Lecture 2: Speech Melody

2A: Modulation Codes

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II Brazilian Congress of Prosody
Minicourse 9: 25, 27, 29 April 2022
(09:00-11:30 Brazilian Standard Time)

RANK INTERPRETATION SEMIOTIC MODEL

OF LANGUAGE AND SPEECH

Rank Hierarchy:
    Units, Categories, Functions

Interpretations:
    Functional Interpretation
    Modality Interpretation
    • Auditory
    • Visual

Semiotics and Prosody
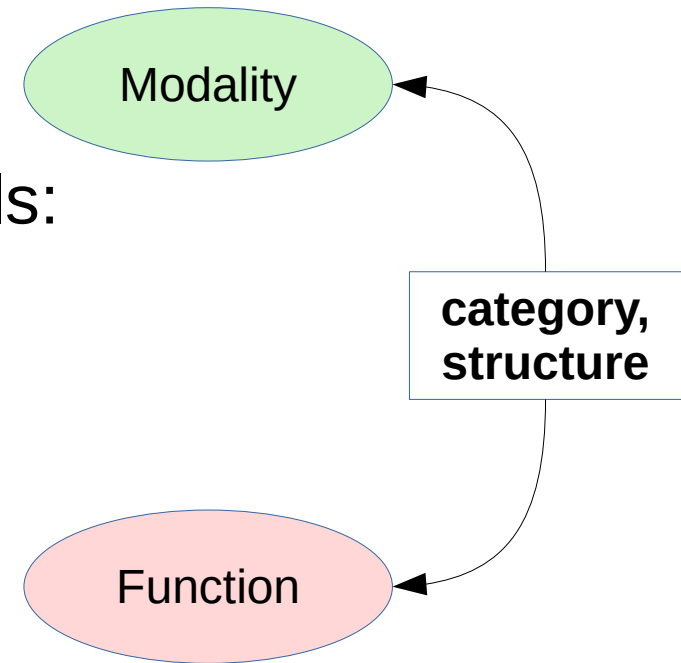
Prosody is

    an independent <u>sign</u> system

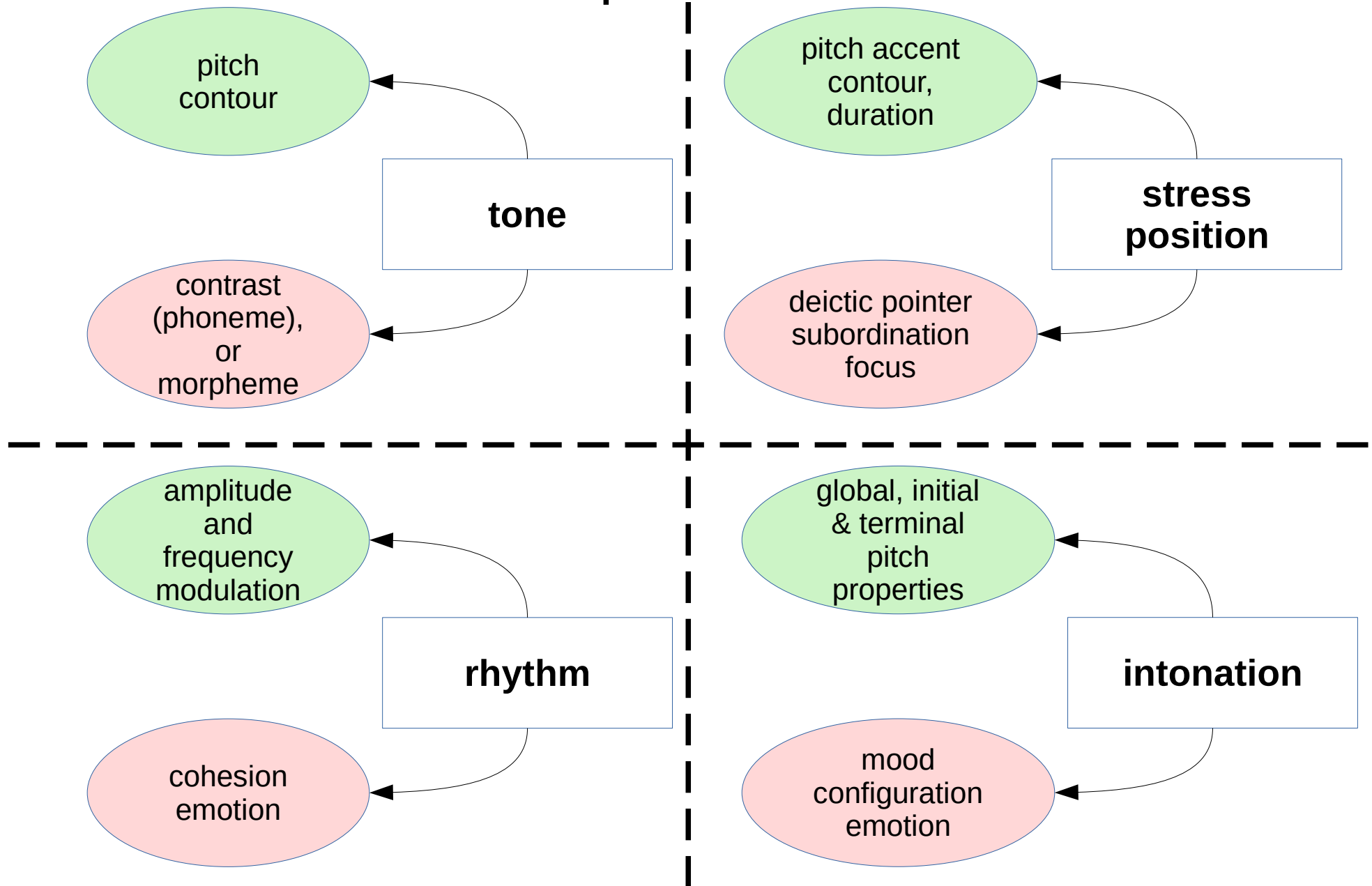   with two main subsystems / channels:

- rhythms
- melodies

    with its own

- syntax:
  - linear and hierarchical patterns
- modality:
  - low frequency amplitude and frequency modulation of speech
  - layout, punctuation and highlighting hierarchy in writing
- functionality:
  - semantics: deictic pointing to associated words, phrases
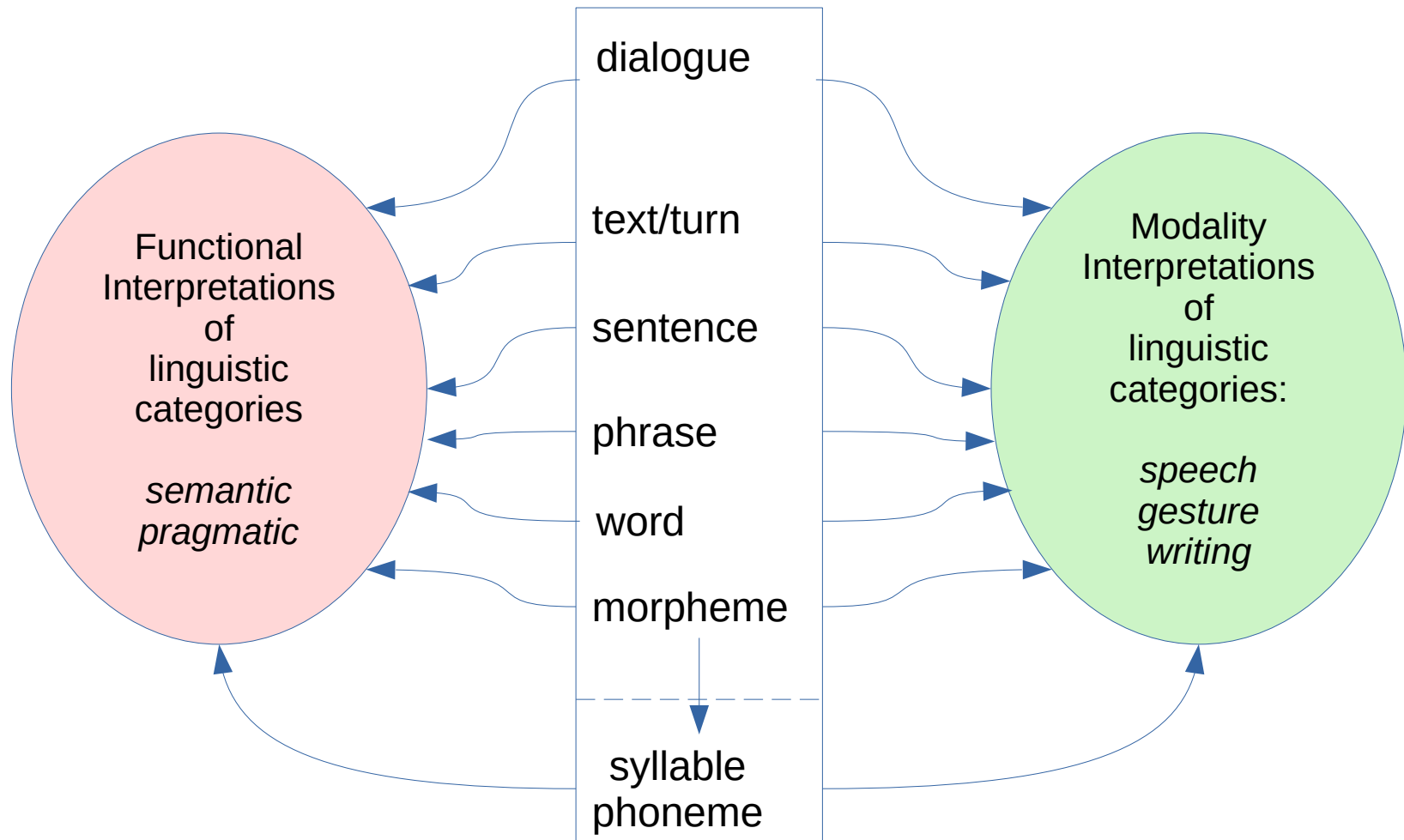 - pragmatics: attitudinal and emotional meanings

Modality

Function

category, structure

Semiotics of Prosody – four categories and their interpretations

tone
- pitch contour
- contrast (phoneme), or morpheme

stress position
- pitch accent contour, duration
- deictic pointer subordination focus

rhythm
- amplitude and frequency modulation
- cohesion emotion

intonation
- global, initial & terminal pitch properties
- mood configuration emotion

Rank Interpretation Architecture

1. Hierarchical ranks of signs
2. For each rank, its interpretations

D. Gibbon: Practical Prosody II

Rank-Interpretation Architecture of Prosody

CATEGORIES
STRUCTURES

dialogue interaction	← encounter →	intonation idioms e.g. call contours	encounter prosody
adjacency pair / triplet	← exchange →	aligned contours rise & fall terminal contours	exchange prosody
argument, narration speech act ...	← turn / text →	rise/fall high/low global contours	turn / text prosody
quantified proposition focus, information structure	← sentence →	pitch accent, pitch height	sentence / phrase prosody
complex predicate, operator	← word →	pitch accent: local pitch contour	word formation tone stress-pitch accent
predicate, operator	← morpheme →	pitch height / contour	morphemic tone pitch accent
distinctive code	← syllable phoneme →	pitch height / contour	phonemic tone pitch accent

