Acoustic analysis of prosody: linguistic and forensic applications

Ling 450

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Roadmap

- Introduction to prosodic analysis of speech
- How to do prosodic analysis in Praat
- Assignment

Speech prosody

- The pitch and rhythmic features of suprasegmentals of speech:
  - fundamental frequency (f0)
  - voice quality
  - duration, etc.

- Linguistics:
  - Prosodic grouping and prominence
  - Linguistic use of f0, voice quality and duration

- Forensic linguistics:
  - Speaker profiling and comparison

Linguistic prosodic structure

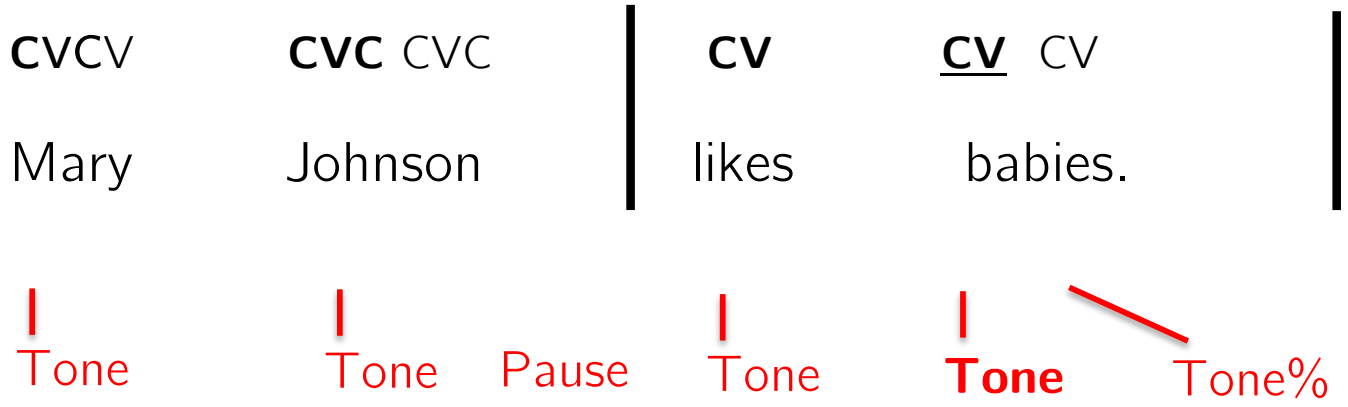
- Prosodic grouping:
  - Basic units: consonants and vowels (C and V).
  - C and V group into syllables.
  - Syllables group into higher-level prosodic phrases.

- Prosodic prominence
  - Lexical stress
  - Phrasal prominence

CVCV	**CVC** CVC	**CV**	**CV** CV
Mary	Johnson	likes	babies.

