

Speech Science

WiSe 2024/2025

Exercise 5: Acoustic Analyses I

Nov 25, 2024

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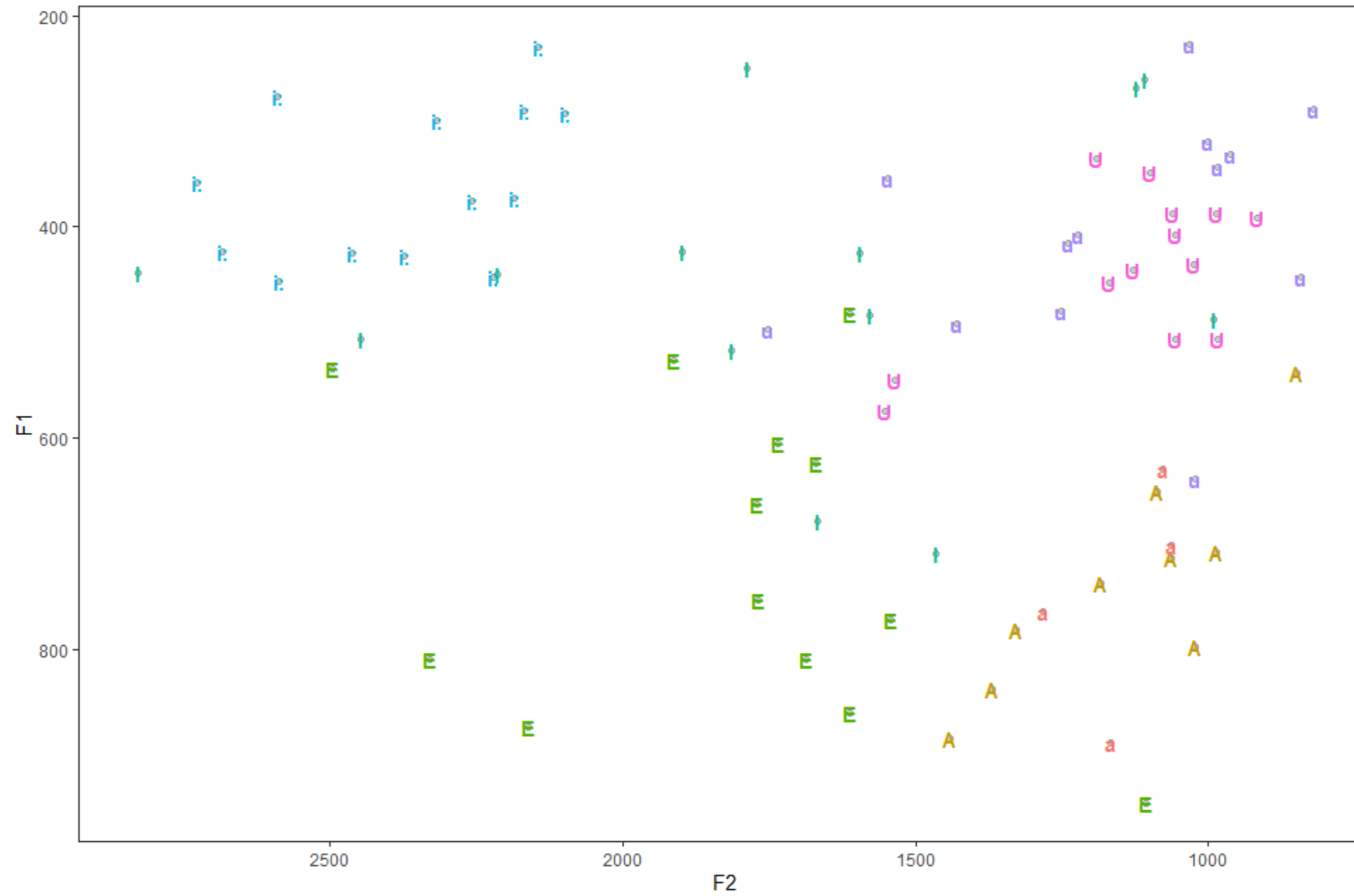
Language Science and Technology
Saarland University

Quick recap: Praat

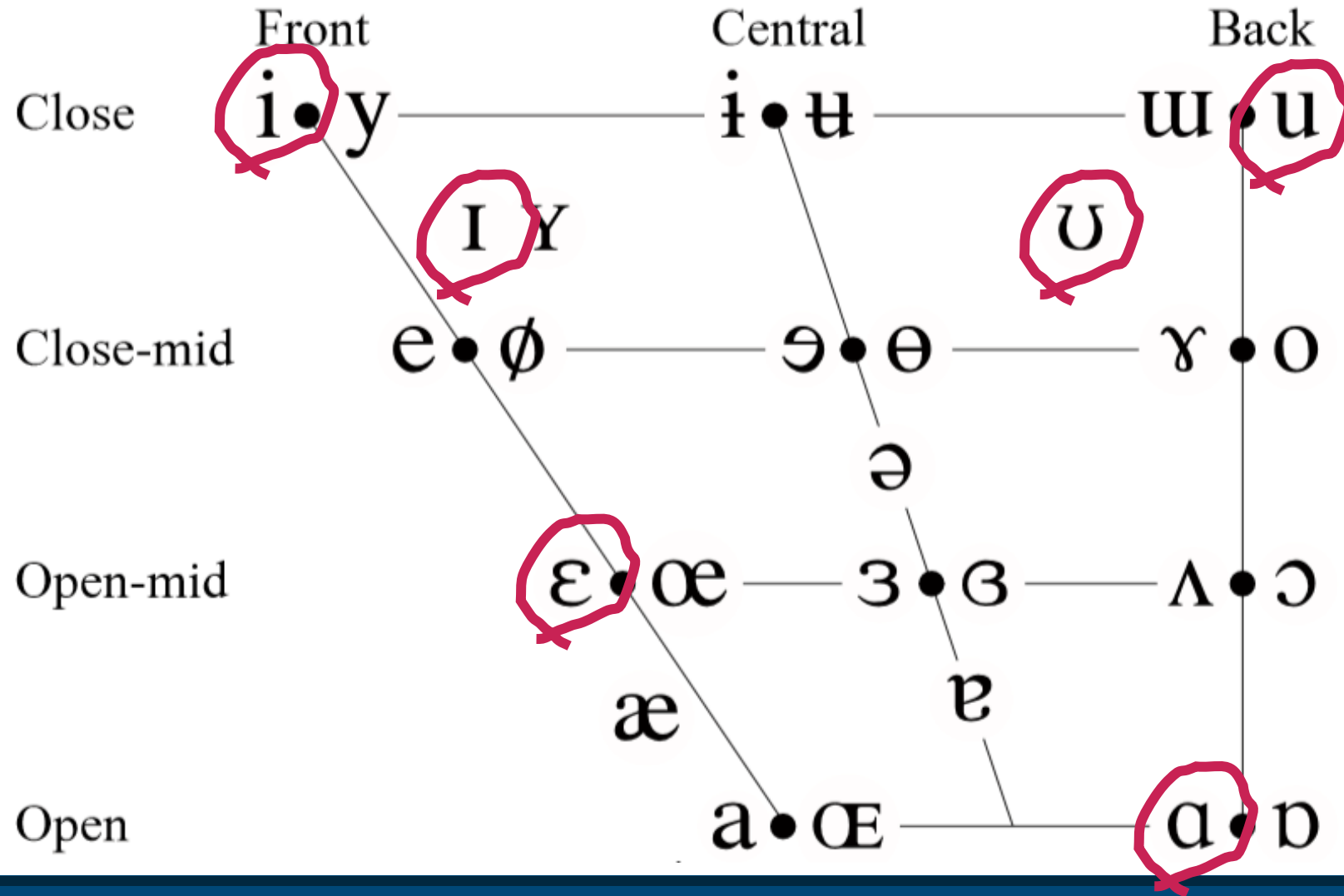
- Tool for Phonetic analyses
- Open and save files
- Navigate through the editor window (zoom, enabling spectrogram, etc.)
- Create and work with TextGrids
- Create and save recordings
- Use pre-made scripts