Encoding Information by Modulating a Carrier Signal

Timer

Indexical and Linguistic Information

Configuration

Thorax	Phonation (Larynx)		Articulation (Oral & Nasal Cavities)	
Energy AM_{volume}	Position FM_{tone}	Manner AM_{mode}	Position $FM_{formant}$	Manner AM_{phone}

Source

Carrier Signal = F0 + Harmonics

Filter

Carrier Signal + HF Formants
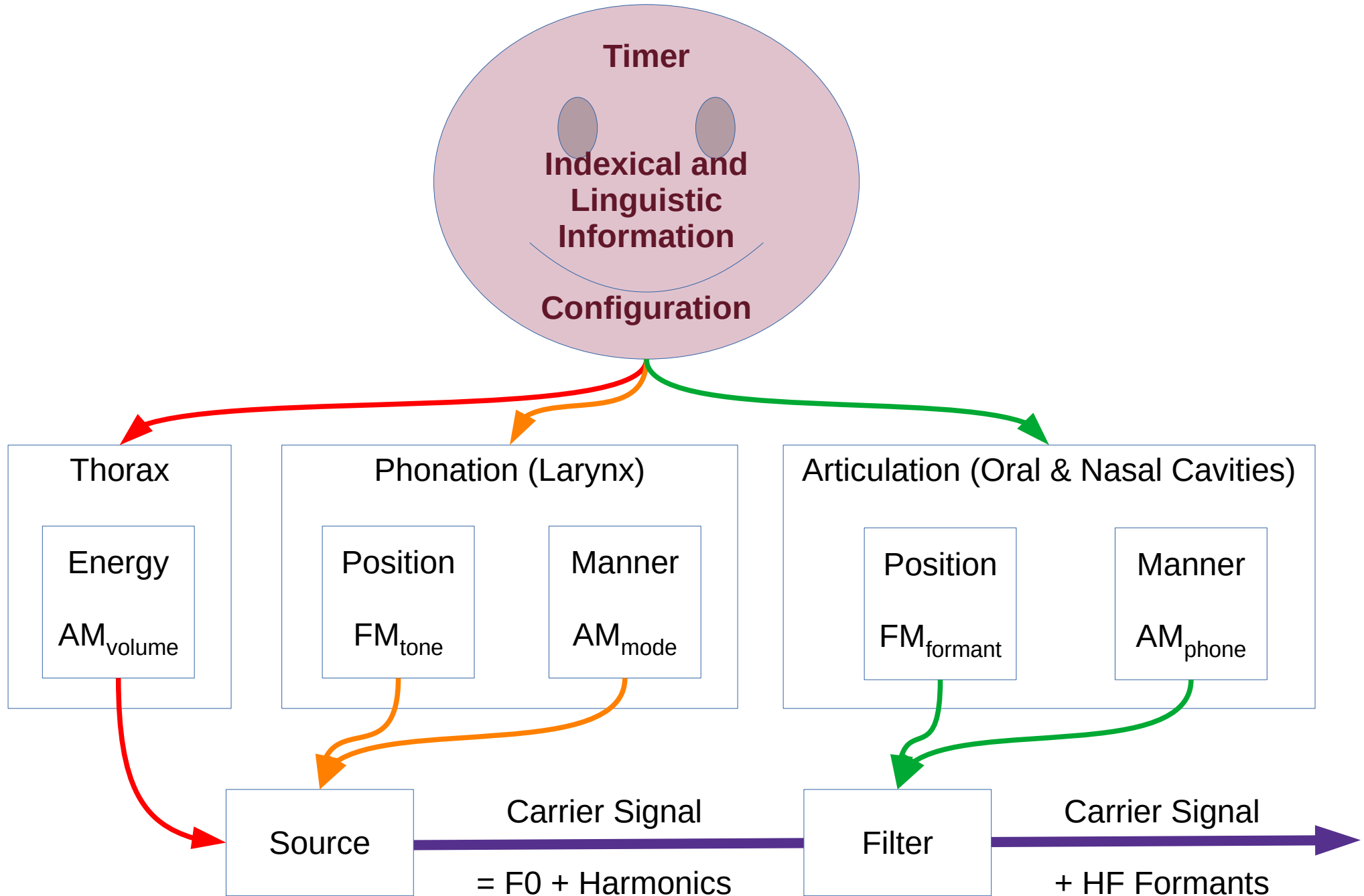
Modulation Codes: AM and FM

AM envelope modulation signal:
- phonetics:
  amplitude curve, syllable,
  stress-accent
- phonology:
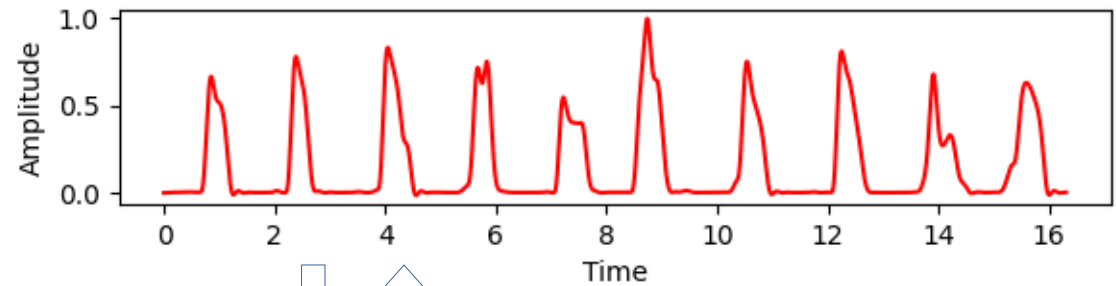 sonority curve, syllables, stress

Carrier signal:
- larynx:
  harmonic sounds
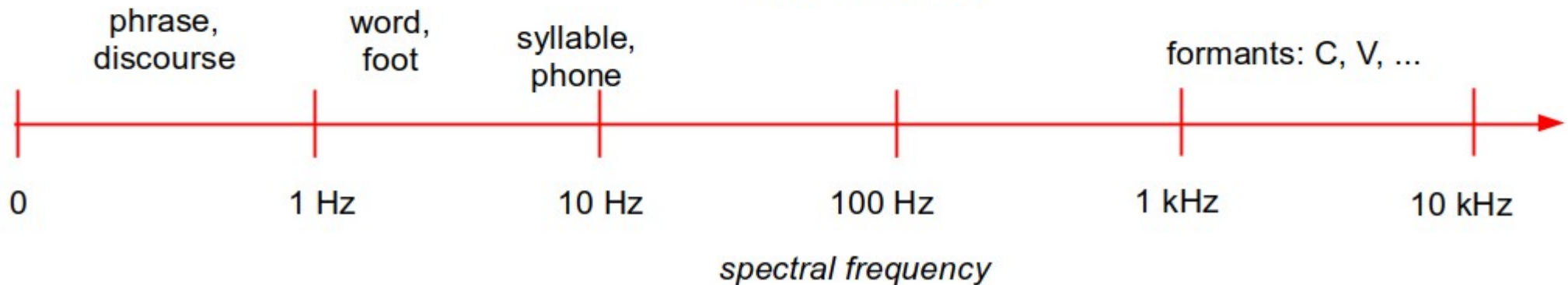- constriction:
  noise sounds

FM envelope modulation signal:
- phonetics:
  F0, pitch track
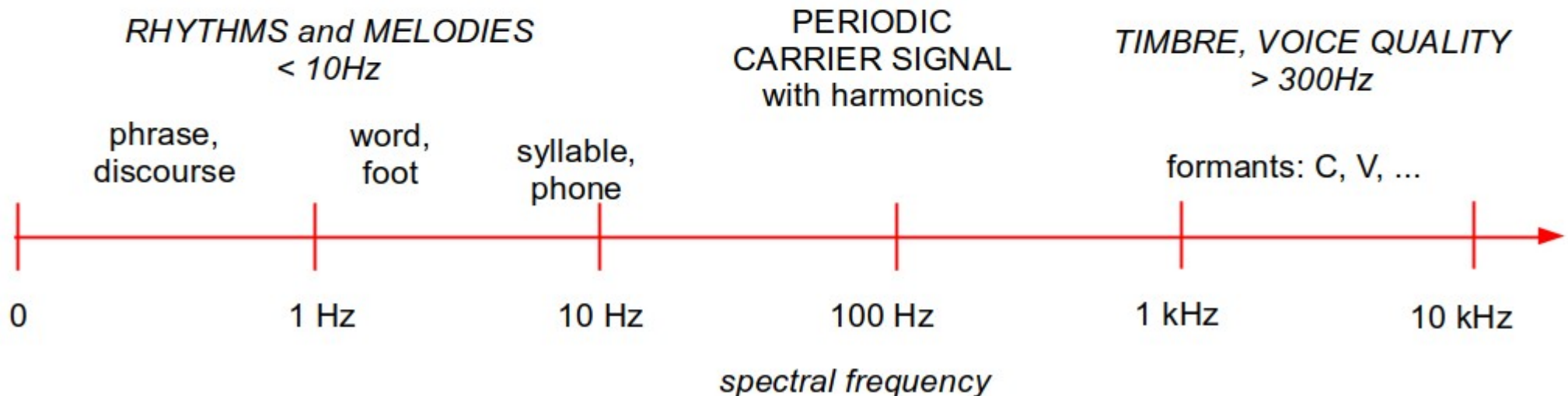- phonology:
  tones, pitch accents, intonation
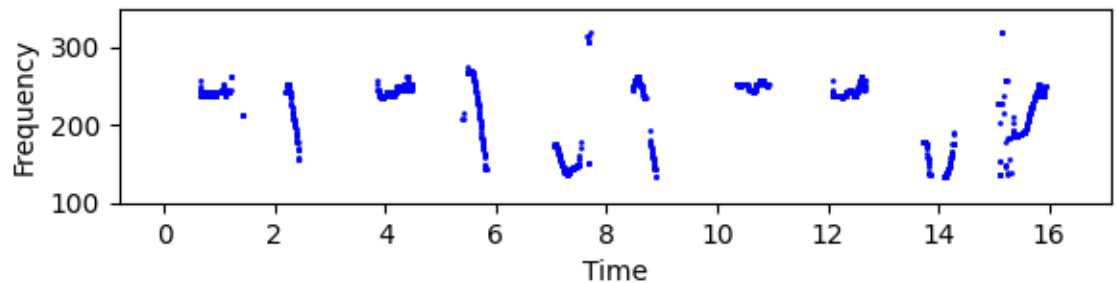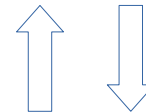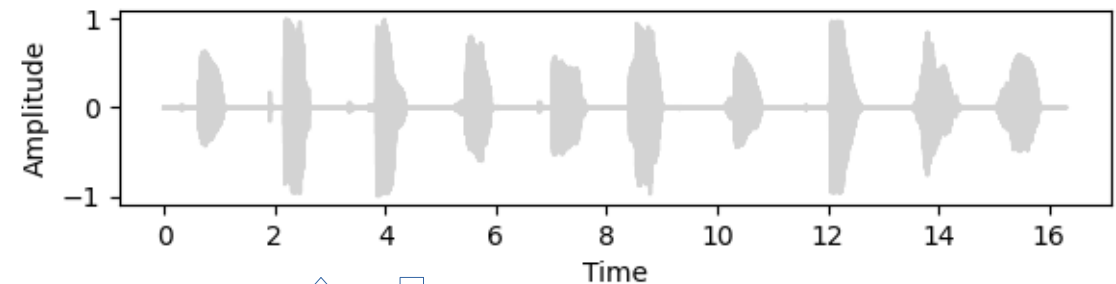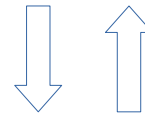
Modulation Codes: AM and FM

