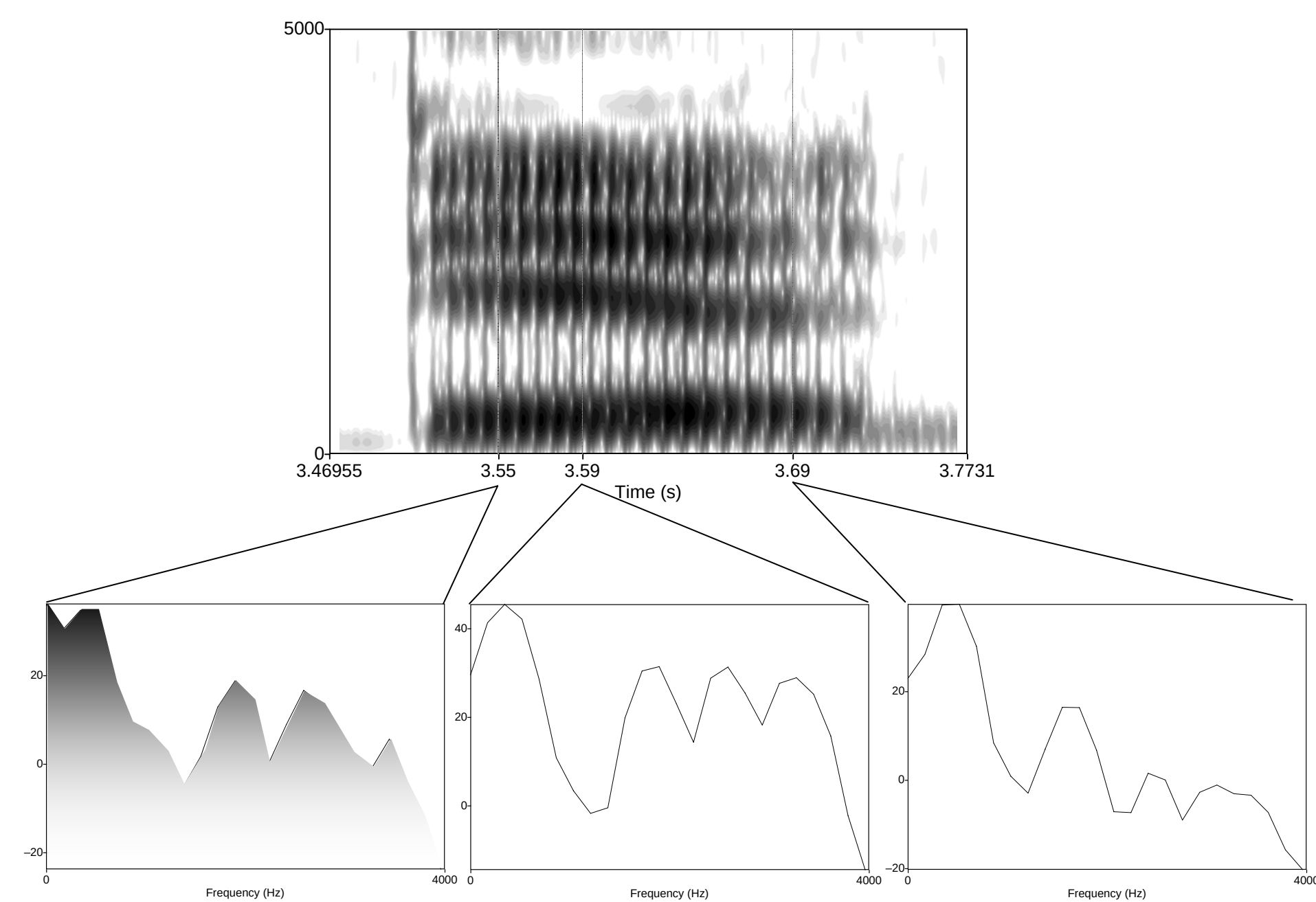



narrow band
(long window)

broad band
(short window)