Acoustic Analyses I

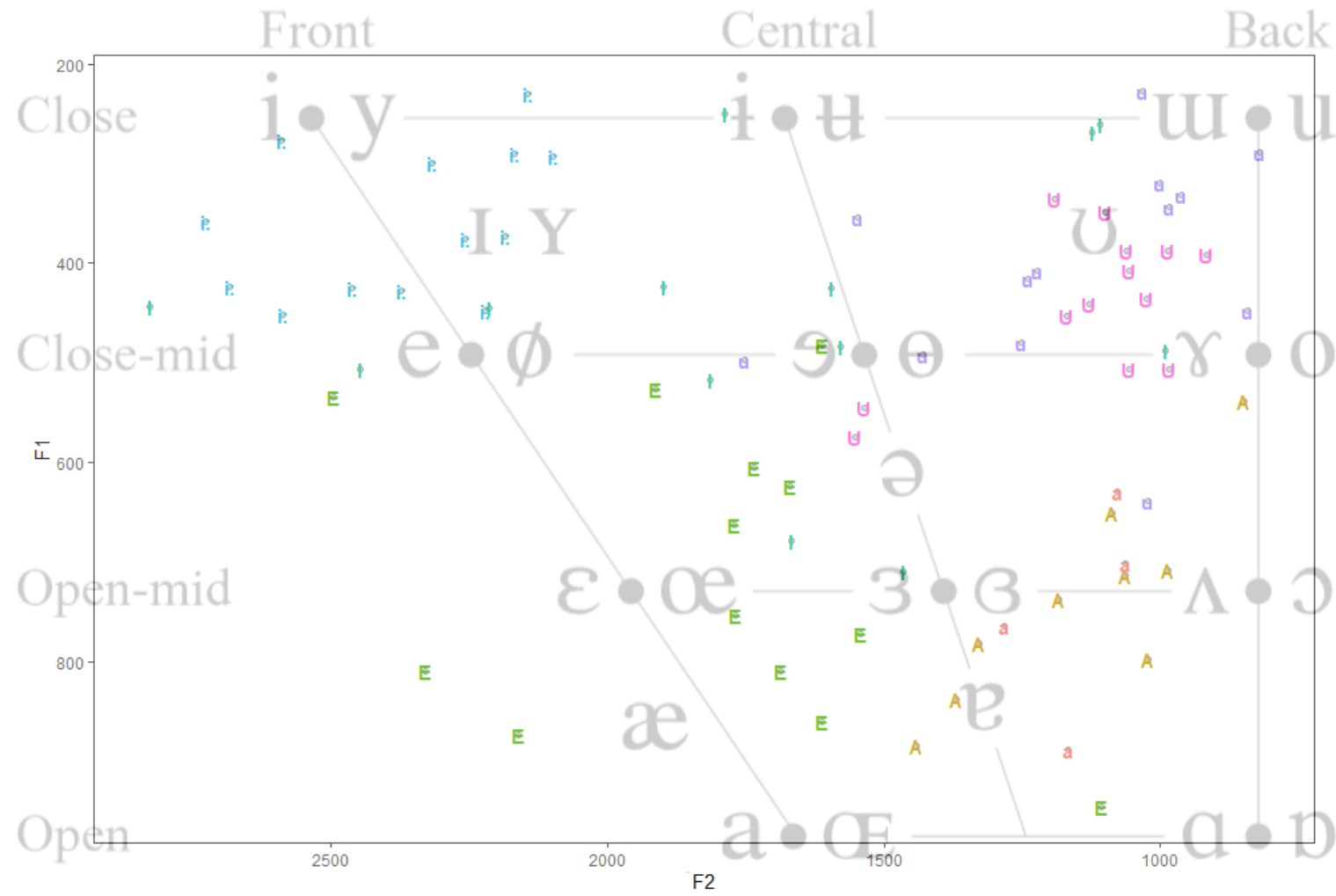
Assignment 4



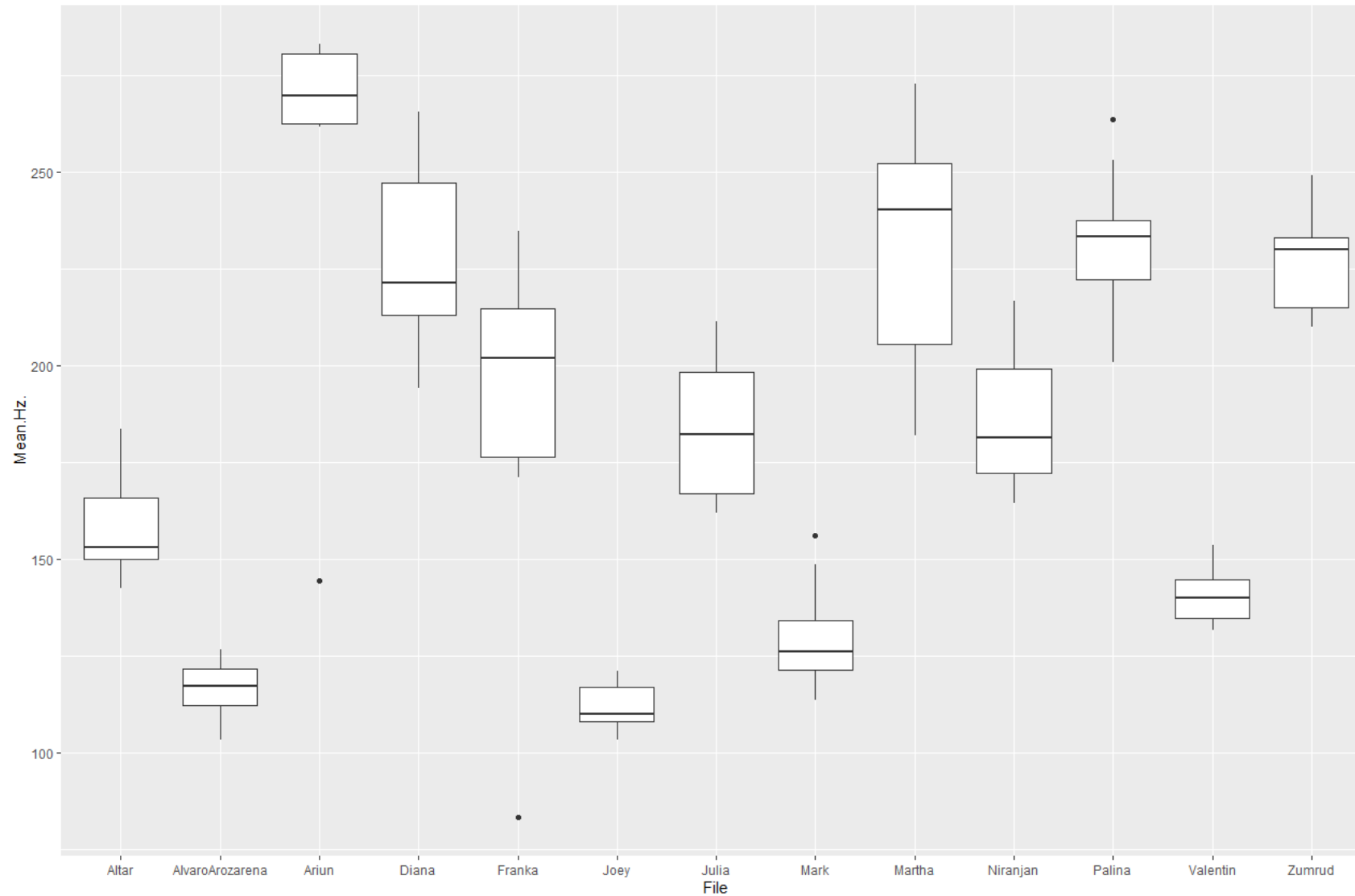
...close enough!



Assignment 4

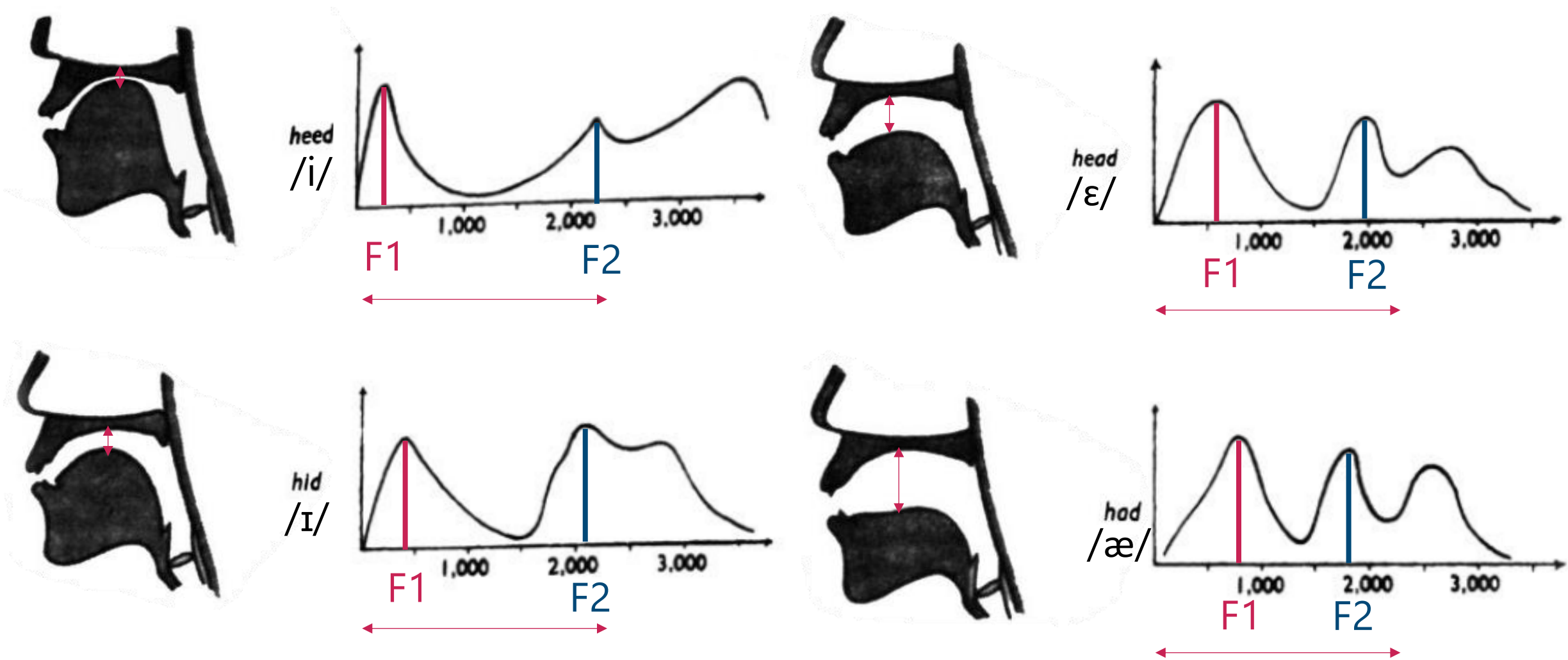


Assignment 4

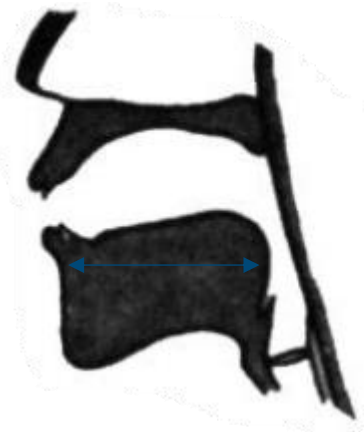


- Concentration of acoustic energy around a particular frequency in the speech wave
 - Local maxima in the spectrum
- Several formants, each at a different frequency
- Emerge as consequence of reinforcement of certain frequency ranges, corresponding to resonance characteristics of the vocal tract