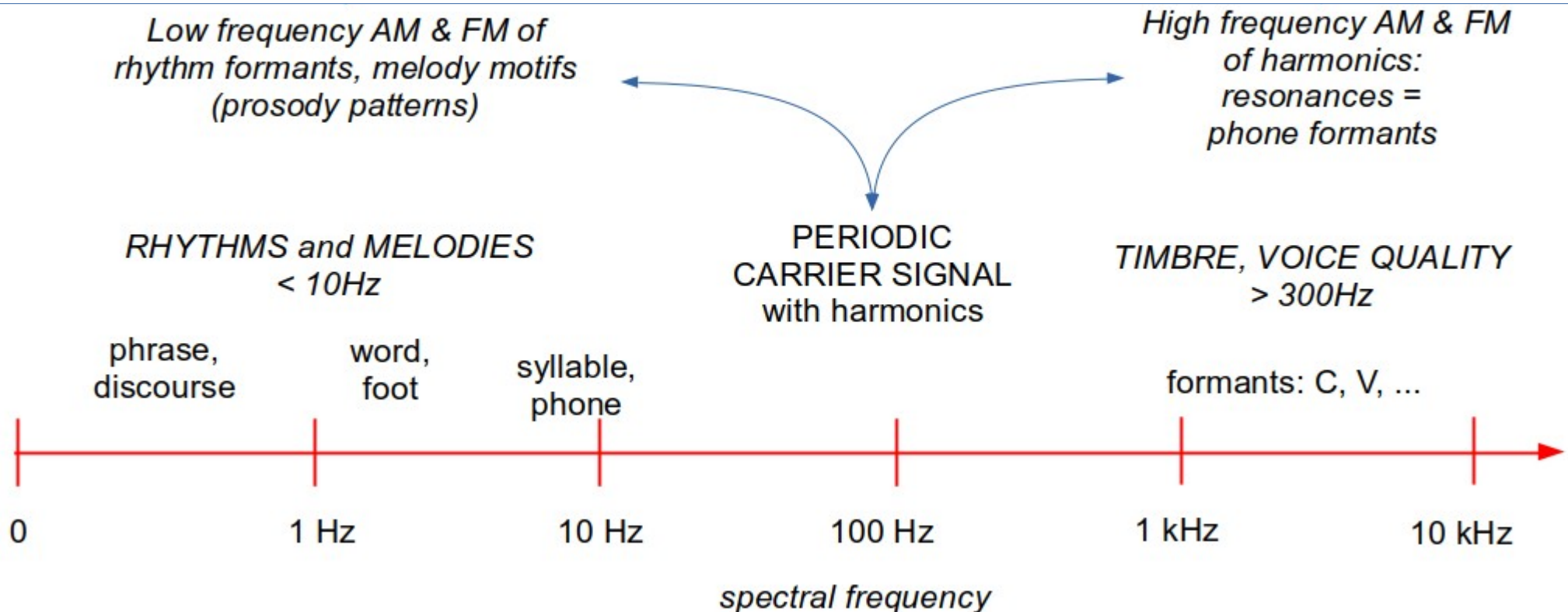Frequency ranges occupied by linguistically relevant categories

phrase, discourse | word, foot | syllable, phone | formants: C, V, ...

0 — 1 Hz — 10 Hz — 100 Hz — 1 kHz — 10 kHz

spectral frequency

Modulation Codes: AM and FM

AM and FM modulation types

RHYTHMS and MELODIES
< 10Hz

PERIODIC
CARRIER SIGNAL
with harmonics

TIMBRE, VOICE QUALITY
> 300Hz

phrase,
discourse

word,
foot

syllable,
phone

formants: C, V, ...

| 0 | 1 Hz | 10 Hz | 100 Hz | 1 kHz | 10 kHz |

spectral frequency

Modulation Codes: AM and FM

Low frequency vs. high frequency AM and FM modulation types

Low frequency AM & FM of rhythm formants, melody motifs (prosody patterns)

High frequency AM & FM of harmonics: resonances = phone formants

PERIODIC CARRIER SIGNAL with harmonics

RHYTHMS and MELODIES < 10Hz

TIMBRE, VOICE QUALITY > 300Hz

phrase, discourse	word, foot	syllable, phone		formants: C, V, ...	
0	1 Hz	10 Hz	100 Hz	1 kHz	10 kHz

spectral frequency

Modulation Codes: AM and FM

SPEECH INFORMATION SIGNALS

source (de)modulation → Low frequency AM & FM of rhythm formants, melody motifs (prosody patterns)

filter (de)modulation → High frequency AM & FM of harmonics: resonances = phone formants

RHYTHMS and MELODIES < 10Hz

PERIODIC CARRIER SIGNAL with harmonics

TIMBRE, VOICE QUALITY > 300Hz

phrase, discourse — word, foot — syllable, phone

formants: C, V, ...

0 — 1 Hz — 10 Hz — 100 Hz — 1 kHz — 10 kHz

spectral frequency

Modulation Codes: AM and FM

Fundamental Frequency Modelling

Many approaches:

- Examples of traditional observational approaches:
  - Tadpole style
  - Tonetic style
  - ToBI style
  - IntSint style
- Examples of model, measurement, visualisation approaches:
  - Regression fitting (My preferred approach)
  - Spline interpolation (Hirst; *Empirical Mode Decomposition*)
  - Pulses and smoothing (Fujisaki Model)
  - Tilt (Black, rise-fall events)

Prosodic typology: stress-pitch accents

Semiotics of Prosody: local modulations

        autonomous grammar:
            linear concatenation
            cyclical finite state grammar
                - intonation
                - tone sandhi
            <u>phonetic interpretations of abstract stress positions</u>

        modality interpretation:
            pitch accent contours:
                high, low, high-low, low-high

        functional interpretation:
            tones: contrastive coding
            stress-pitch accents:
                metadeictic denotation of focal positions
                indexical (attitudinal, emotional)

FM Code: Tone, Pitch Accent, Intonation
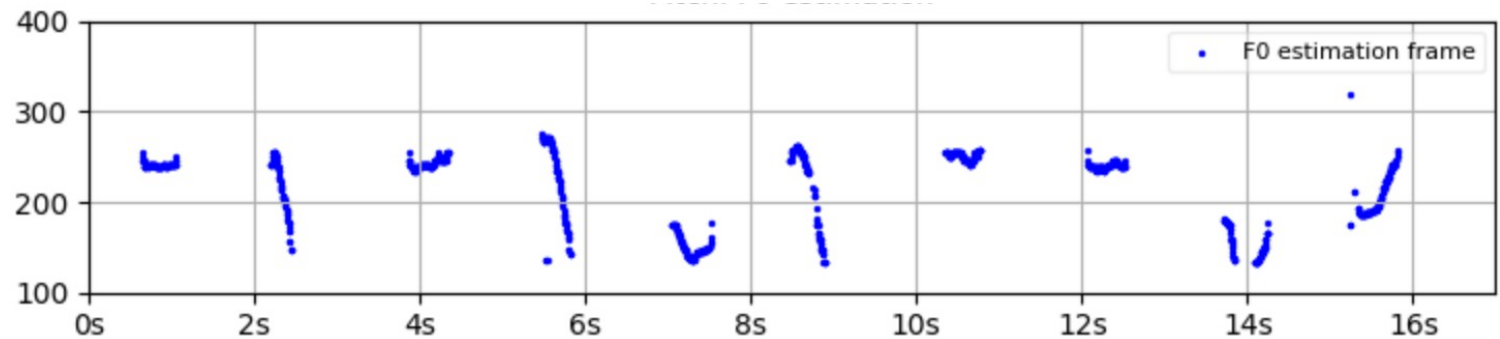
Sino-Tibetan
Pǔtōnghuà
ISO-693-3 *cmn*

lexical tone

FM Code: Tone, Pitch Accent, Intonation
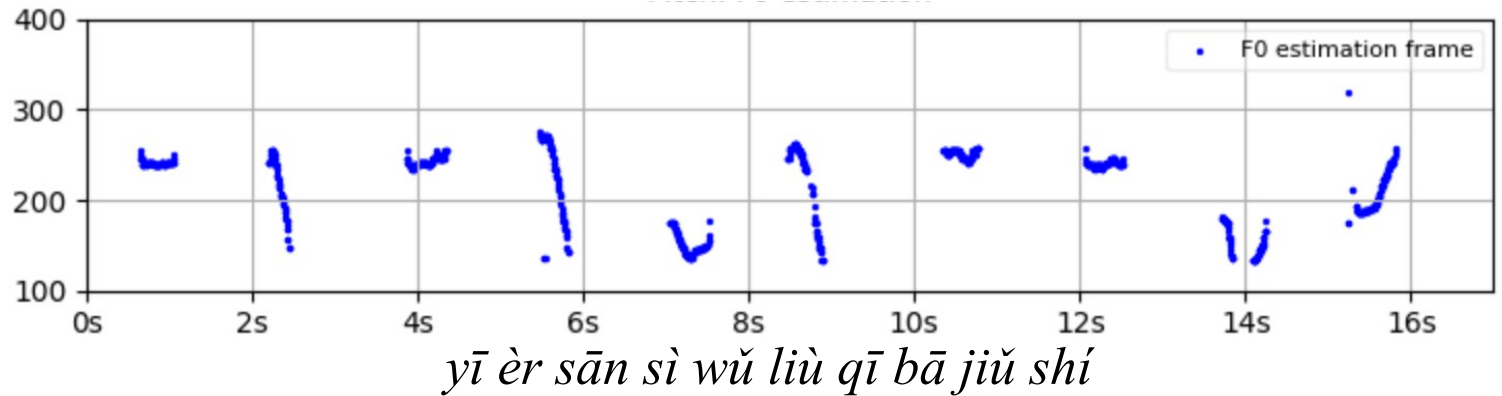
Sino-Tibetan
Pǔtōnghuà
ISO-693-3 *cmn*

lexical tone

yī èr sān sì wǔ liù qī bā jiǔ shí

Niger-Congo
Ibibio
ISO-693-3 *ibb*

lexical and morphological tone

kèèd ìbà ìtá ìnààñ ìtíòn ìtíòkèèd ìtíàbà ìtiáìtá ùsúkkéèd dùòp

FM Code: Tone, Pitch Accent, Intonation

Sino-Tibetan
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ISO-693-3 *cmn*