Linguistic prosodic structure

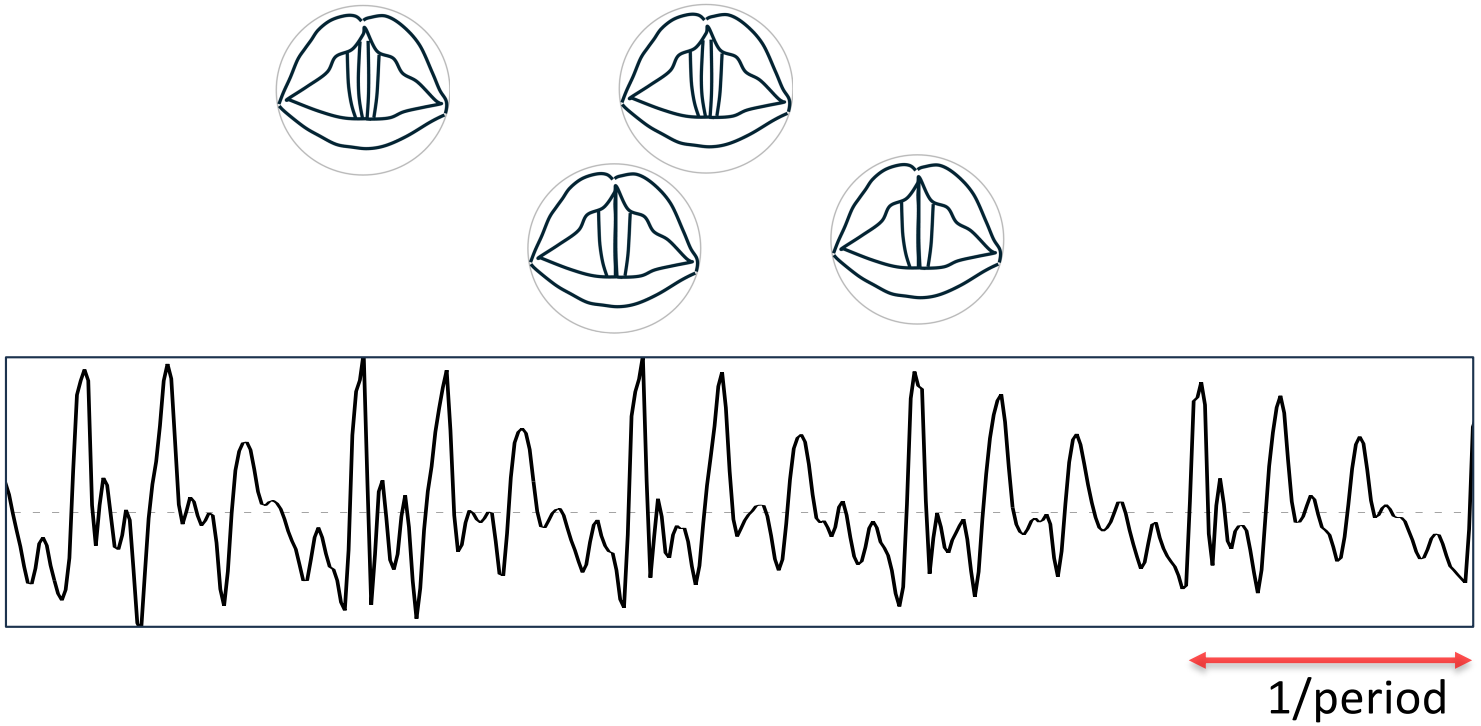
- Phonetic properties:
  - Tones (f0),
  - voice quality (like phonation type),
  - tempo (duration), etc



Fundamental Frequency (f0)

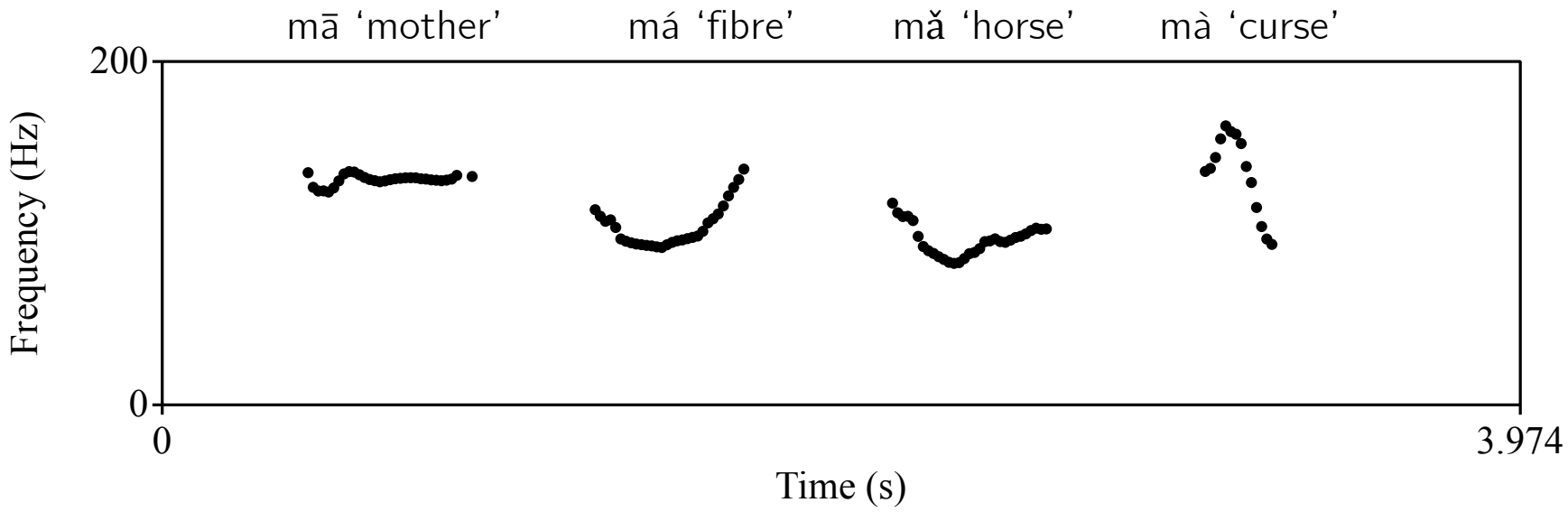
What is f0?