5000
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3.46955
3.55
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Time (s)
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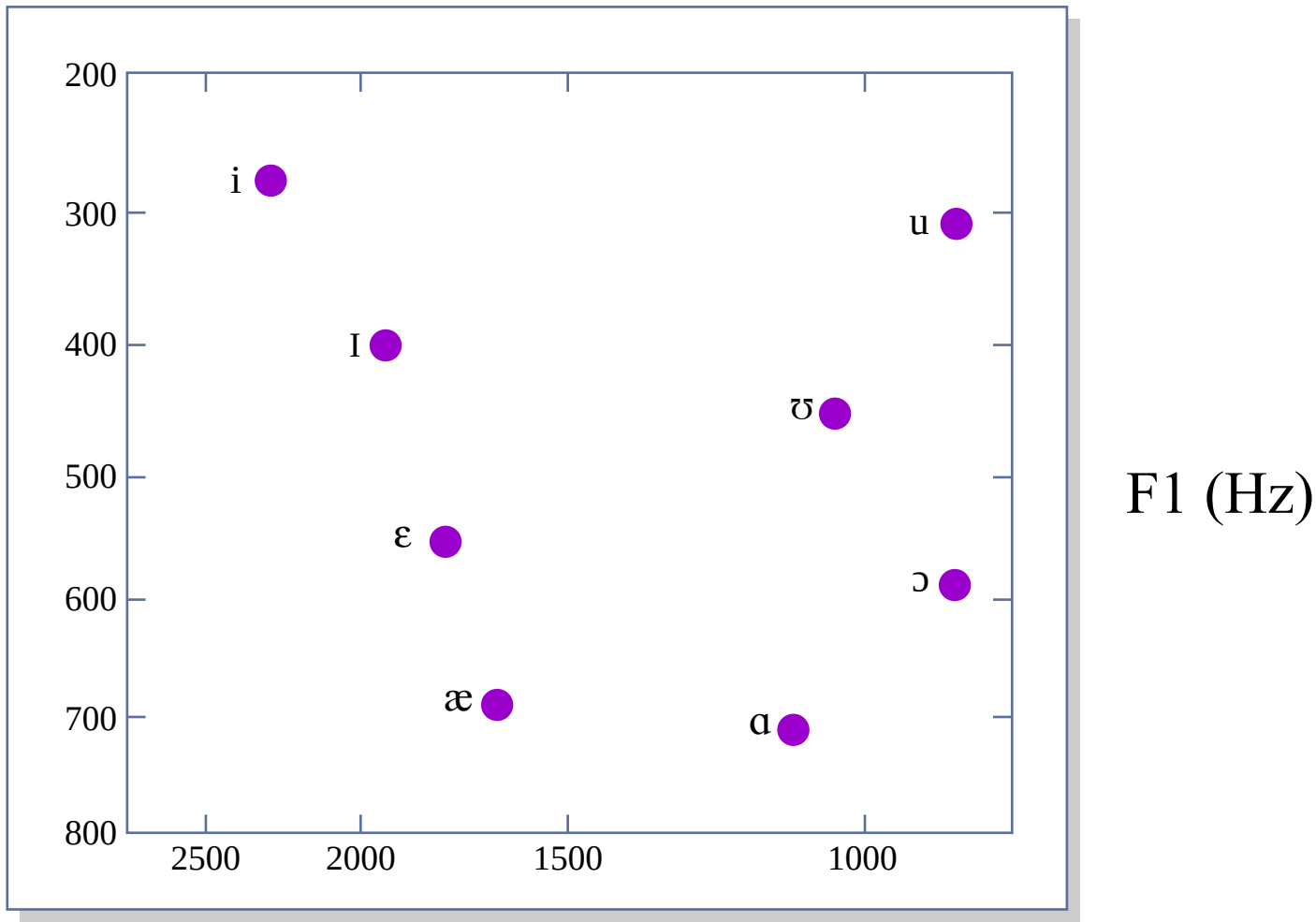
Spectrogram image removed due to copyright restrictions.
See: http://hctv.humnet.ucla.edu/departments/linguistics/VowelsandConsonants/course/chapter8/8.3.htm

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