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lexical and morphological tone

kèèd ìbà ìtá ìnààñ ìtíòn ìtíòkèèd ìtíàbà ìtiáìtá ùsúkkéèd dùòp

Indo-Germanic
English
ISO 693-3 *eng*

stress-pitch accent & intonation

one two three four five six seven eight nine ten

FM Code: Tone, Pitch Accent, Intonation

Sino-Tibetan
Pǔtōnghuà
ISO-693-3 *cmn*

lexical tone

yī èr sān sì wǔ liù qī bā jiǔ shí

Niger-Congo
Ibibio
ISO-693-3 *ibb*

lexical and morphological tone

quinary number system

kèèd ìbà ìtá ìnààñ ìtíòn ìtíòkèèd ìtíàbà ìtiáìtá ùsúkkéèd dùòp

Indo-Germanic
English
ISO 693-3 *eng*

stress-pitch accent & intonation

pitch accent iteration constraint

one two three four five six seven eight nine ten
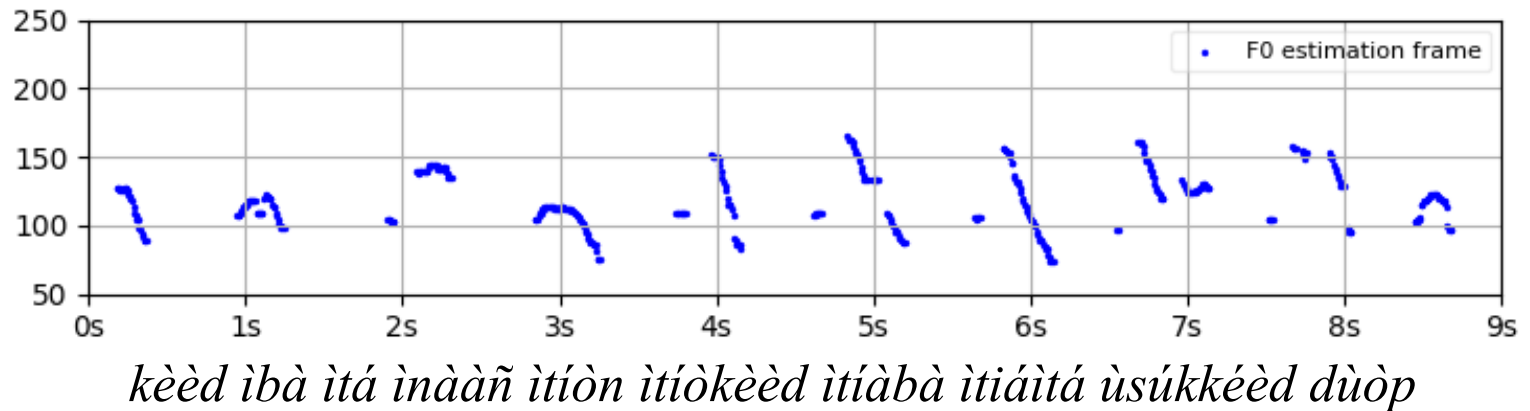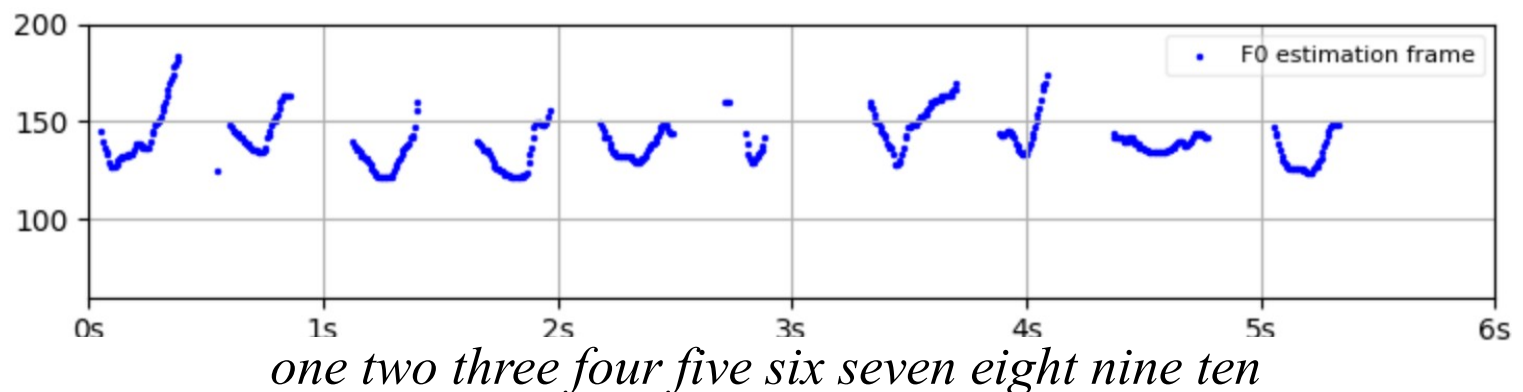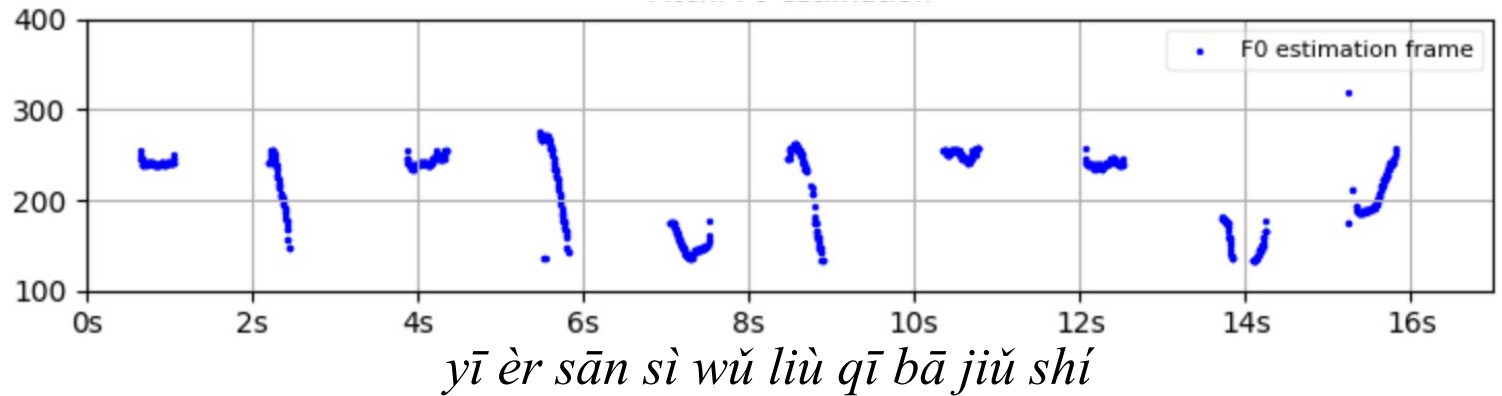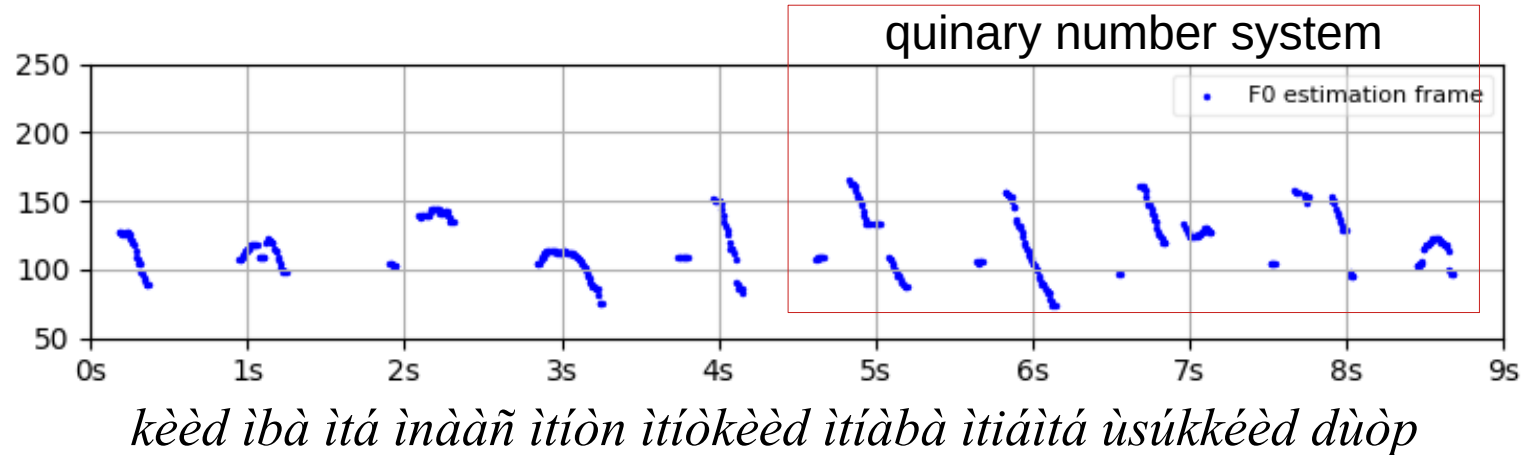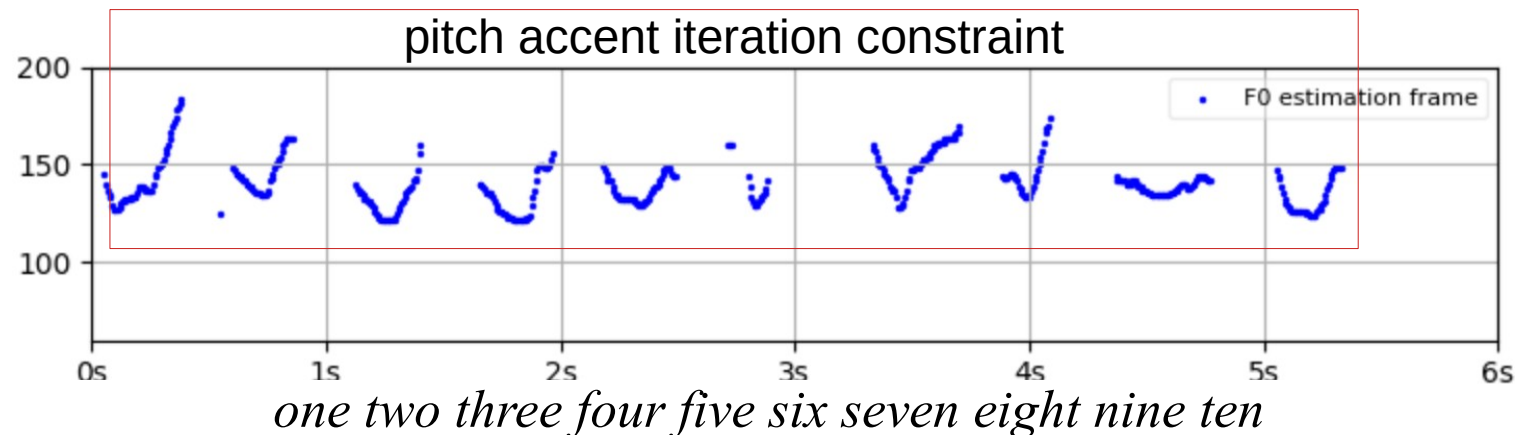
FM Code: Tone, Pitch Accent, Intonation