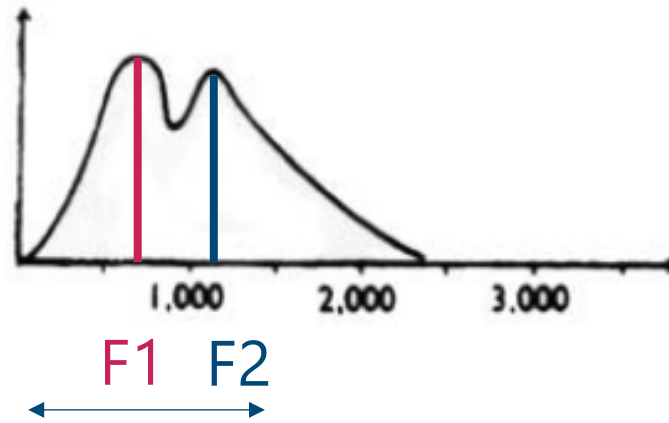
Formants



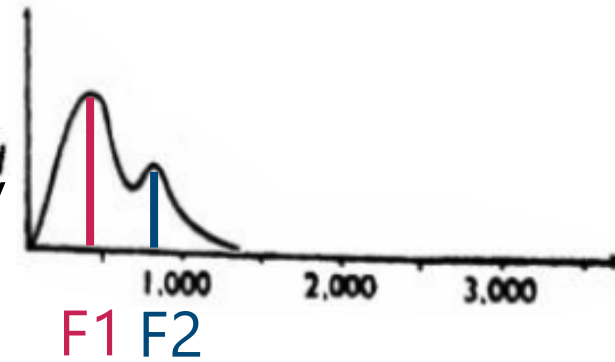
Formants



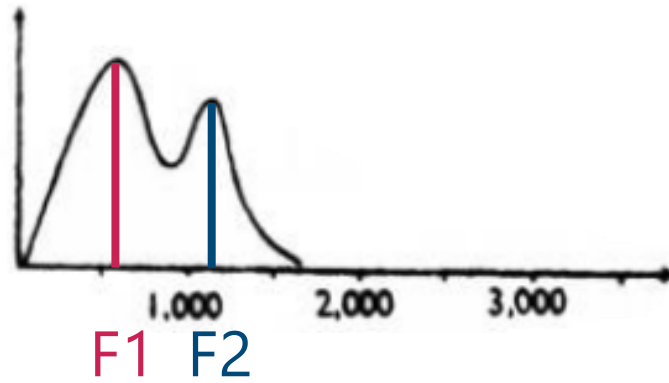
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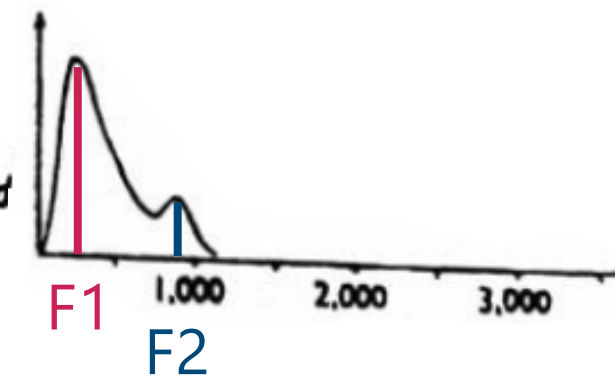
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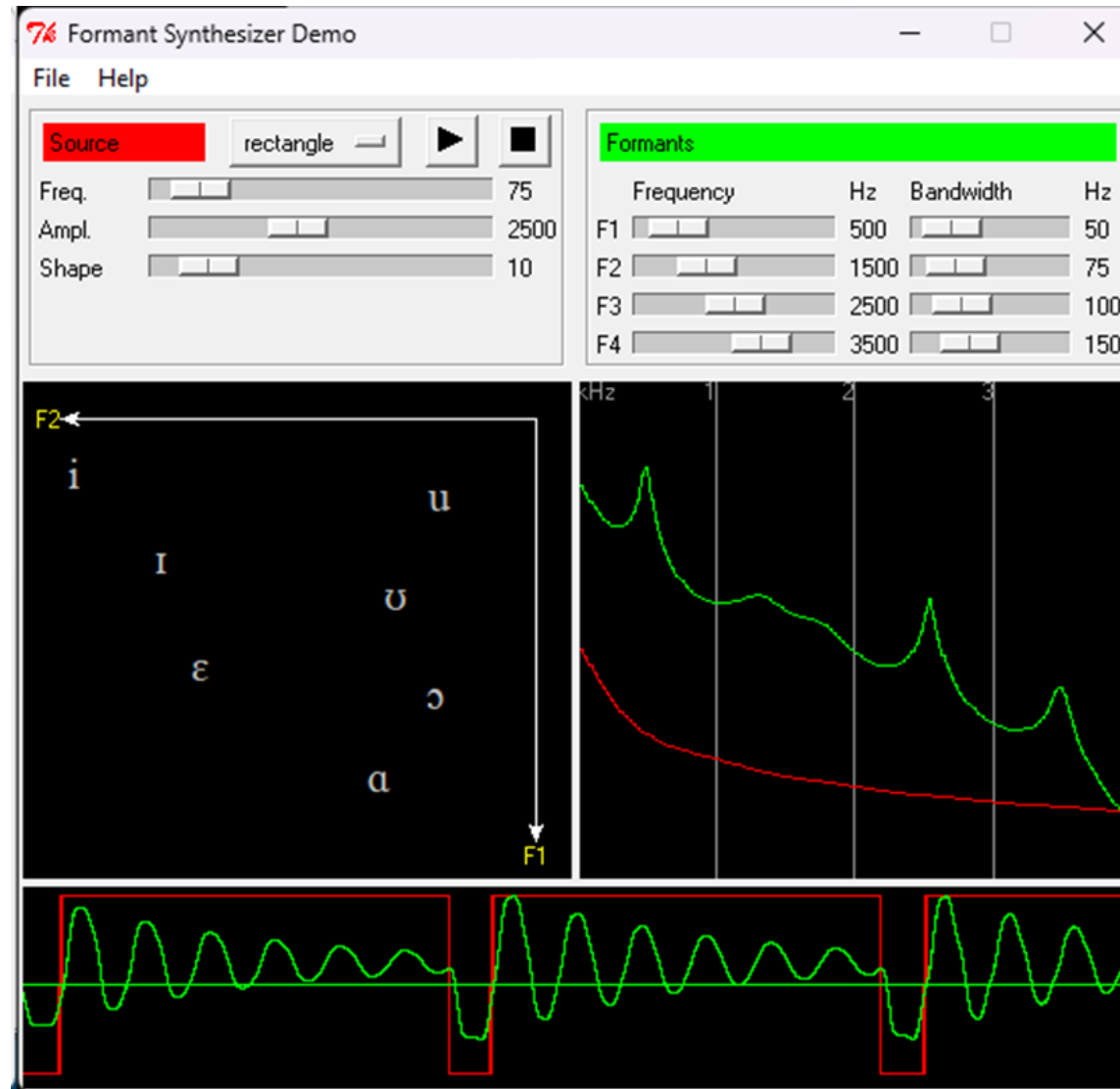
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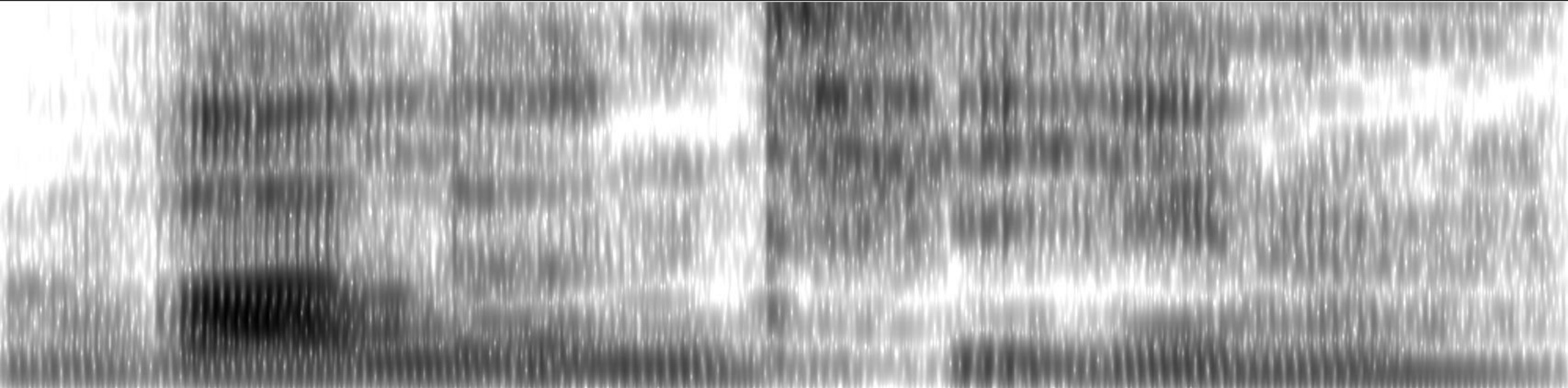
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Formant Synthesizer