- Production: fundamental frequency (f0) of vocal fold vibration
- Acoustics: lowest frequency component of a periodic sound wave
- Perception: Pitch



Linguistic use of f0: lexical tone

- F0 over time—f0 track.
- e.g., how do f0 tracks differ among the four Mandarin tones?



Linguistic use of f0: intonation

- Declaratives vs. yes-no questions:
  - Final f0 rise for yes-no questions

    American English:

    Mary Johnson likes babies./?

    HL/LH

  - Final f0 fall for yes-no questions

    Kabiye:

    édí./? 'and he licked.'

    HH./HHL?

Linguistic use of f0: intonation

- Global rise for yes-no questions

Mandarin:
張丹蒸山雞./? 'Zhang Dan steams wild chicken./?'
HHHHH.

Setswana:
Ba bona podi./? 'They see a goat./?'
HHHHL

Sociolinguistic f0 patterns of intonation

- **British and American English'**
  - British: more generally final fall rise (polite)
  - American: final rise

'Was it **di**fficult?'
'You mean Mount **E**verest?
'Do you want some **tea**?'

Sociolinguistic f0 patterns of intonation

- Other varieties of English 

  Please call Stella. Ask her to bring these things with her from the store: Six spoons of fresh snow peas, five thick slabs of blue cheese, and maybe a snack for her brother Bob. We also need a small plastic snake and a big toy frog for the kids. She can scoop these things into three red bags, and we will go meet her Wednesday at the train station.

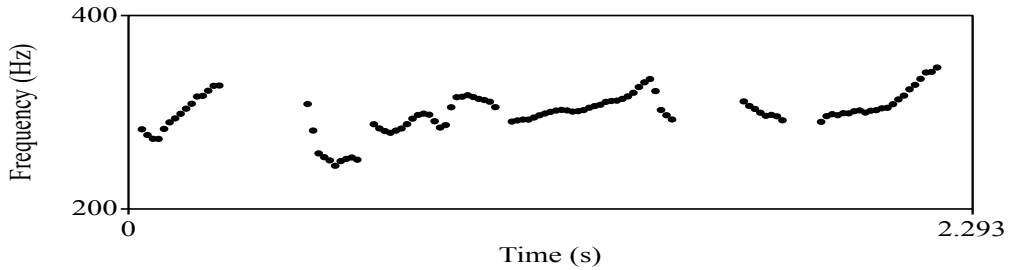
  What intonational patterns do you notice?
  Can you guess the speaker's regional or dialectical background?

https://accent.gmu.edu/browse_language.php?function=detail&speakerid=3033

Sociolinguistic f0 patterns of intonation

- Uptalk

I am not thinking about marriage right now. ---^



- Is there any pitch difference between questions and uptalk?
- Beyond the stereotype: Is there any other meaning of uptalk intonation?