Pierrehumbert's
Finite State Automaton

Indo-Germanic
English
ISO 693-3 *eng*
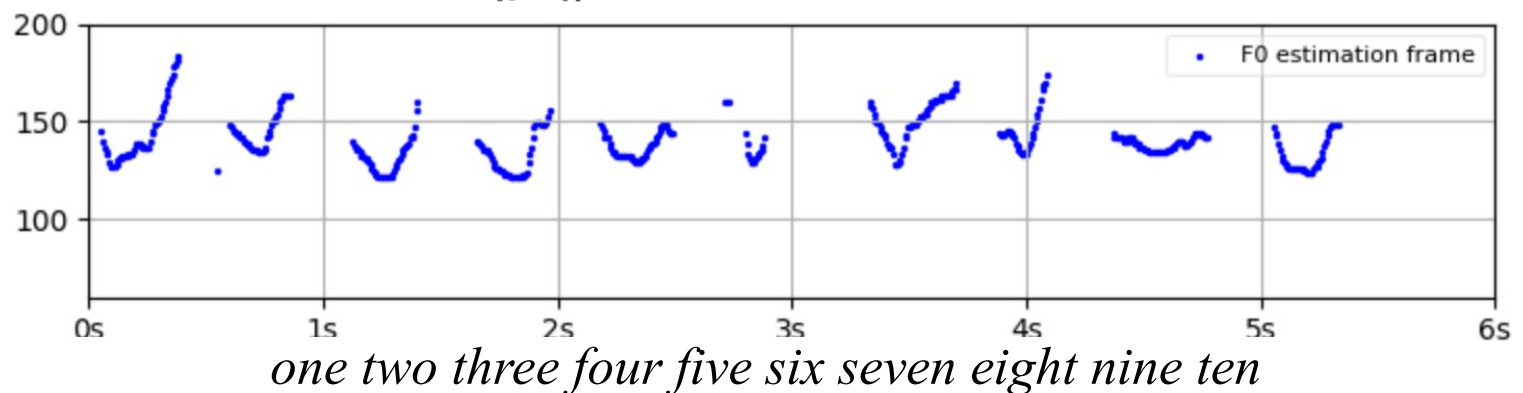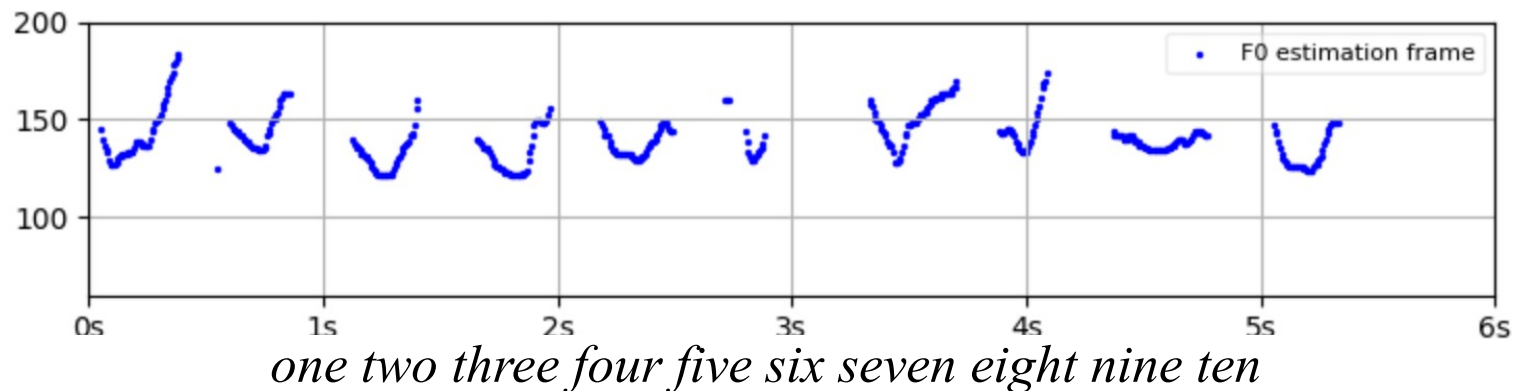
stress-pitch accent & intonation

one two three four five six seven eight nine ten

FM Code: Tone, Pitch Accent, Intonation

Pierrehumbert's
Finite State Automaton

H*

L*

H%

L%

L*+H⁻

L⁻+H*

H*+L⁻

H⁻+L*

H*+H⁻

H⁻

L⁻

H%

L%
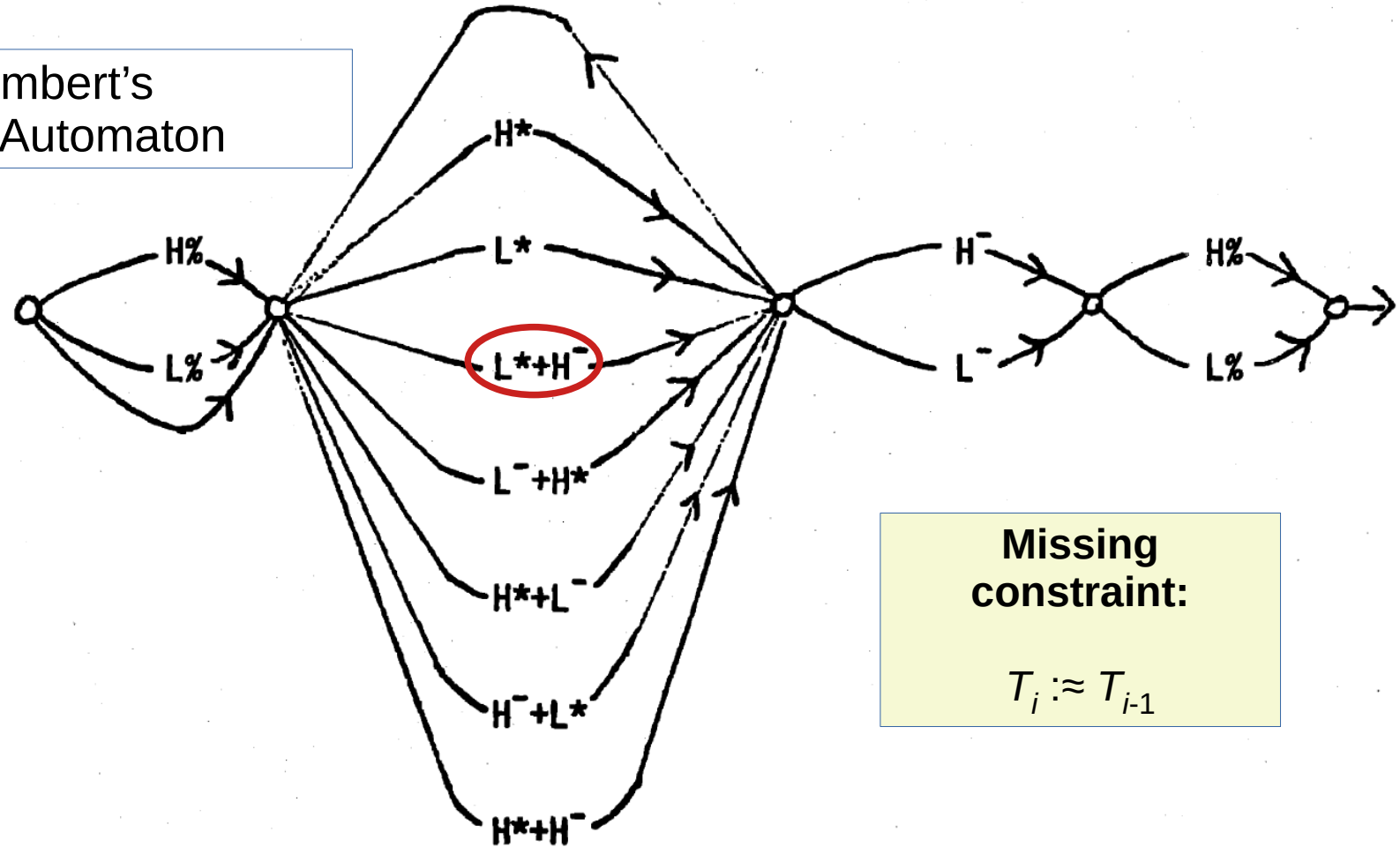
Missing constraint:

$$T_i :\approx T_{i-1}$$

Indo-Germanic
English
ISO 693-3 *eng*

stress-pitch accent & intonation

one two three four five six seven eight nine ten

Tones, Pitch Accents and Intonation: the 'Modulation Code'

Pierrehumbert's
Finite State Automaton

H*

H%

L*

L*+H⁻

H⁻

H%

L%

L⁻

L⁻+H*

L⁻

L%
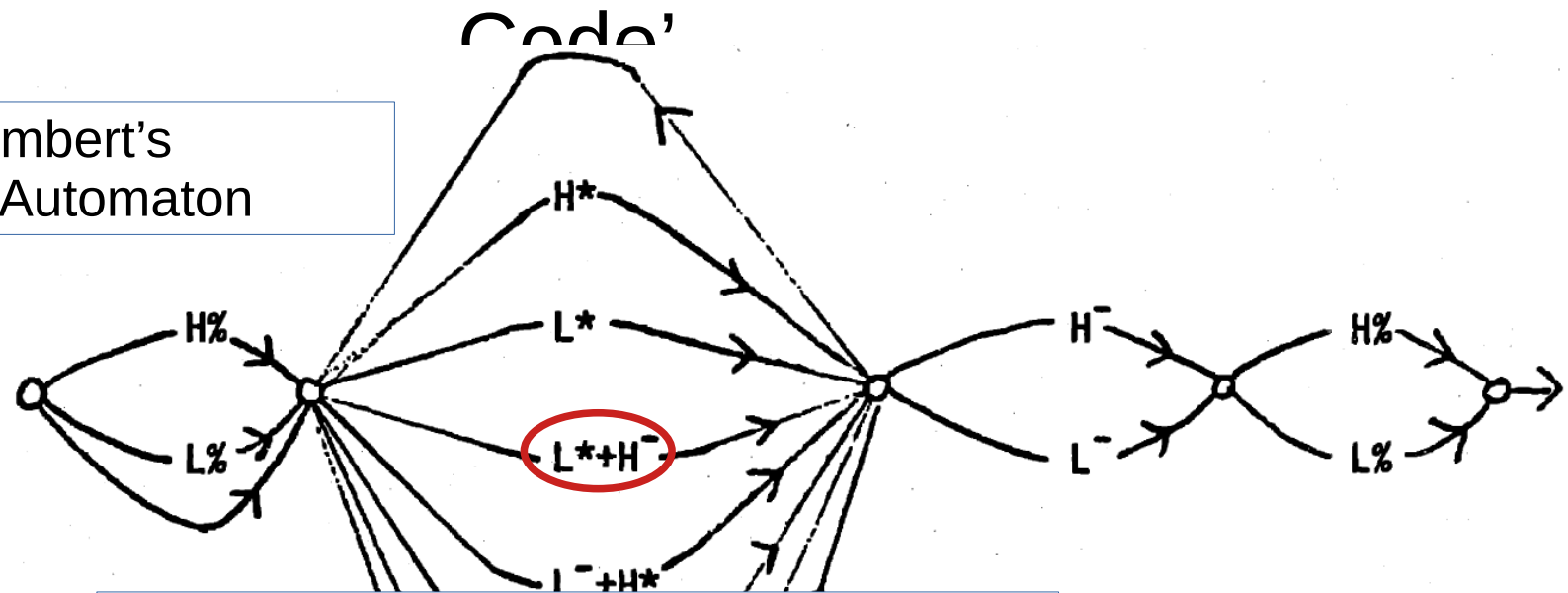
In traditional textbooks on English intonation, during the past 100 years, the **cyclical sequence of similar tones** is called the ***body*** (sometimes the ***head***) of an intonation group.