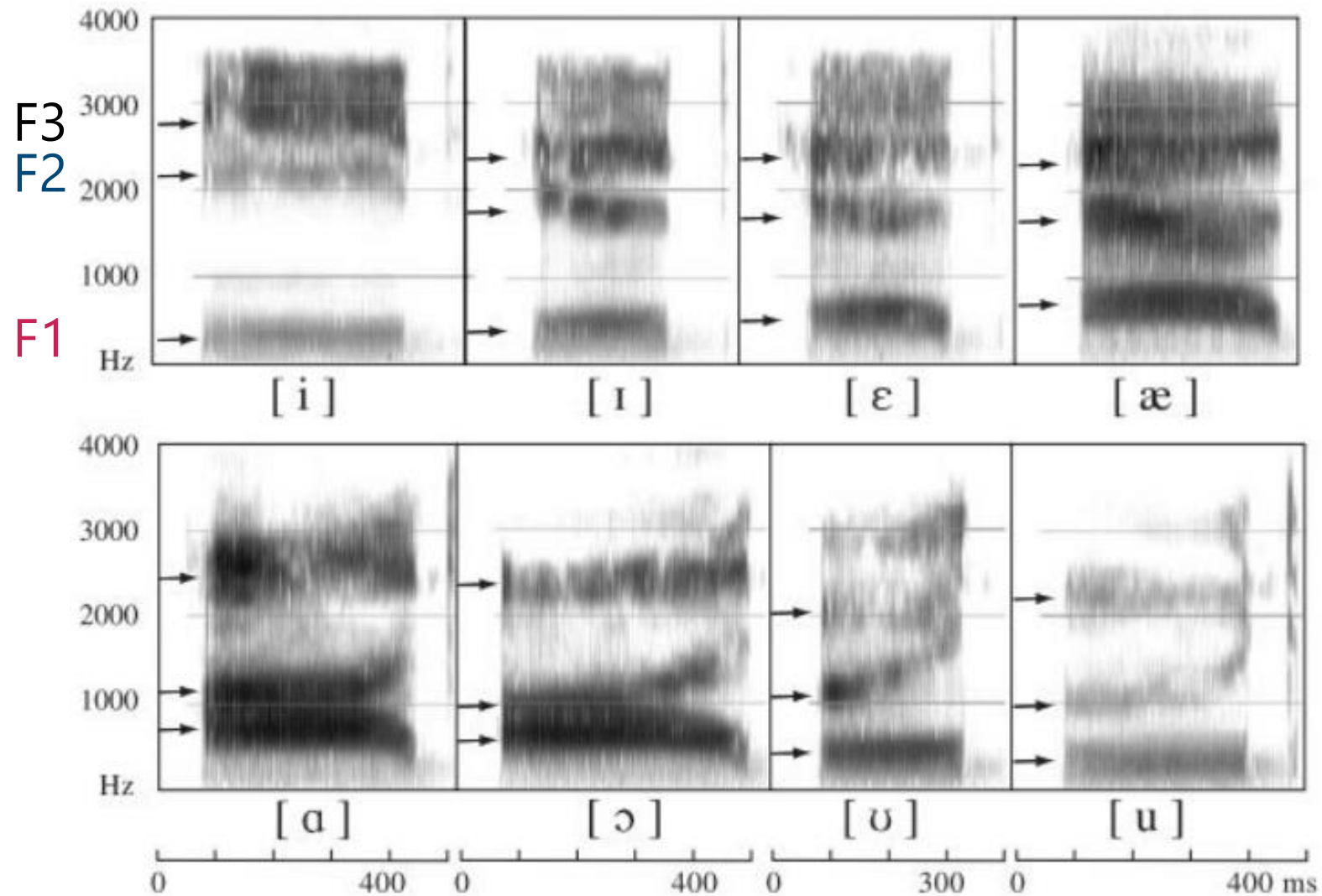


Spectrogram

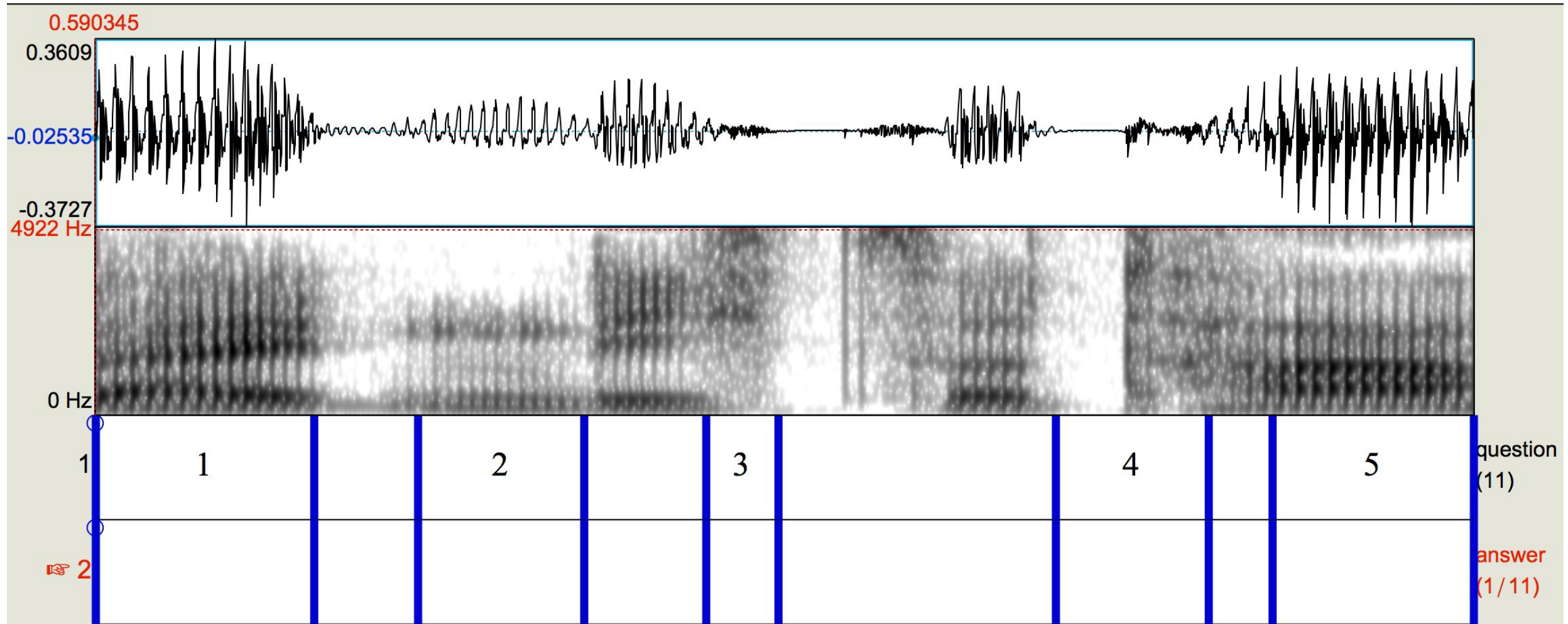


- X-axis: Time (s)
- Y-axis: Frequency (Hz)
- Blackening: sound pressure (p)

Formants in spectrogram

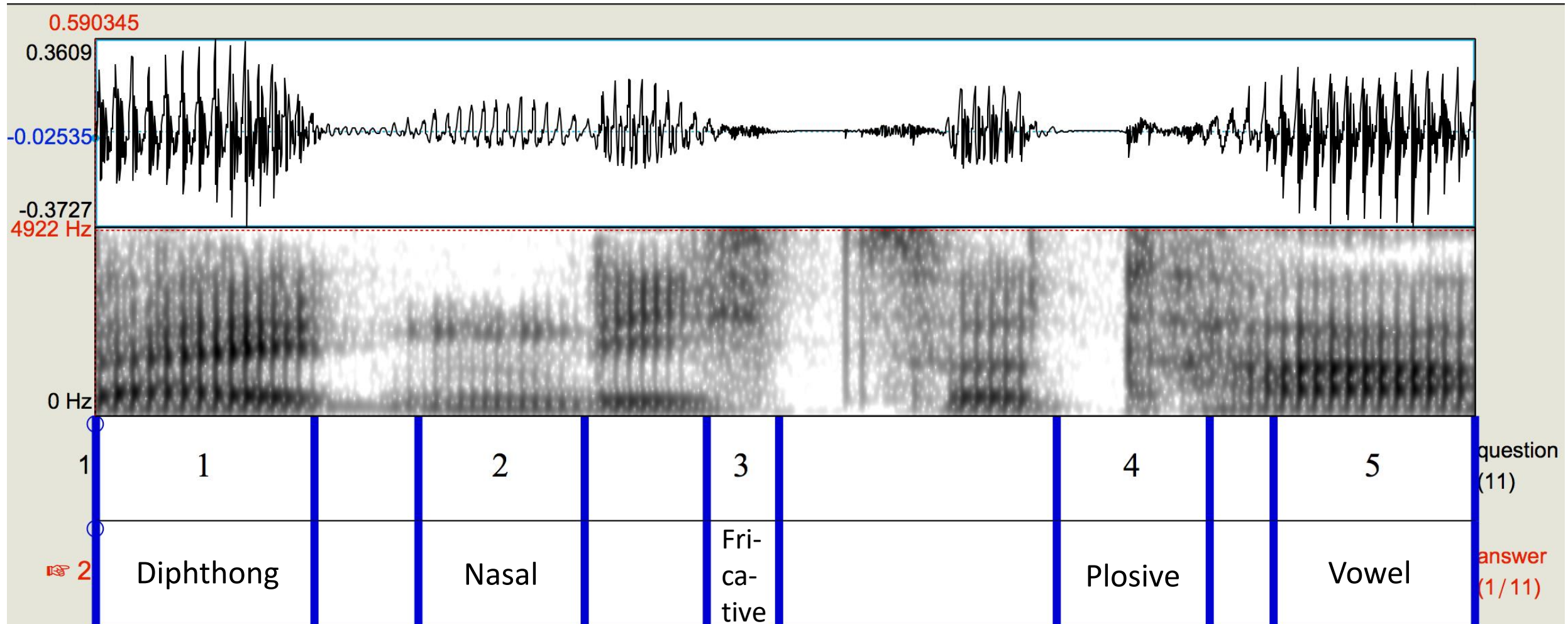


Exercise 1: Reading a spectrogram



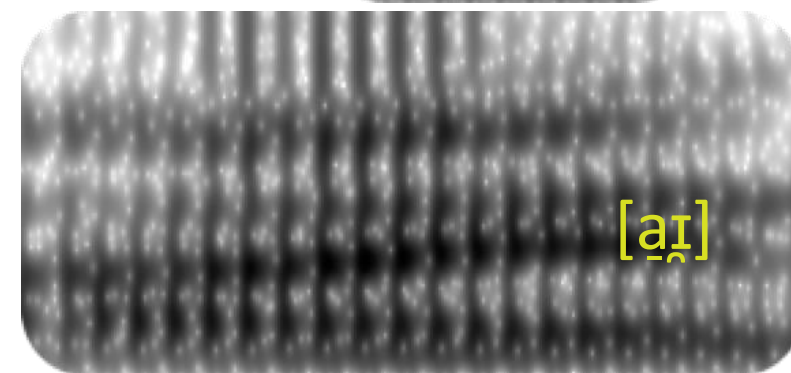
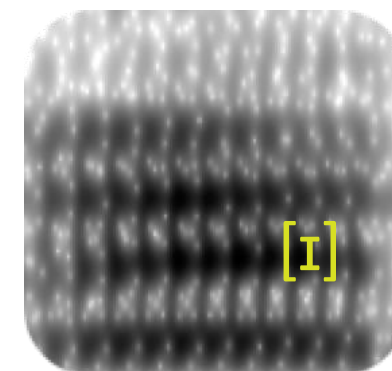
→ declarative.wav
→ declarative.TextGrid

Exercise 1: Reading a spectrogram



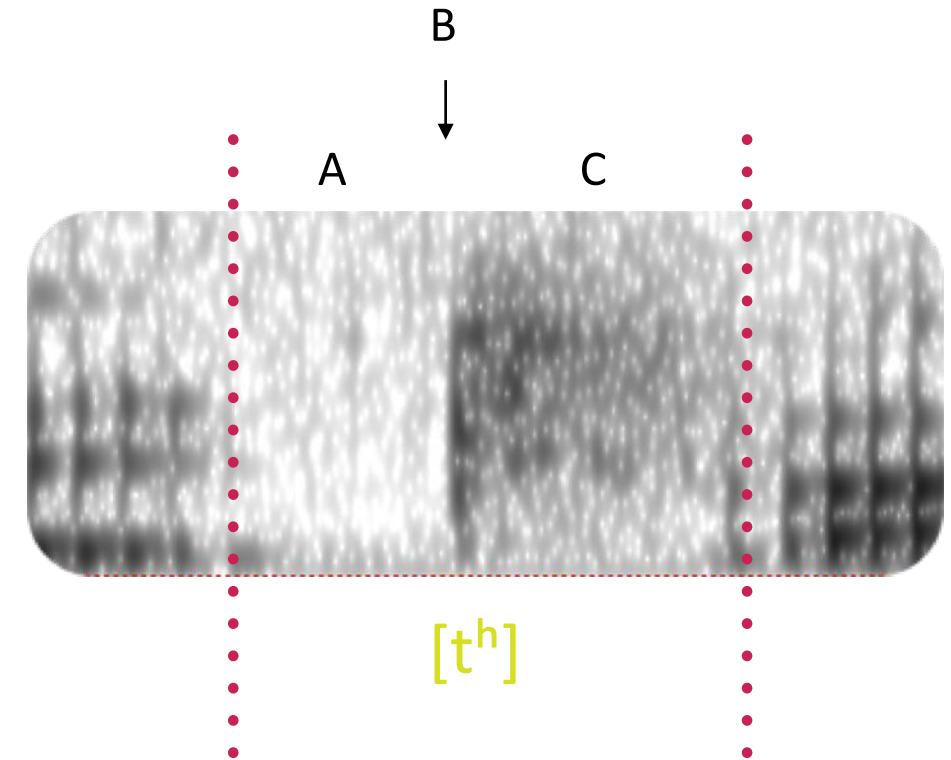
Reading a spectrogram: Vowels

- Voiced → quasi-periodic signal, **voice bar** in the lowest frequency area
- Concentrations of energy that can be found as horizontal frequency bands → Formants (F1, F2, F3, etc.)
- Discrimination from consonants:
 - Clearly visible formant structure
 - Can most likely be confused with laterals and nasals
- Diphthongs: clearly visible change of the vowel quality (formant structure) within the segment