From Accurate English– Lisa Mojsin https://www.tiktok.com/t/ZTMYq1shb/

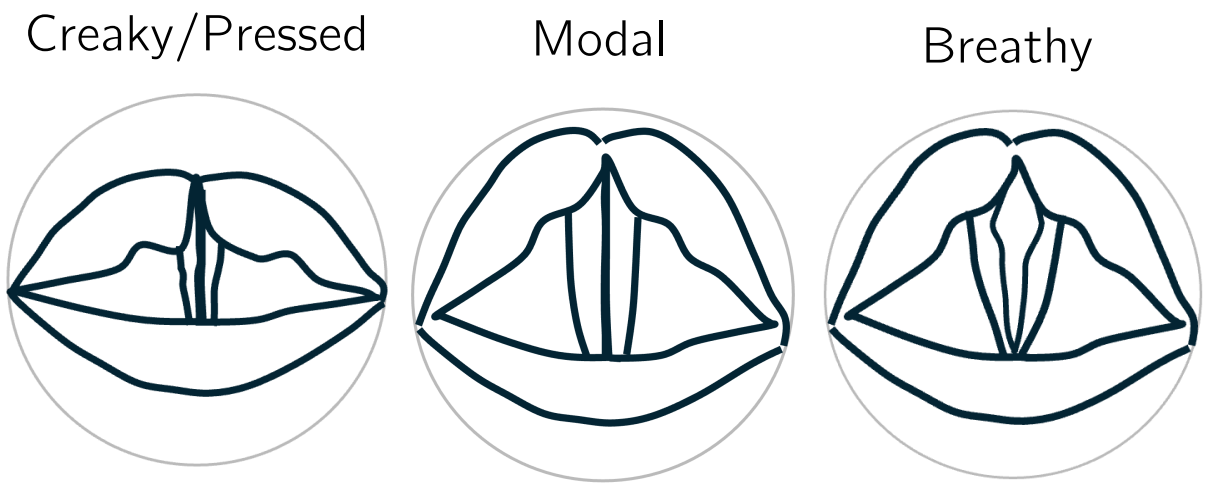
F0 analysis in forensic linguistics

- Speaker profiling and comparison:
  - F0 as a primary indicator of sex and gender
  - Long-term statistics: F0 averages, ranges, standard deviations
  - Tone and intonational properties: may signal a speaker's region and dialectal background
  - Could be tricky due to ***within-speaker variation***. Needs to consider other features as well

Voice Quality

Production of voice quality

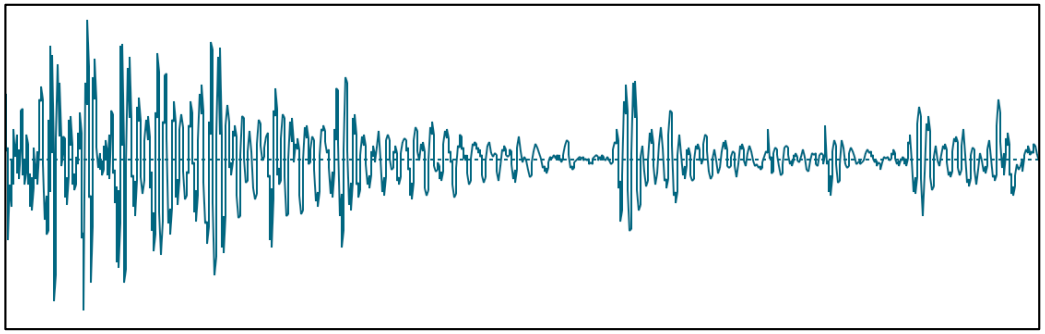
- Phonation types:
  - How is the state of glottis different?



Acoustics of voice quality

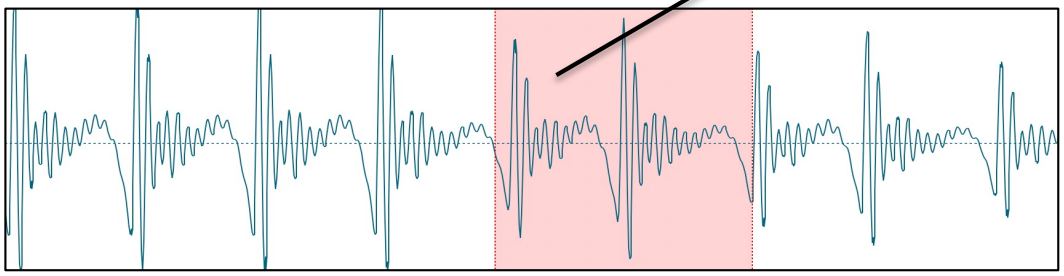
- Acoustics of phonation types
  - Creaky voice tends to have irregular vocal fold vibration.