H*+H⁻

Indo-Germanic
English
ISO 693-3 *eng*

stress-pitch accent & intonation

one two three four five six seven eight nine ten
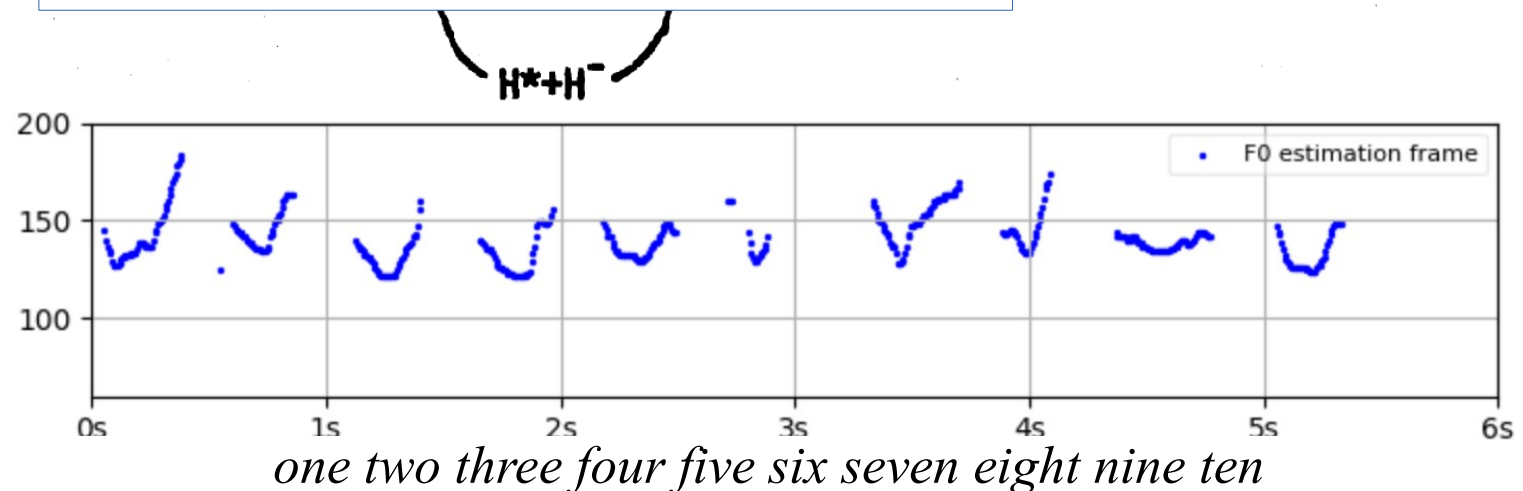
FM Code: Tone, Pitch Accent, Intonation

Pierrehumbert's
Finite State Automaton (1980)

H*

H%   L*

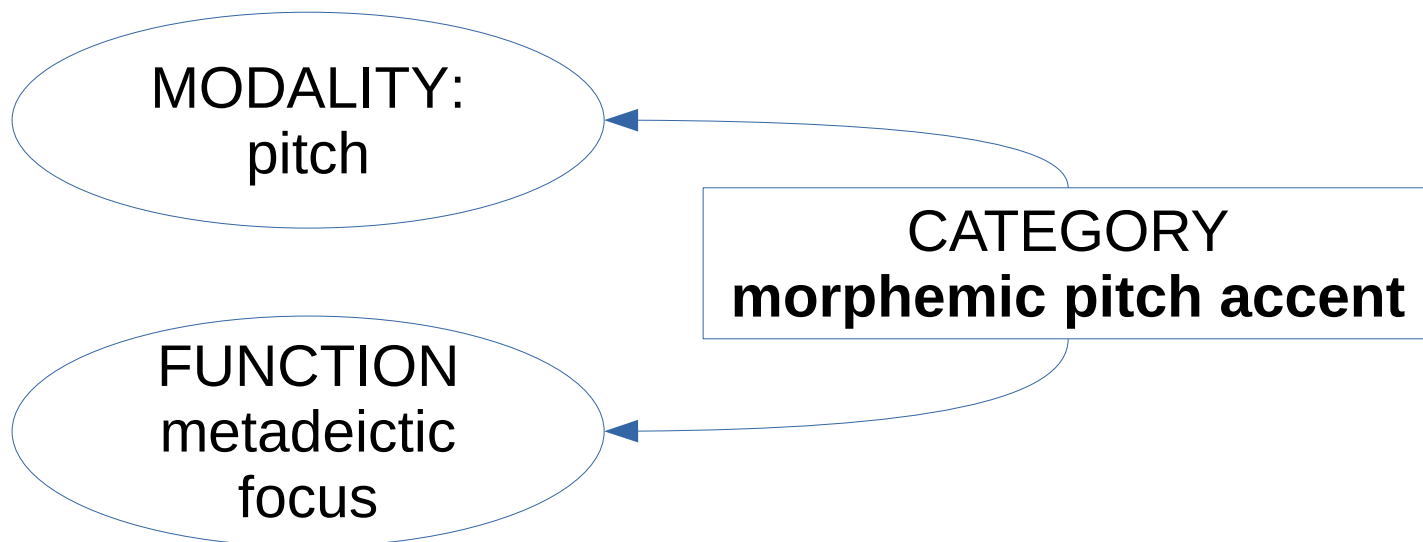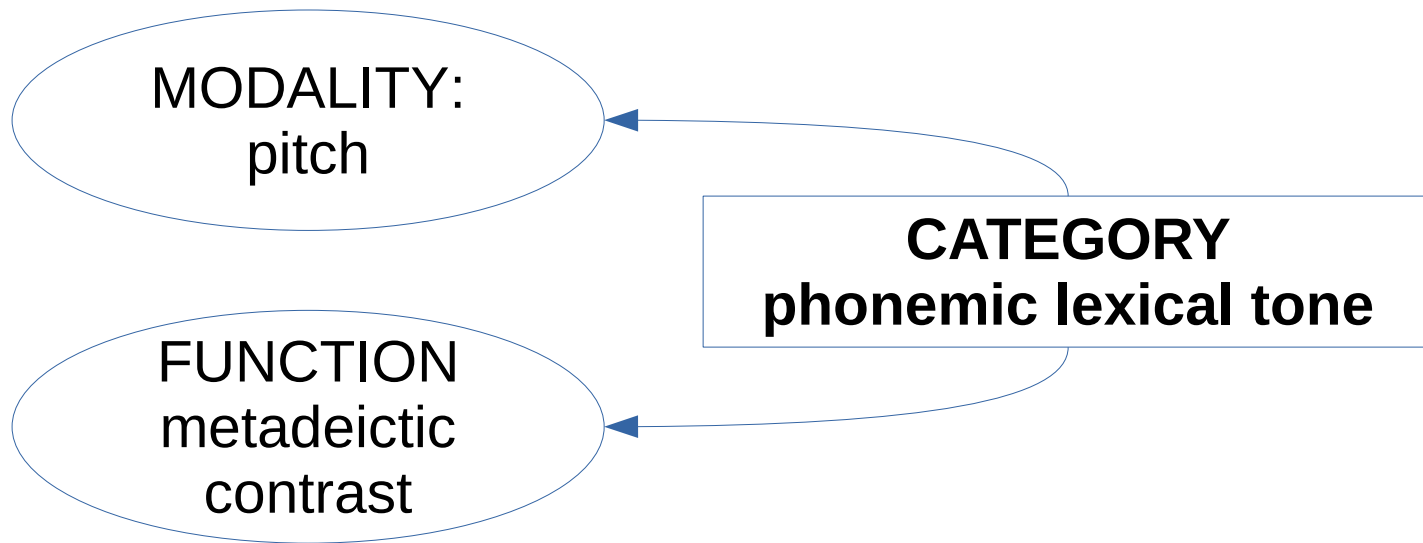L%   L*+H⁻   H⁻   H%

L⁻   L%
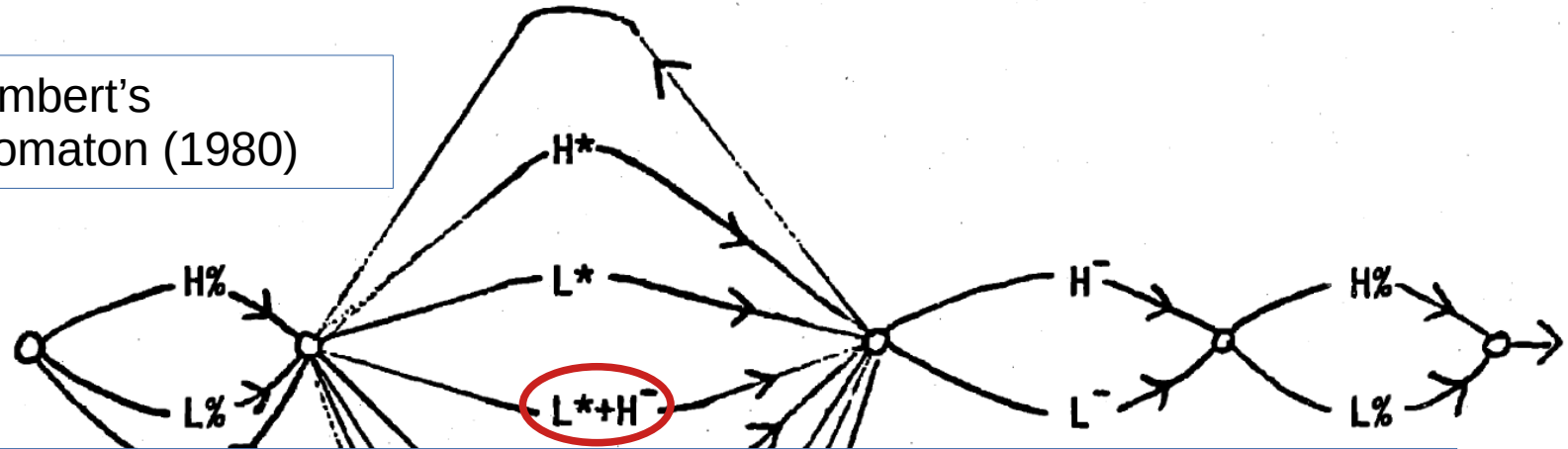
Dilley (1997: 87ff.)
- proposed an **accent sequence similarity constraint** for the head pattern,
- in order to explain such sequential pitch accent patterns as **correlate of coherent grammatical patterns** and
- as a means of **entraining the attention of listeners** to expect pattern changes such as nuclear tones.