Reading a spectrogram: Plosives

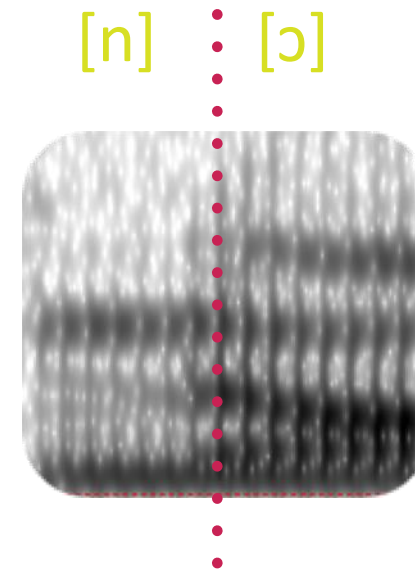
- (A) closure phase:
 - Acoustic silence → voiceless
 - (partially) visible voice bar → voiced
- (B) release of closure:
 - Sudden rise in spectral energy
- (C) aspiration phase → voiceless



Reading a spectrogram: Nasals

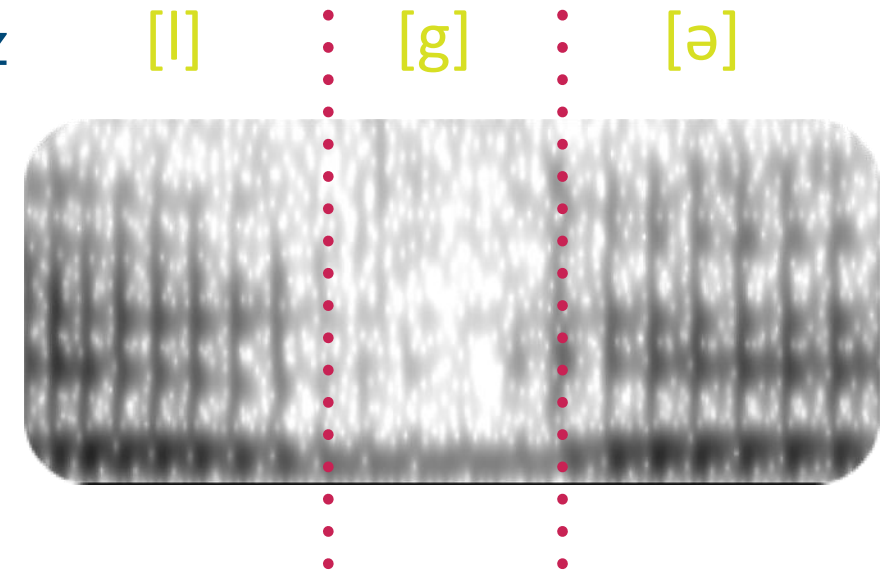
Discrimination from vowels:

- Opening nasal cavity → anti-formants emerge, muting parts of the spectrum → especially above 500 Hz
- Sudden change of formant structure



Reading a spectrogram: Laterals

- Strong similarity to vowels → classification at the intersection between consonants and vowels
- Anti-formants less apparent than for nasals
- Oftentimes: $F1 < 500$ Hz and $F2 = 1800$ Hz

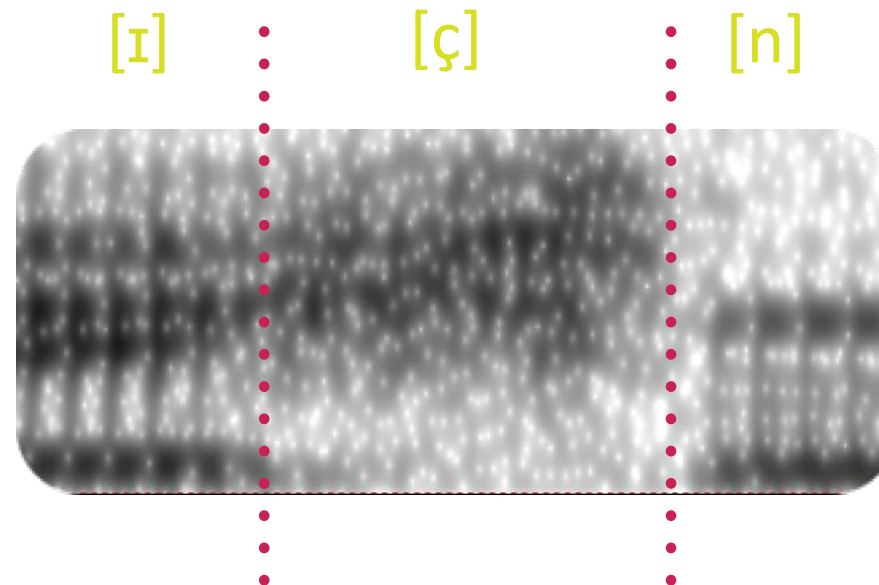


Reading a spectrogram: Fricatives

white noise = „all possible frequencies in the range of hearing are randomly present, at random amplitudes and in random relationships.“ CYF, p.216

Friction noise acoustically roughly resembles white noise

→ stochastic blackening, especially in higher frequency area, depends on place of articulation

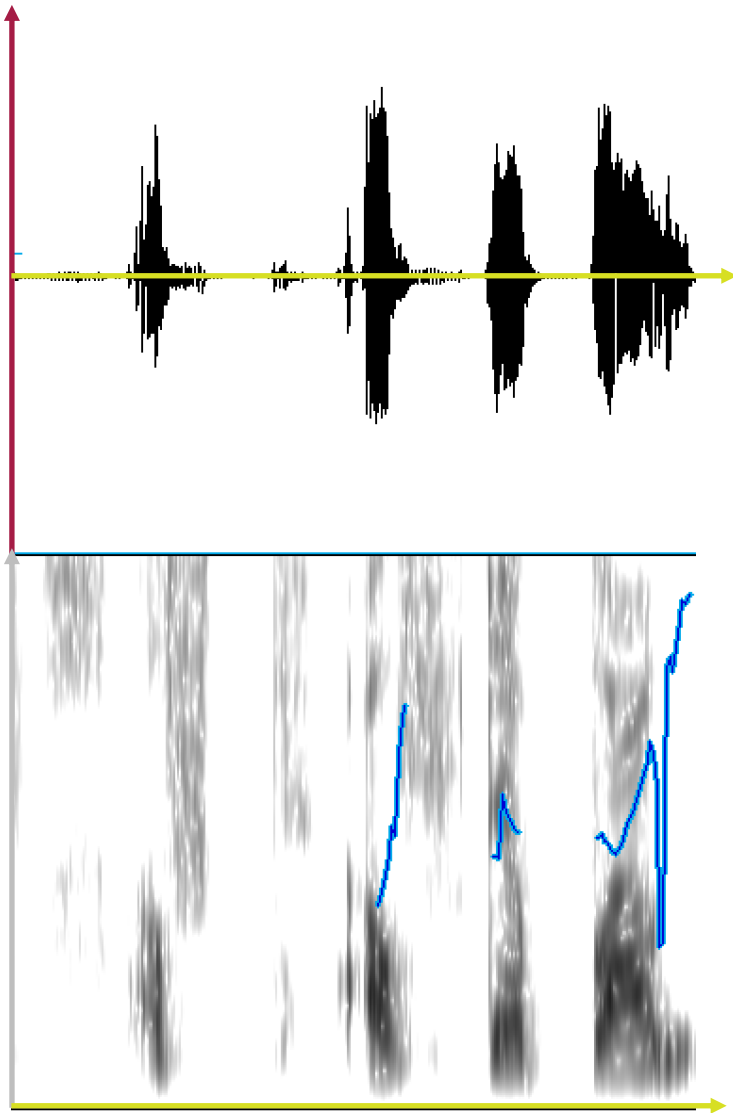


Exercise 2: Reading a spectrogram (again)

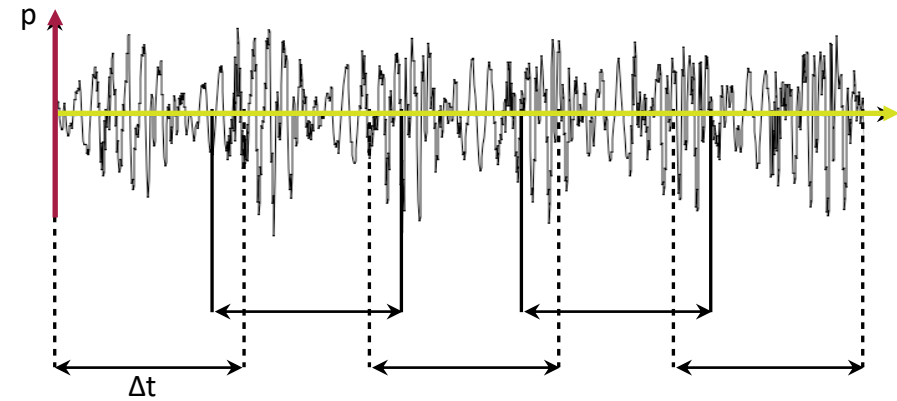
1. Please open Nordwind.wav and Nordwind.TextGrid in Praat
2. Zoom in on the area between 4.7s~ and 9.3s~
3. Classify the categories in the segments 1 to 10 **without listening**

*Diphthong – voiceless/voiced Fricative – Lateral –
Vowel – Nasal – voiceless/voiced Plosive*