Irregular pulsing



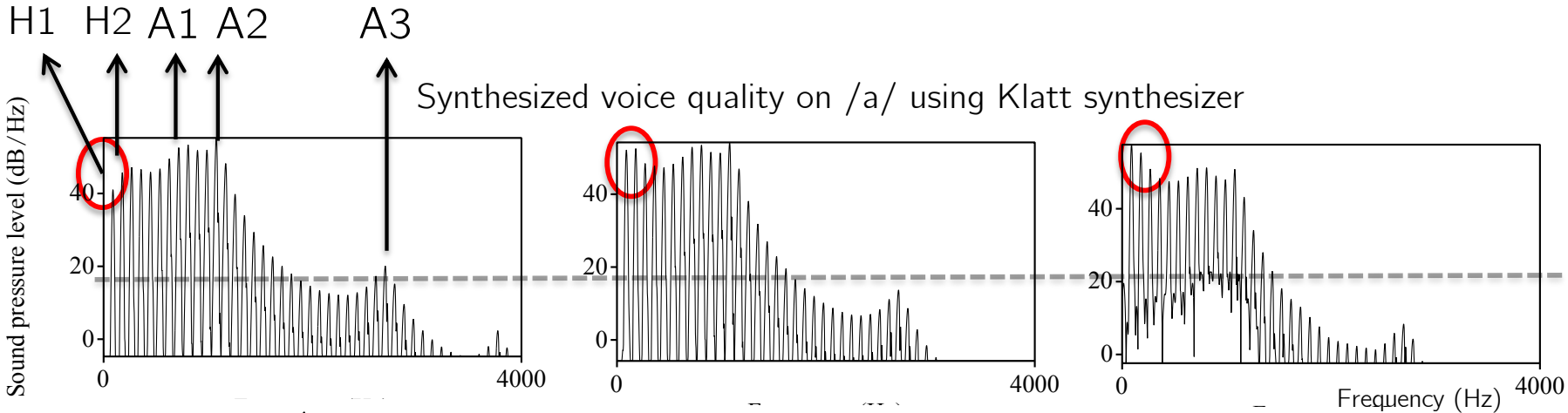
Double pulsing

Shorter period/ attenuated amplitude



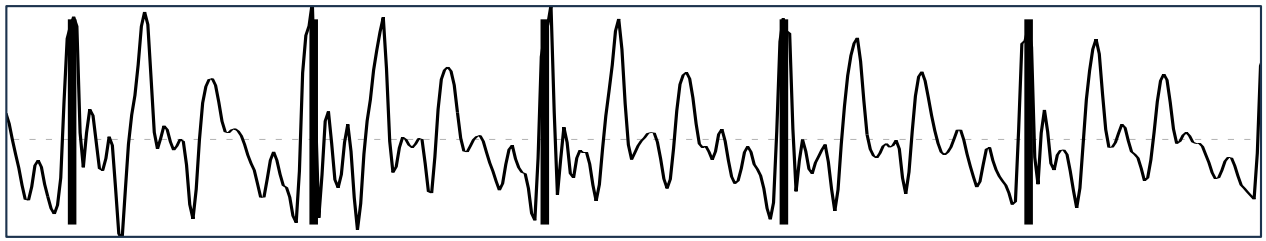
Acoustics of voice quality

- Acoustics of phonation types
  - H1-H2 (amplitude differential between first and second harmonics)
  - Lower energy in higher-frequency region (H1-An)
  - H1-H2: creaky < modal < breathy

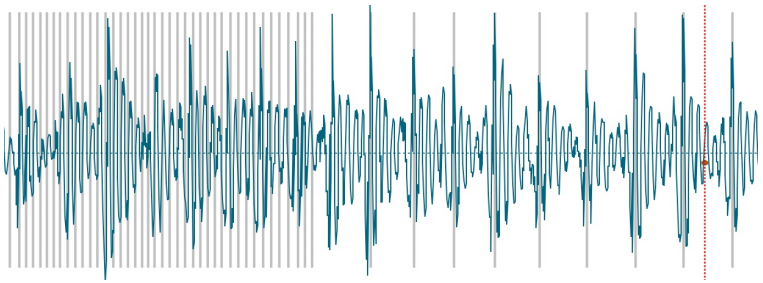


Acoustics of voice quality

- Perturbation measures:
  - Jitter: Cycle-to-cycle variation in period.
  - Shimmer: Cycle-to-cycle variation in the amplitude



- Do different phonation types differ in these measures?



Linguistics use of voice quality

- In Southern Yi:

na^{21}‘you’	n̲a^{21}‘nag’
na^{33} ‘paste’	n̲a^{33} ‘quantifier’

modal vs. pressed

- In Mazatec:

t^{h}æ ‘seed’	ndæ̤‘horse’	ndæ̰ ‘buttocks’

https://phonetics.ucla.edu/vowels/chapter12/chapter12.html
https://www.phonetics.ucla.edu/voiceproject/voice.html

Voice quality in sociophonetics

- Social meanings of creaky voice.
- Beyond the stereotype: Other meanings?

From Amy Joy
https://www.tiktok.com/t/ZTMY4sKxA/

Voice quality in forensic contexts

- Speaker profiling and comparison:
  - Sex, gender, region, etc.
  - Pathological voice
  - Use of drugs

Duration/Tempo

Duration/Tempo

- Duration:
  - The measurable time span of a sound.
  - Length: perceived duration.