H*+H⁻

Indo-Germanic
English
ISO 693-3 *eng*

stress-pitch accent & intonation

one two three four five six seven eight nine ten

FM Code: Tone, Pitch Accent, Intonation

MODALITY: pitch

**CATEGORY
phonemic lexical tone**

FUNCTION metadeictic contrast

- - - - - - - - - - - - - - - - - - -

MODALITY: pitch

CATEGORY
morphemic pitch accent

FUNCTION metadeictic focus
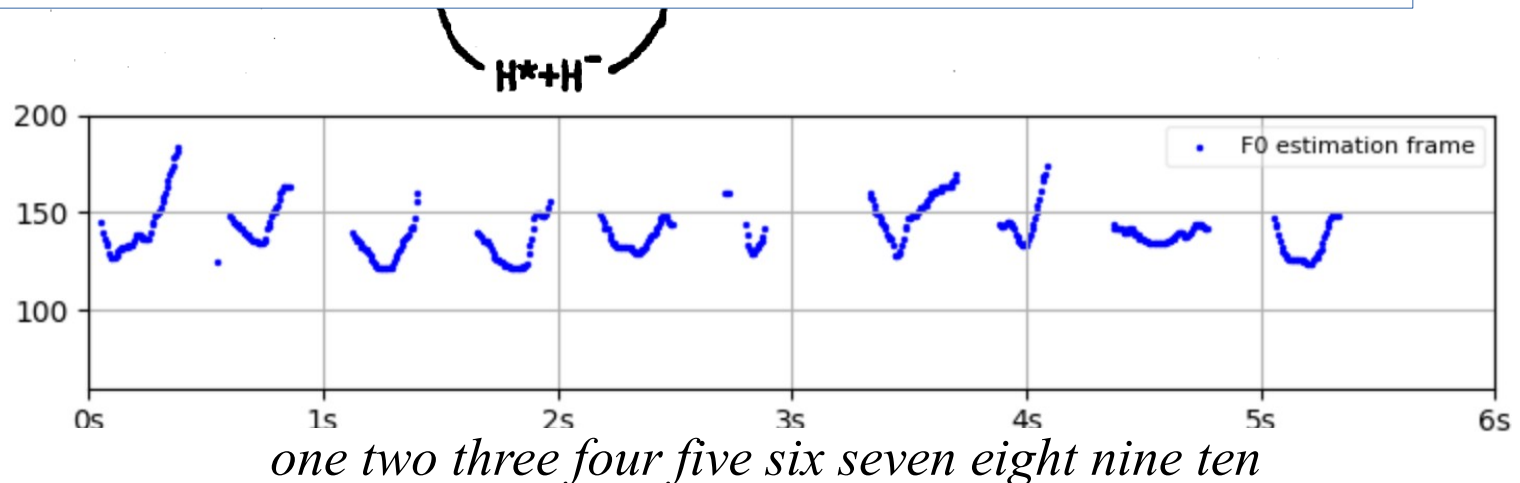
Intonation: Global Text and Dialogue Contours

Semiotics of Prosody, the argument:

Global intonation contours are signs with syntax, modality and function:

       global contours and syntax:
          denotation of extent of locutionary units
          linear concatenation

       modality interpretation of global contours:
          pitch contours:
             rise, level, fall, rise-fall, fall-rise

       functional interpretation of global contours:
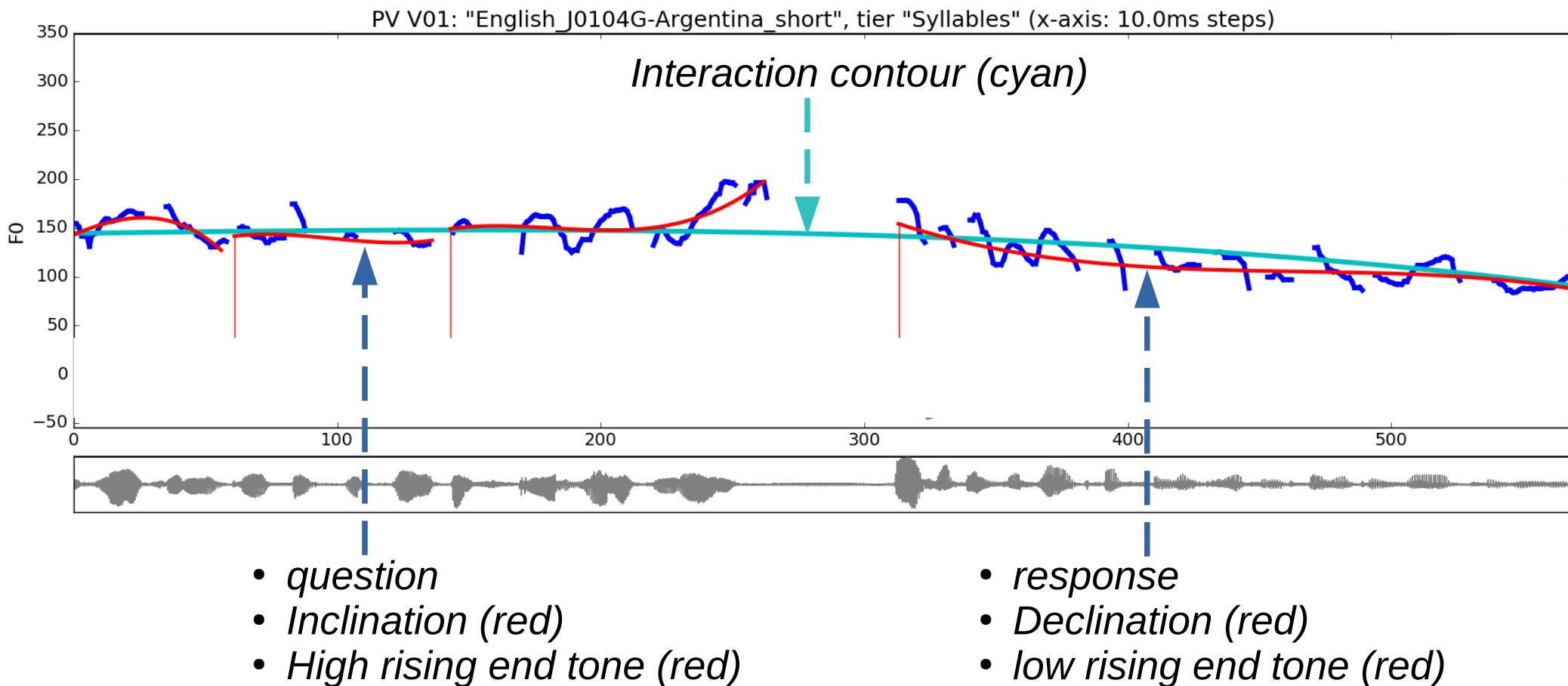   metadeictic denotation of relational properties
             incomplete (rise), complete (fall), closed gestalt (rise-fall)
          indexical:
   attitudinal, emotional

Fundamental Frequency Modelling

Intonation in dialogue – a radio interview about football

PV V01: "English_J0104G-Argentina_short", tier "Syllables" (x-axis: 10.0ms steps)

Interaction contour (cyan)

- *question*
- *Inclination (red)*
- *High rising end tone (red)*

- *response*
- *Declination (red)*
- *low rising end tone (red)*

Method: multiple regression over interpausal segments of F0 contours.

Case Study 3: Global Text and Dialogue Contours
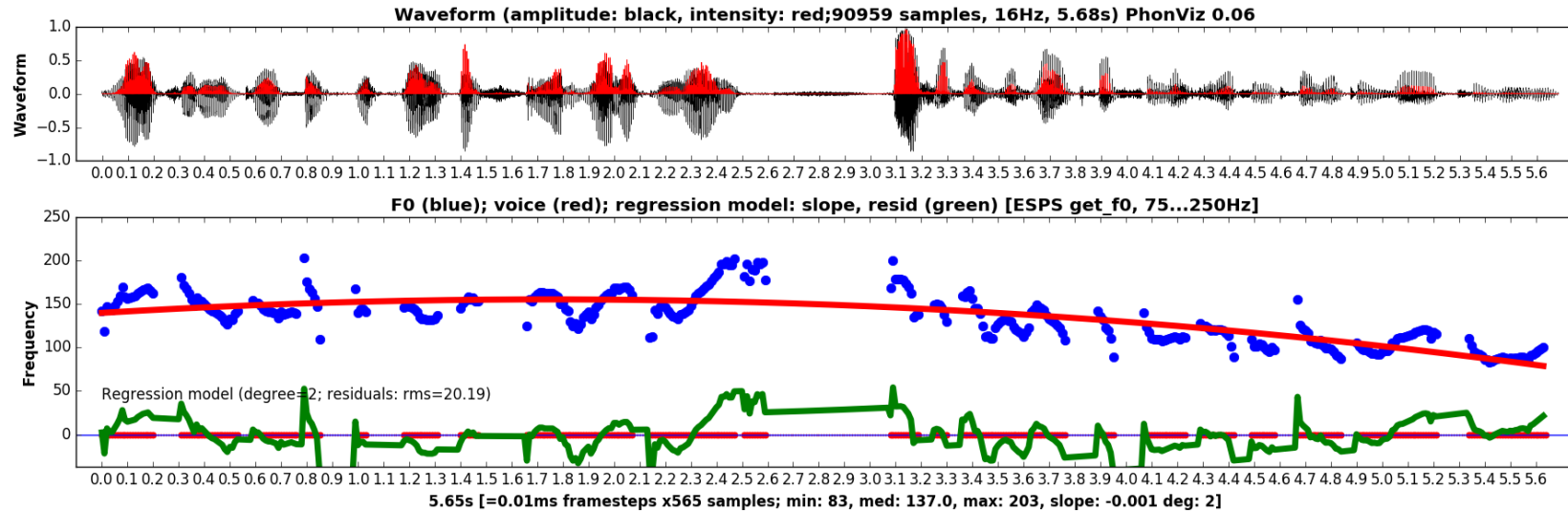