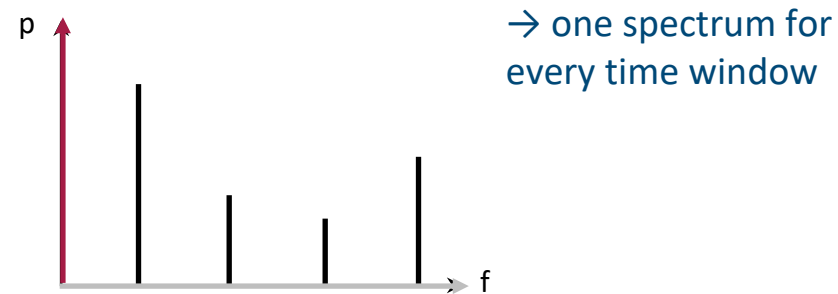
From oscillogram to spectrogram



(a) Windowing

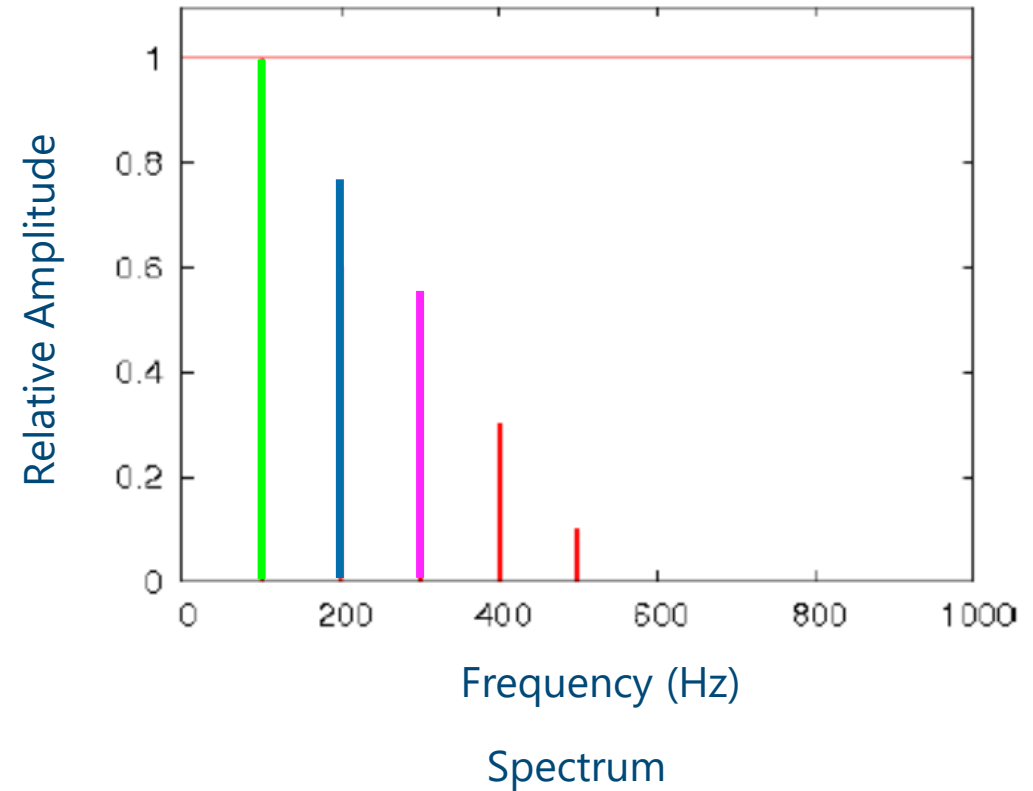
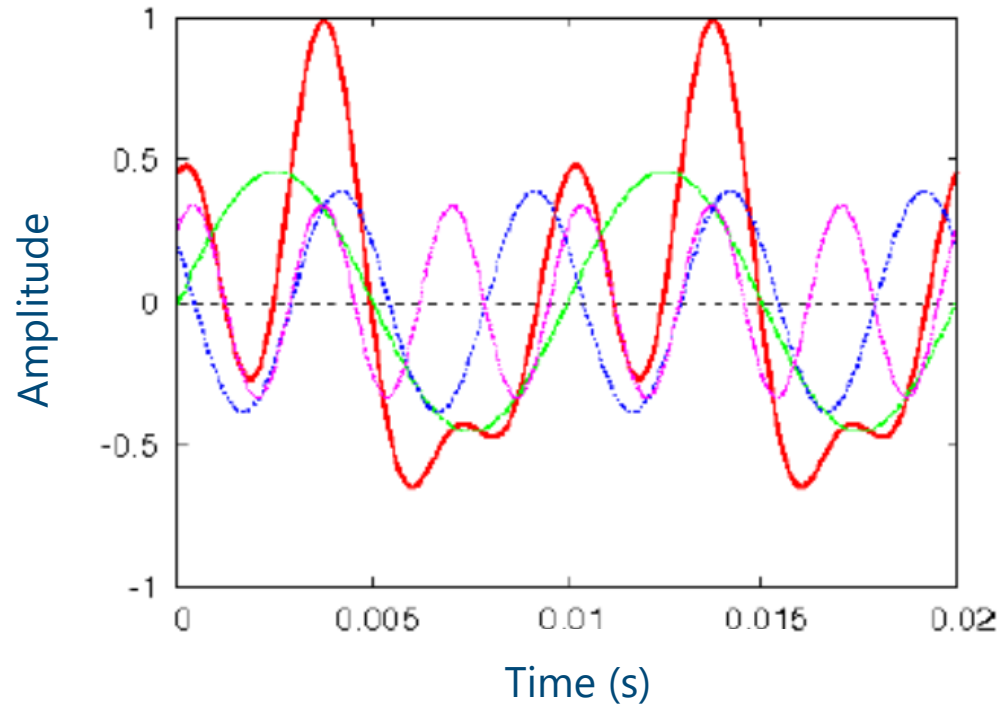