- Tempo
  - Rate or speed of speech (e.g., syllables per second or words per minute)

Duration/tempo in forensic contexts

- Speech rate:
  - Speaking Rate: Words per minute (including pauses).
  - Articulation Rate: Syllables per second (excluding pauses).
  - Previous studies suggest that the second one more favorable.

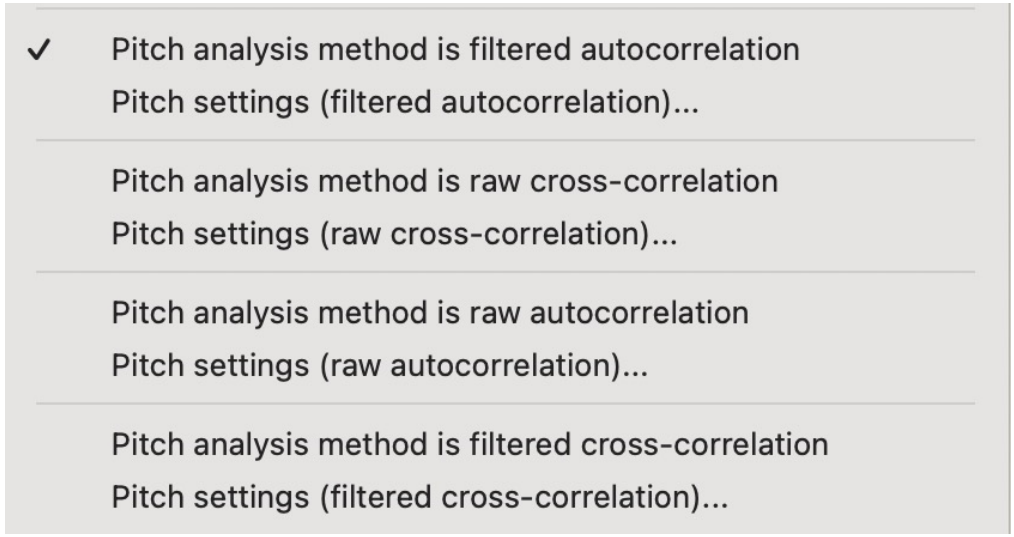
- In forensic linguistics:
  - Could potentially be used as a feature for speaker identification
  - Caveat: not standalone, needs to be combined with other evidence

Leemann, A., Perkins, R., Buker, G. S., & Foulkes, P. (2024). *An Introduction to Forensic Phonetics and Forensic Linguistics*. Routledge.