falling-rising
global
question
contour
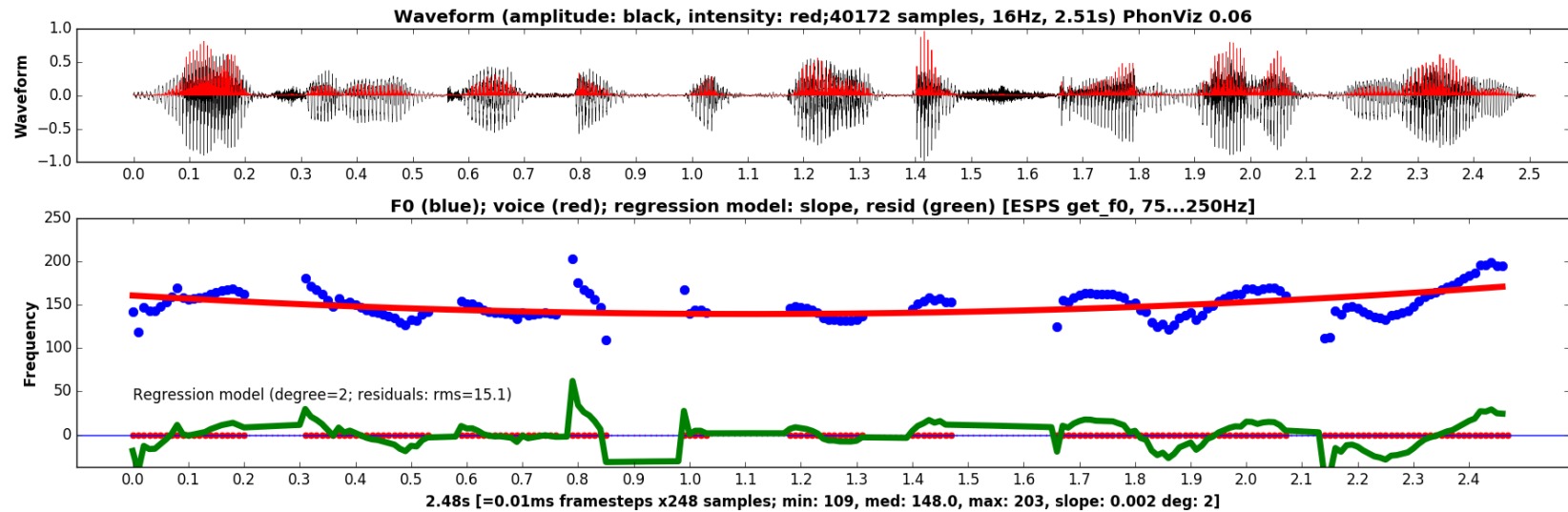
falling
global
answer contour
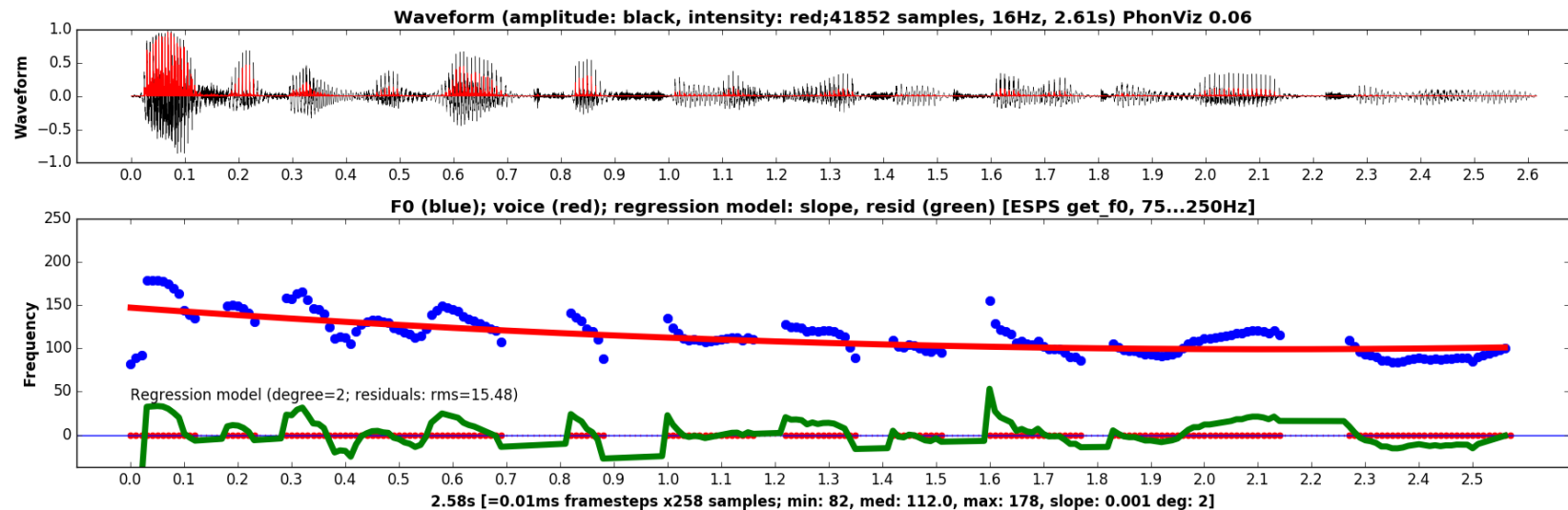
Case Study 3: Global Text and Dialogue Contours
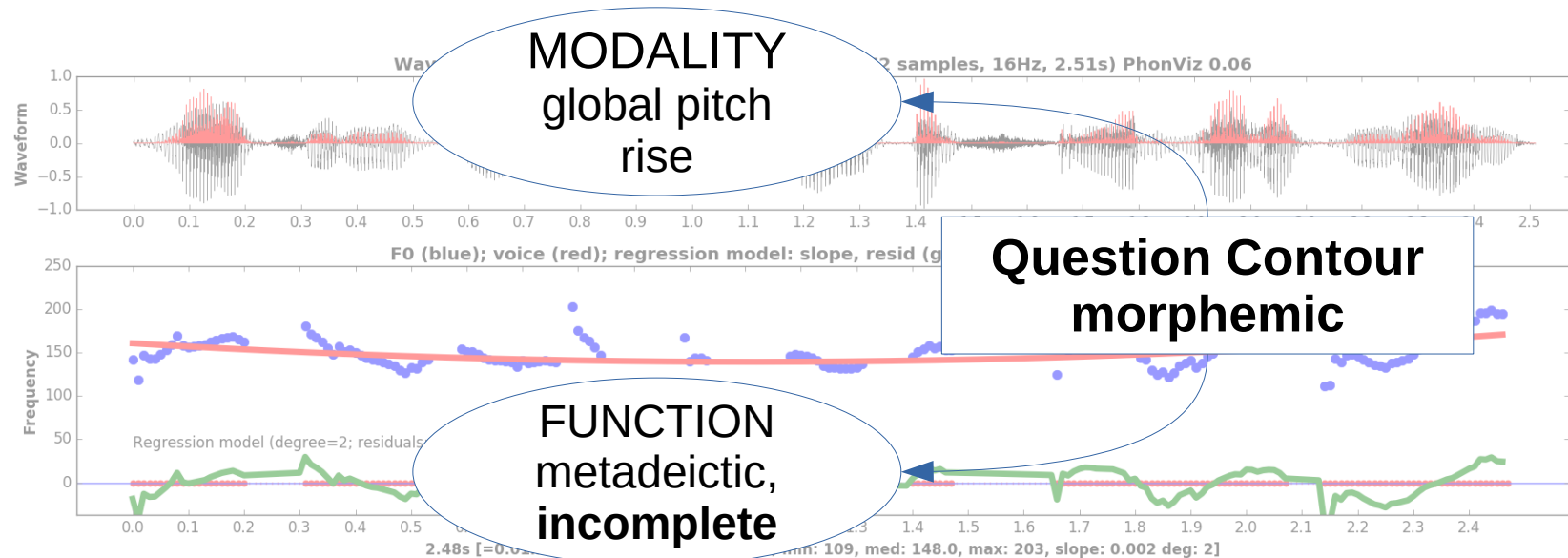

rising-falling
global
dialogue
contour

MODALITY
pitch

**Adjacency Pair Contour
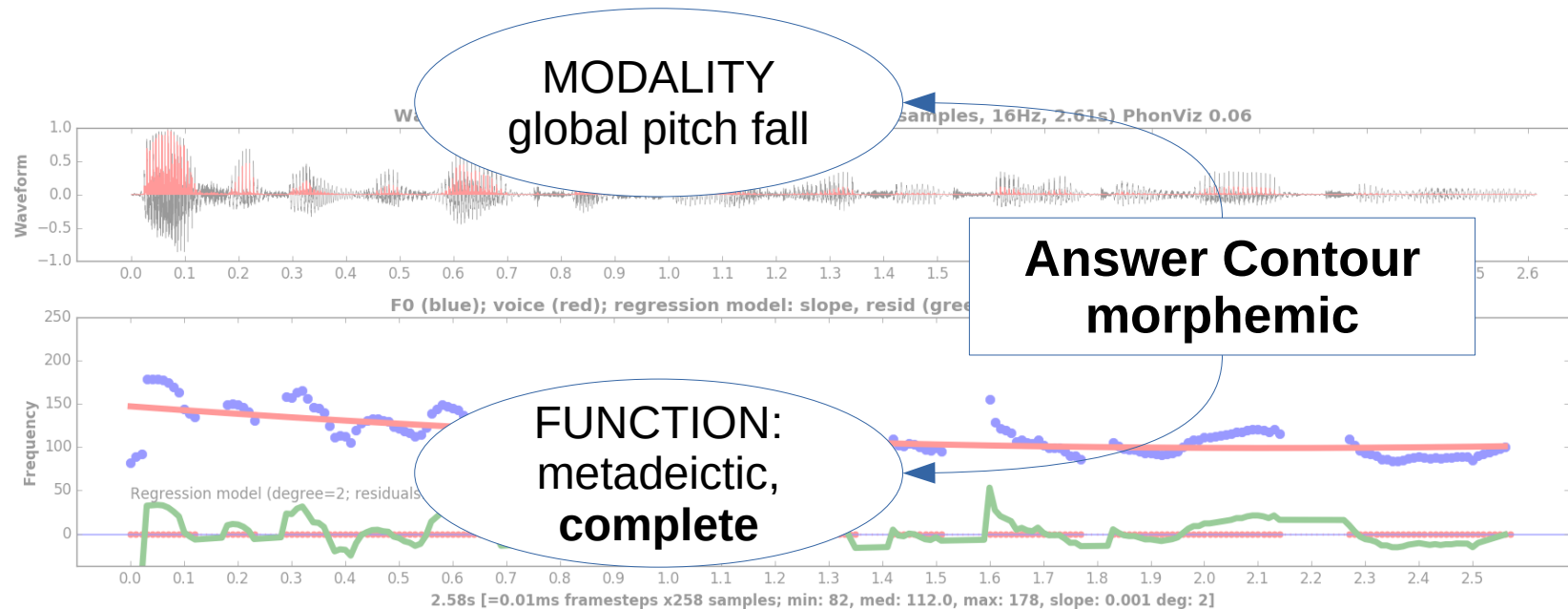morphemic**

FUNCTION
metadeictic,
**iconic gestalt
alignment**

Now listen to
these twins ...

Case Study 3: Global Text and Dialogue Contours

falling-rising global question contour

MODALITY global pitch rise

Question Contour morphemic

FUNCTION metadeictic, **incomplete**

MODALITY global pitch fall

Answer Contour morphemic

falling global answer contour

FUNCTION: metadeictic, **complete**

Break