(b) Fourieranalyse

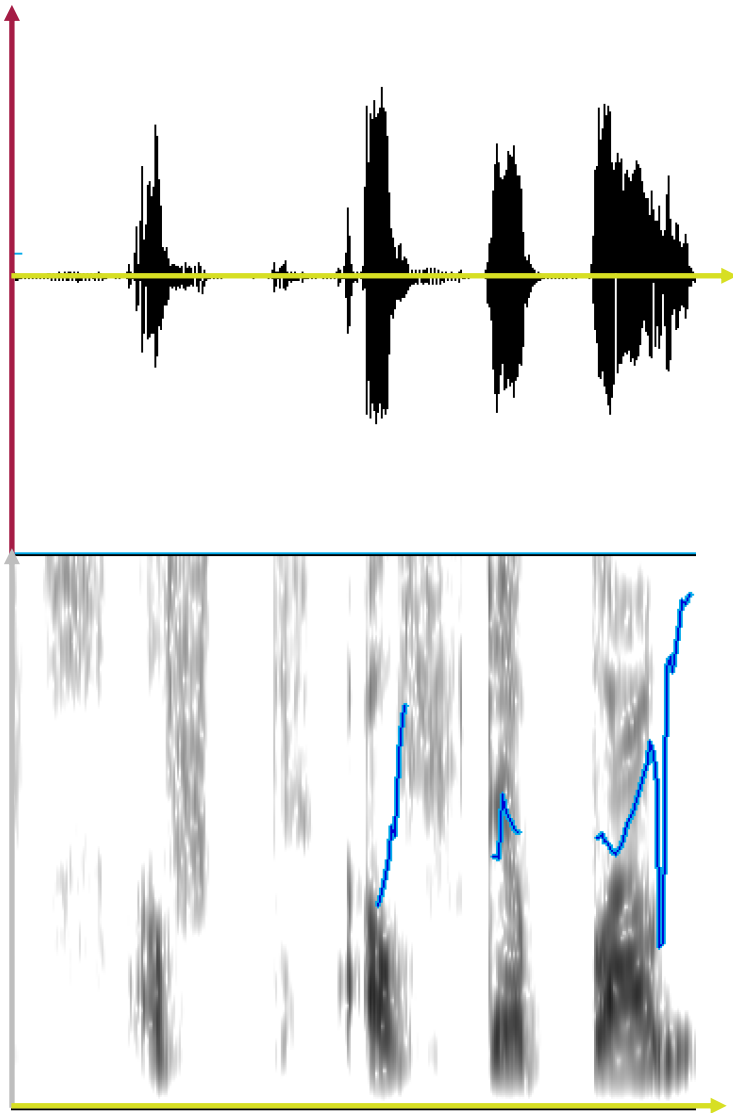


(c) Concatenation of spectra of adjacent time windows

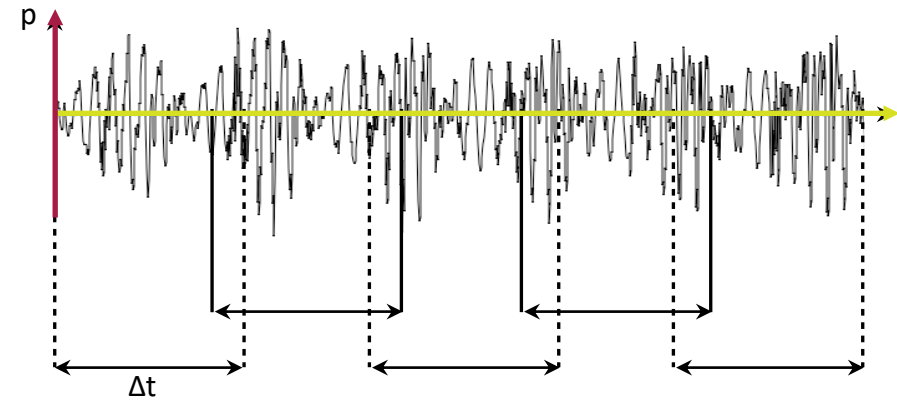
Simple vs. complex sound waves



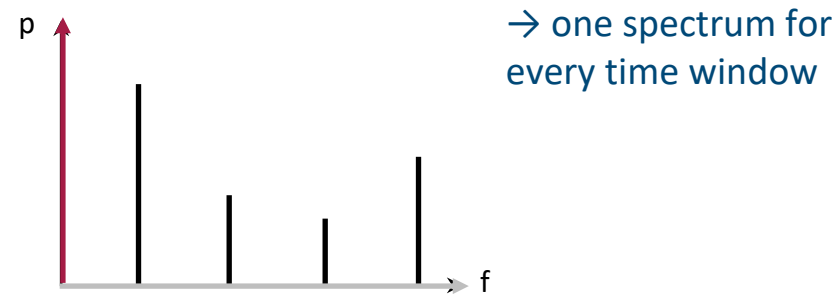
From oscillogram to spectrogram



(a) Windowing



(b) Fourieranalyse



(c) Concatenation of spectra of adjacent time windows

Exercise 3

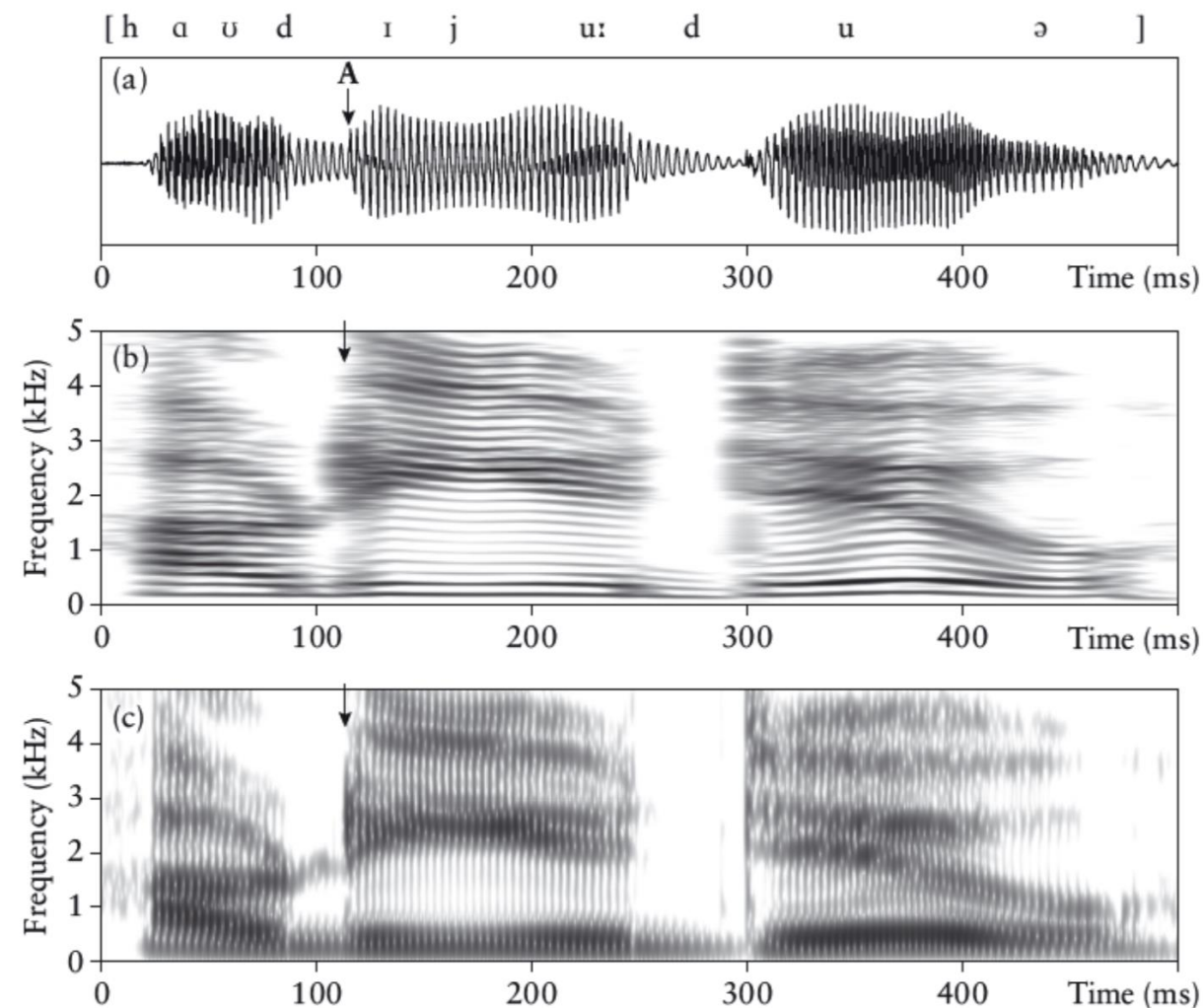
What can you see in
spectrograms (b) and (c)?

✓ Harmonics*

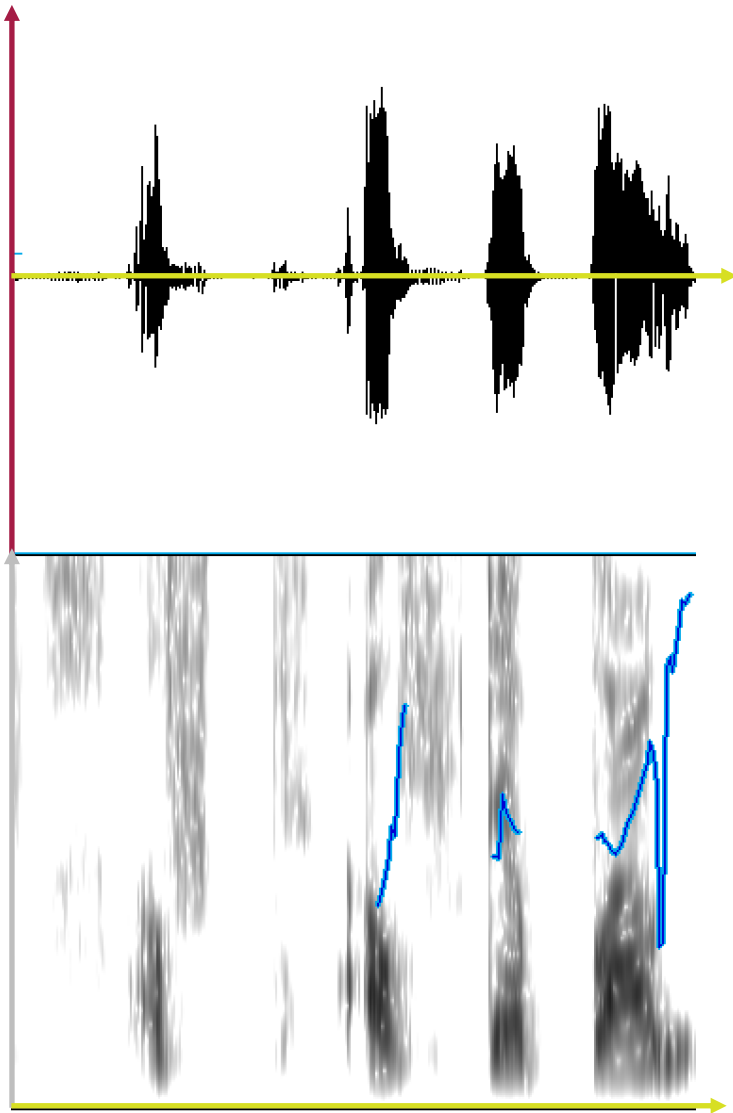
✓ Glottal pulses

✓ Formants

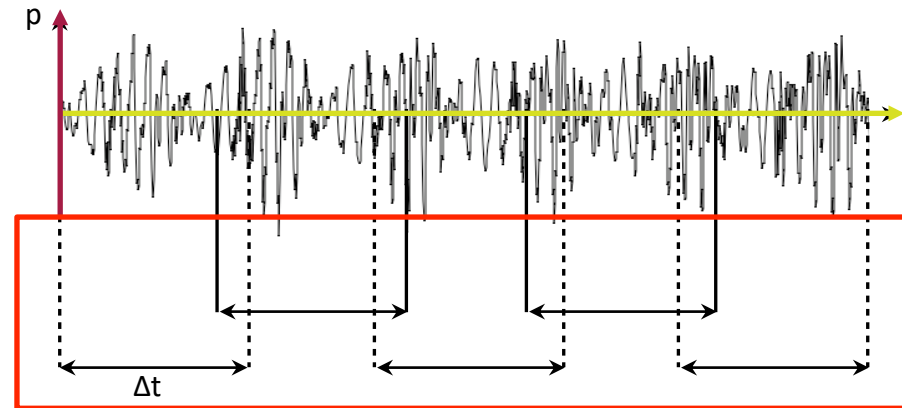
*integer multiple of the fundamental frequency ($\neq$ Formants)



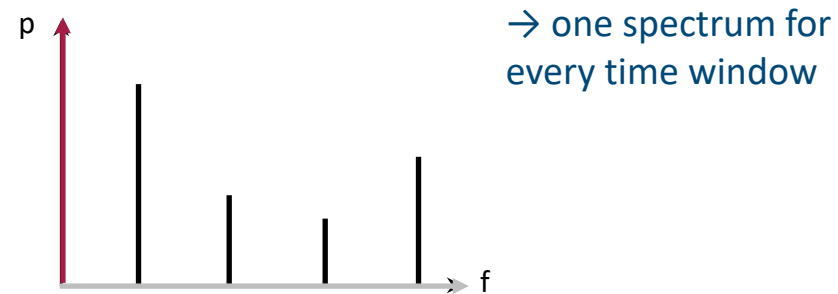
From oscillogram to spectrogram



(a) Windowing

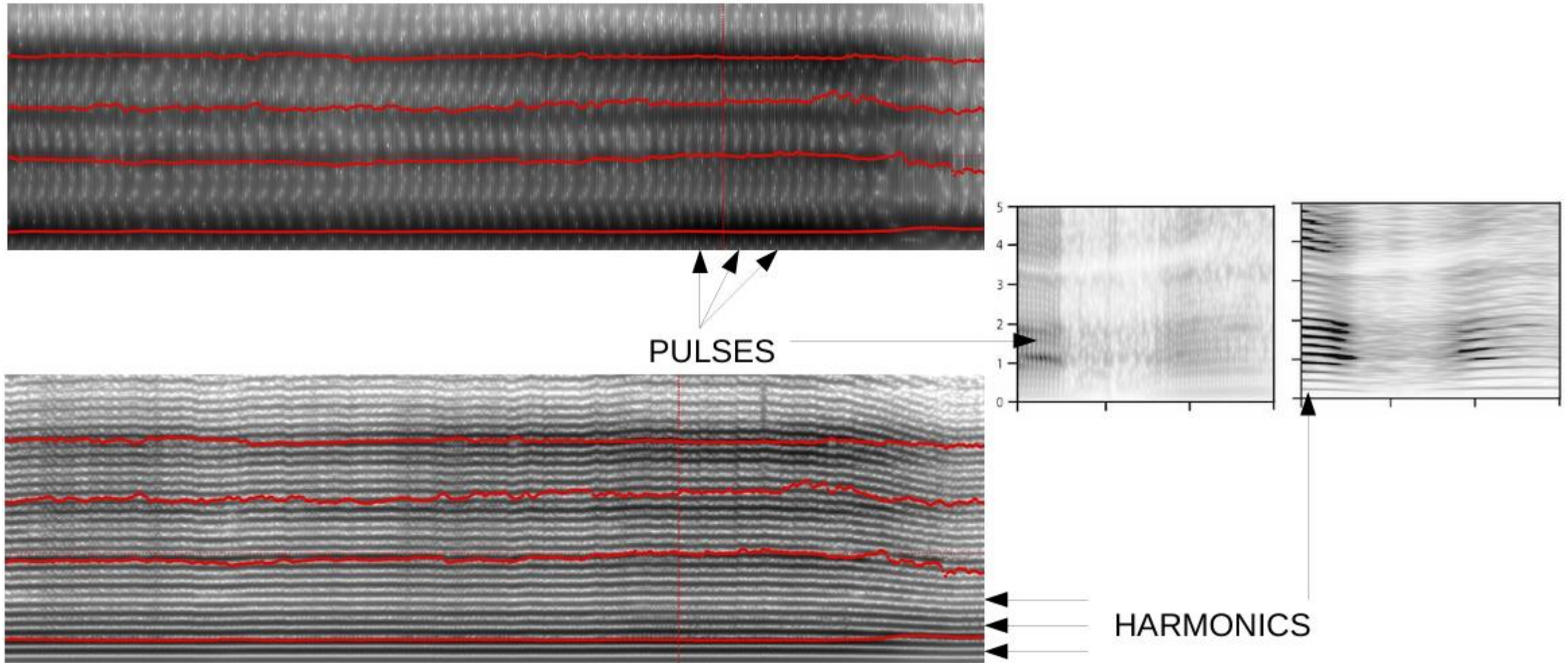


(b) Fourieranalyse



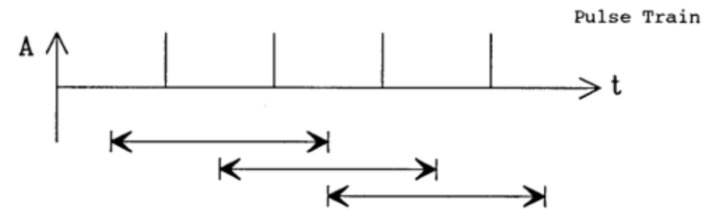
(c) Concatenation of spectra of adjacent time windows