Measuring Prosody in PRAAT

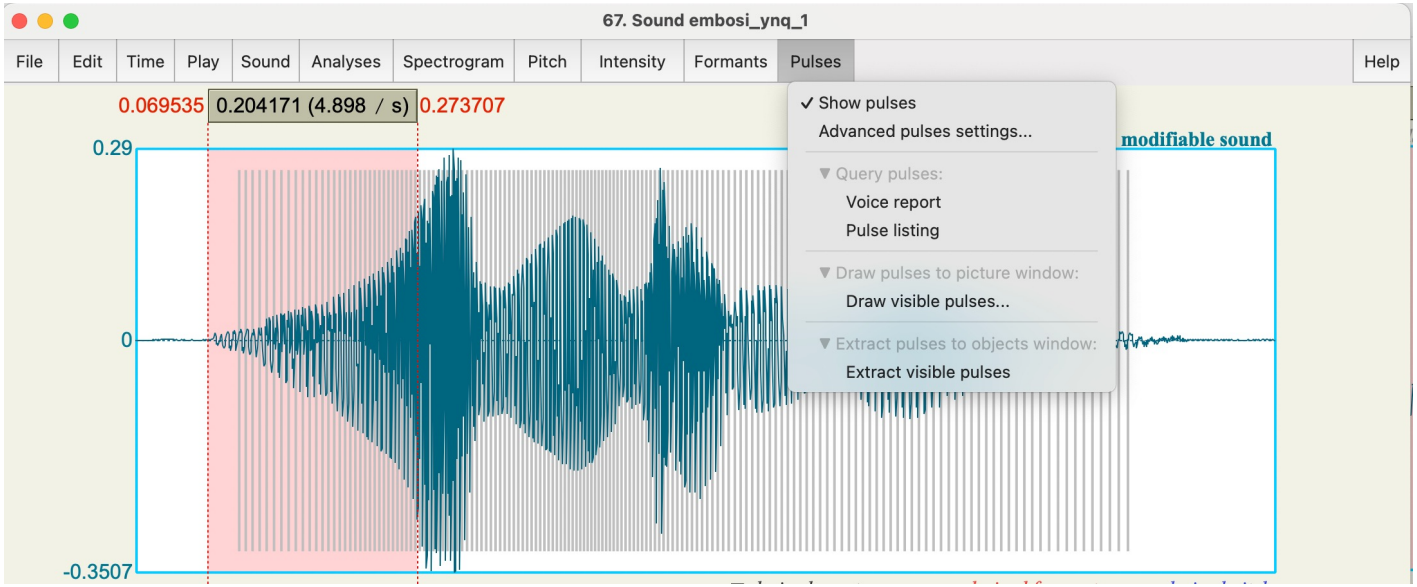
F0 tracking algorithm in Praat

- How to choose an f0 analysis method in PRAAT?
  - Filtered auto-correlation: Vocal fold vibration frequency (intonation)
  - Unfiltered cross-correlation: Voice quality analysis



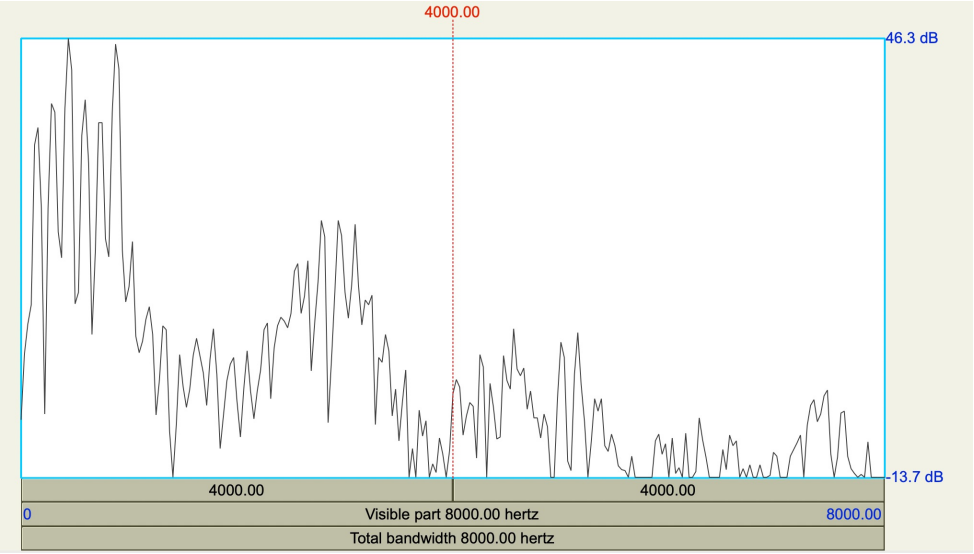
Measuring voice quality in Praat

- Voice report: H1-H2, jitter and shimmer
  - H1-H2: amplitude difference between the 1st and 2nd harmonics
  - Jitter (local, absolute): average absolute difference between consecutive periods in seconds
  - Shimmer (local, dB): average absolute base-10 logarithm of the difference between the amplitudes of consecutive periods, multiplied by 20