Narrowband vs. wideband spectrogram

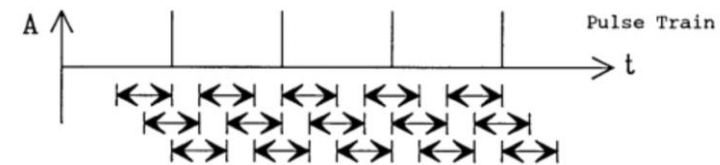


Narrowband vs. wideband spectrogram

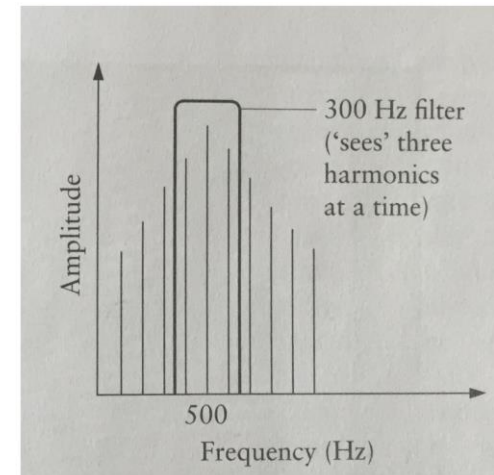
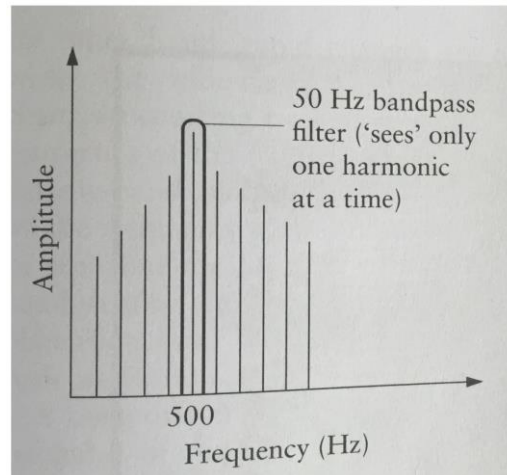
Long Analysis Sections



Short Analysis Sections

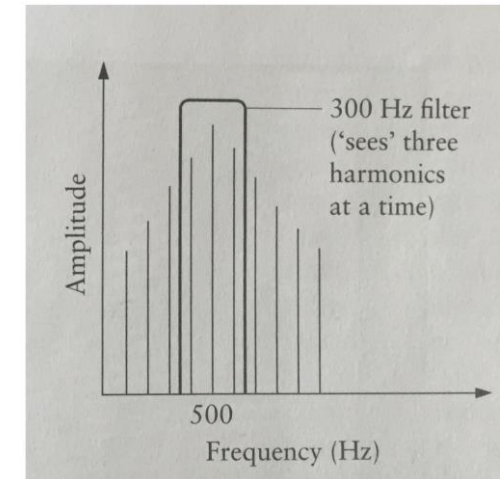
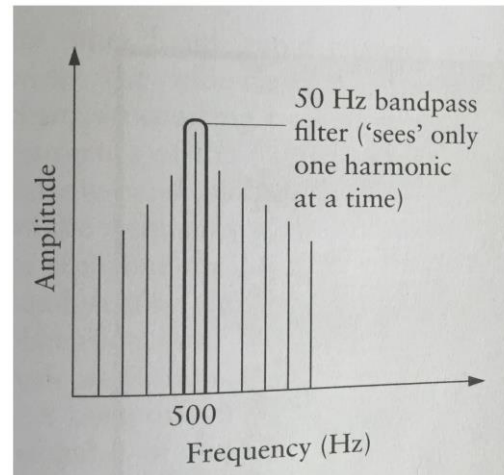


Analysis window		e.g. 30 ms		e.g. 5 ms
Bandwidth		↳ 43 Hz		↳ 260 Hz
Spectrogram		narrow band		wide band



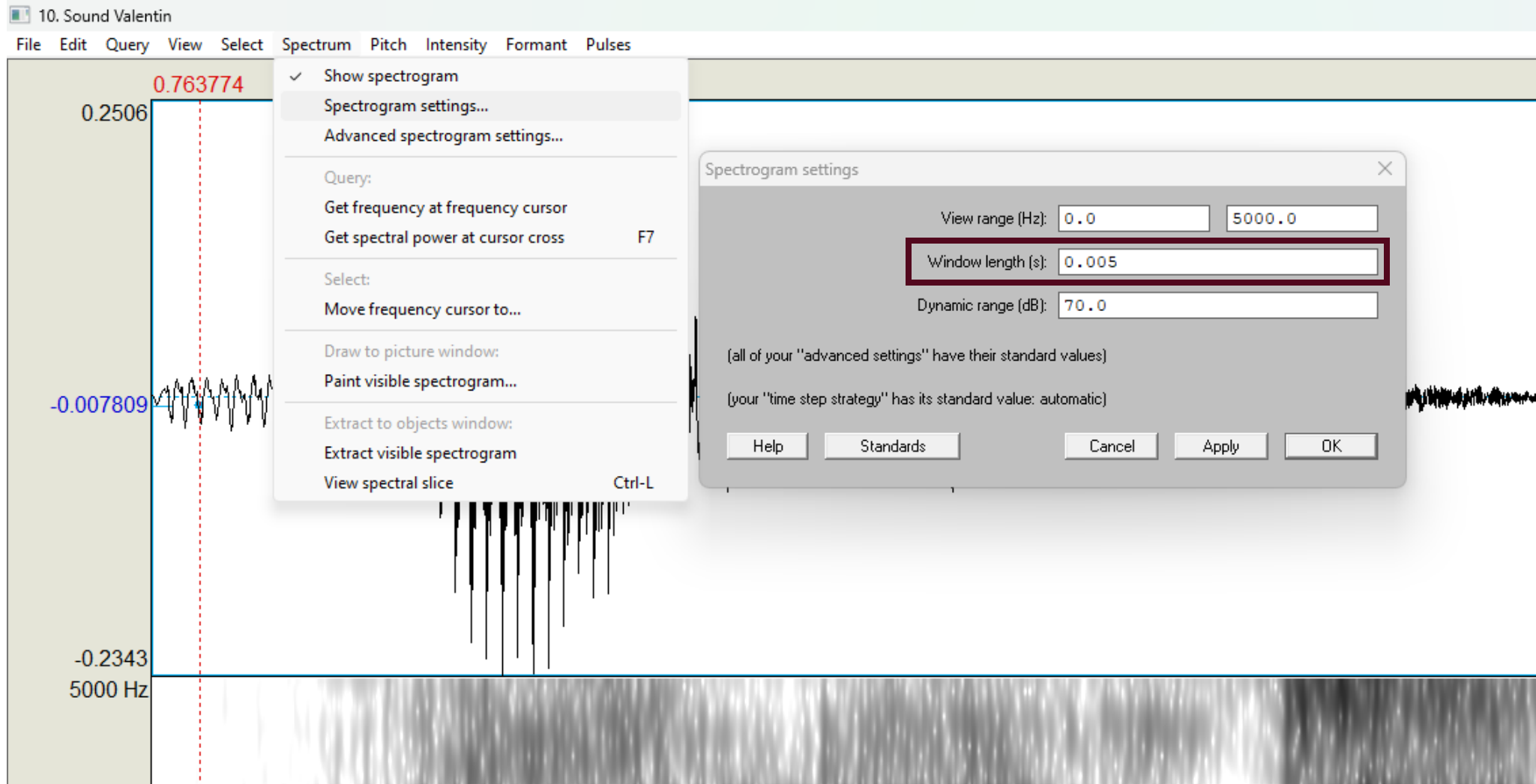
Narrowband vs. wideband spectrogram

Analysis window		e.g. 30 ms		e.g. 5 ms
Bandwidth		↳ 43 Hz		↳ 260 Hz
Spectrogram		narrow band		wide band



Time		low resolution		high resolution
Frequency		high resolution		low resolution
Analysis		✓ harmonics ✓ fundamental frequency / intonation		✓ individual glottal pulses ✓ formant structure

Changing spectrogram in Praat



The screenshot shows the Praat software interface with the 'Spectrum' menu open. The 'Spectrogram settings...' option is selected, which has opened a 'Spectrogram settings' dialog box. The dialog box contains the following settings:

- View range (Hz): 0.0 to 5000.0
- Window length (s): 0.005 (highlighted with a red box)
- Dynamic range (dB): 70.0

Below the settings, there are two informational lines:

- (all of your "advanced settings" have their standard values)
- (your "time step strategy" has its standard value: automatic)

At the bottom of the dialog box are five buttons: Help, Standards, Cancel, Apply, and OK.

The background shows the Praat interface with a waveform and a spectrogram. A red vertical cursor is positioned at 0.763774 seconds. The frequency axis is labeled from 0.2506 to 5000 Hz. The amplitude axis ranges from -0.007809 to -0.2343.

Useful / interesting links

- Resonance: <https://www.youtube.com/watch?v=dihQuwrf9yQ>
- Formant, Fundamental, or Harmonic?
<https://www.youtube.com/watch?v=PLzhqqNaEP0&t=43s>
- How to read spectrograms:
<https://home.cc.umanitoba.ca/~robh/howto.html>

Assignment 5

1. Please make a recording of your first name
2. Segment all sounds
3. Categorize them by looking at the spectrogram
4. Take a screenshot of the spectrogram
5. Send me the screenshot and the resulting wav and TextGrid files via MSTeams or e-mail

Thank you for your participation!