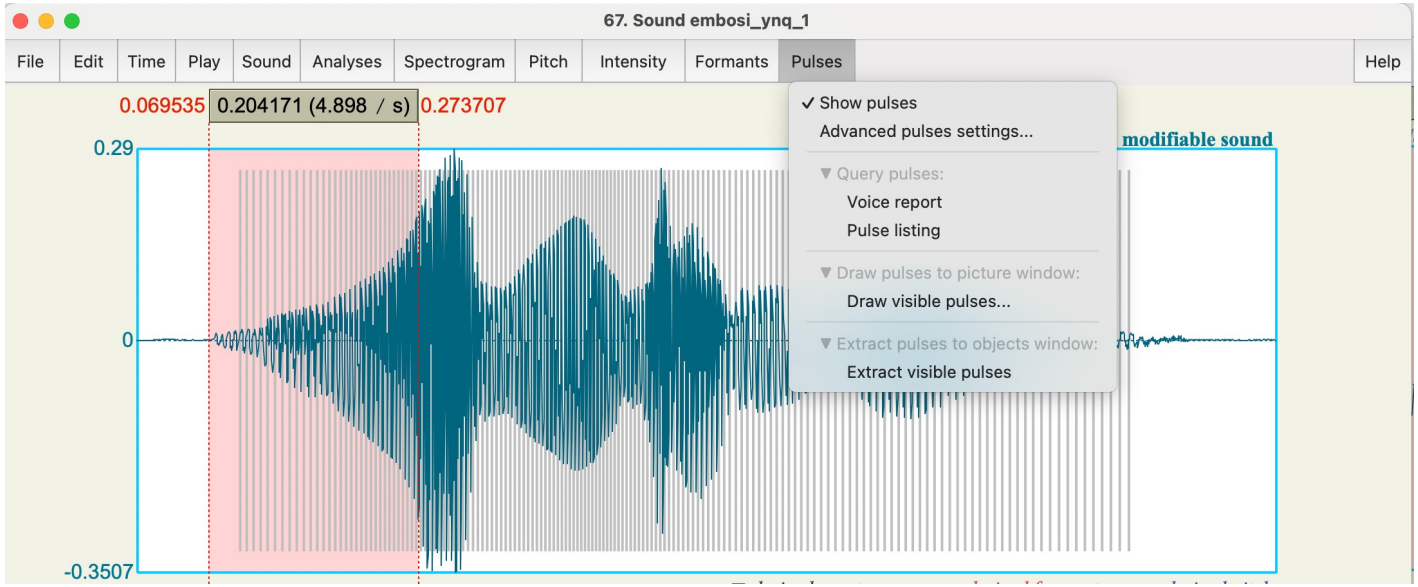
Measuring voice quality in Praat

- Take a spectral slice and measure H1-H2
  - `View & Edit`
  - `Select a portion of the sound`
  - `Spectrogram: view spectral slice`



Measuring voice quality in Praat

- How to generate a voice report
  - View & Edit
  - Select a portion of the sound
  - Show pulses
  - Voice Report



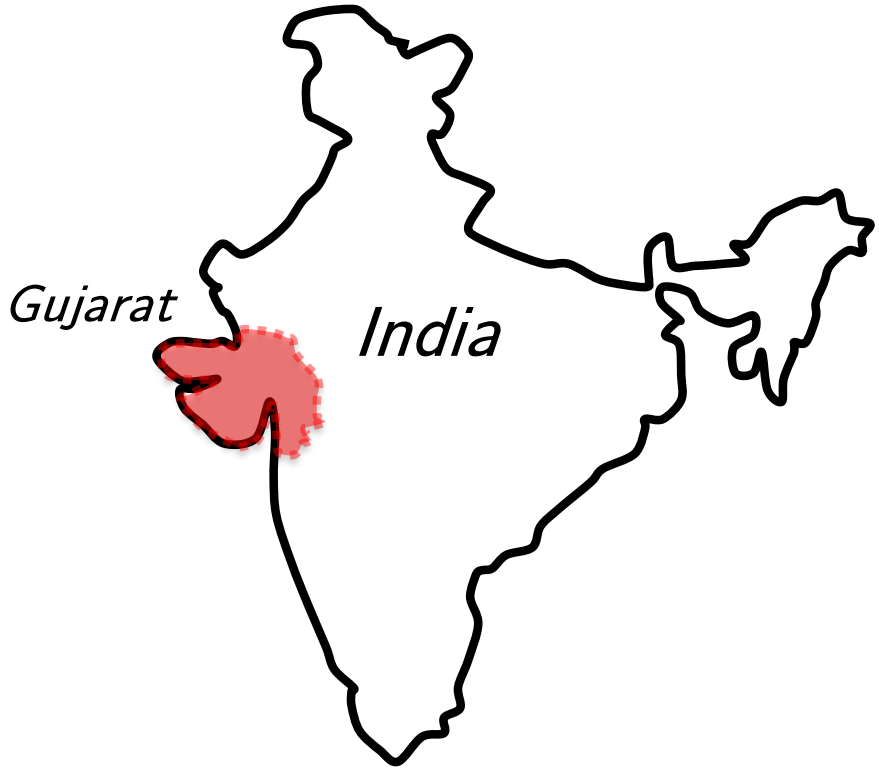
Measuring duration in Praat

- Select the interval to measure duration

Laboratory Exercises

Assignment

Measuring voice quality of Gujarati vowels.



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- Zhang, Y., & Kirby, J. (2020). The role of F0 and phonation cues in Cantonese low tone perception. The Journal of the Acoustical Society of America, 148(1), EL40-EL45.