

Tone & Intonation

Tone

- Linguistic uses of pitch (f_0) gestures
- Two contrasting tones (or pitch gestures): H, L
- Complex tonal patterns can be decomposed into sequences of H and L.
- Tone gestures and sequences of tone gestures can be coordinated with (coupled to):
 - syllables (“lexical tone”) — distinguish lexical items
 - words (“pitch accent”) — distinguish lexical items
 - phrases (“intonation”) — distinguish syntactic and pragmatic structures.

Assignment to Syllables: *Register Tones*

- can be used to contrast lexical items
- used in a majority of the world's languages

Shona (Zimbabwe)

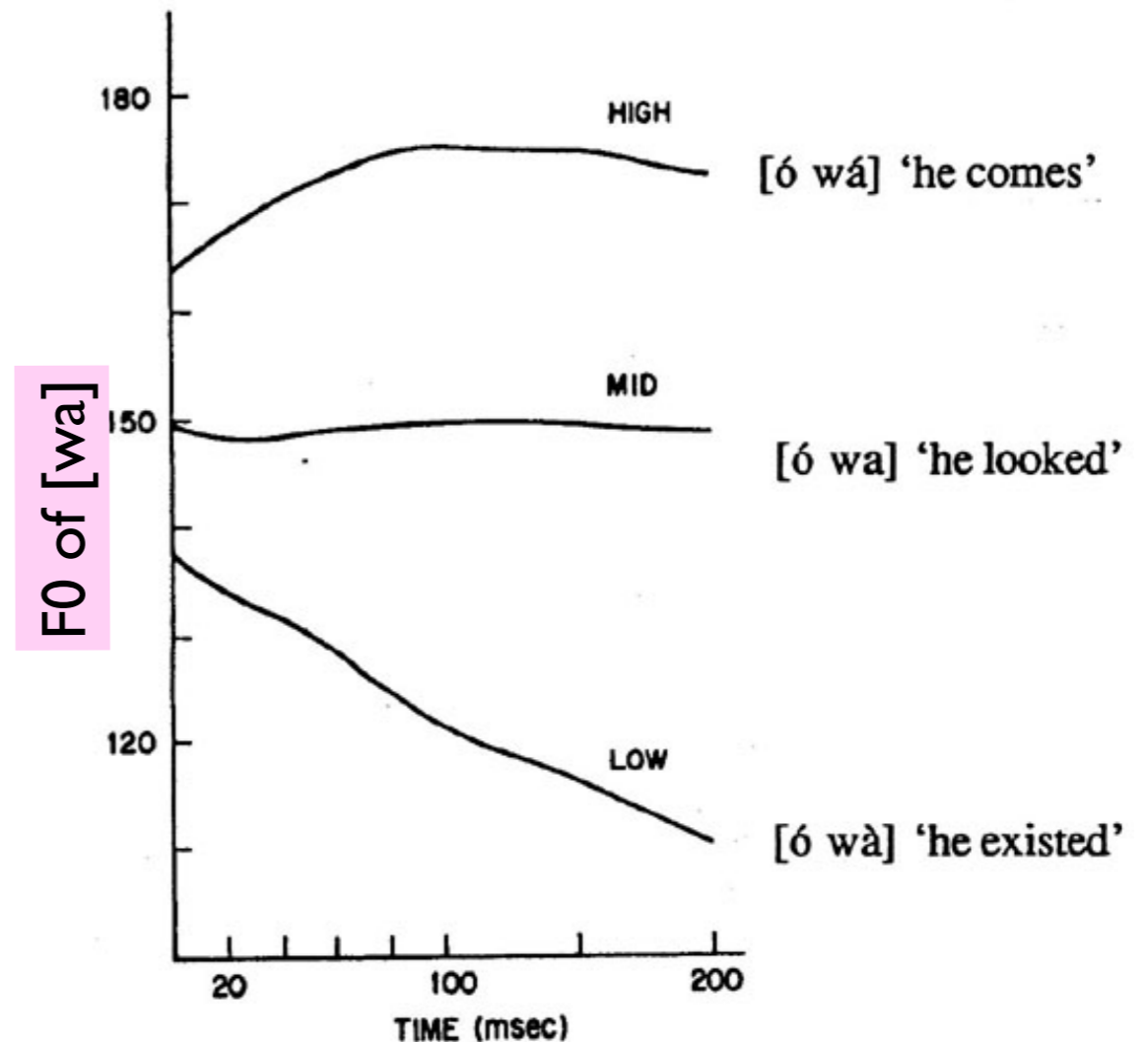
[kùtʃérá] 'to draw water'
[kùtʃèrà] 'to dig'

Bini (Nigeria)

[ì mà] 'I show'
[í mà] 'I am showing'
[ì má] 'I showed'

Yoruba (Nigeria)

Hombert, 1976



up to 5 contrastive tone levels: how do they result from H, L??

H and L tones in Embosi (Bantu Language in Congo)

(6) [ikóóbíílámbíjééβíílaapóimisóóβámina]

(b)i-kóó bíílámbí jééβíí la (m)a-póa (b)í-misáá
 cl8-manioc cl8.REL.cook.REC Gneebii at cl6-yesterday cl8-already.is

ɔ-βámina

cl15-toughen

'The manioc that cooked Gneebii yesterday is already toughened.'

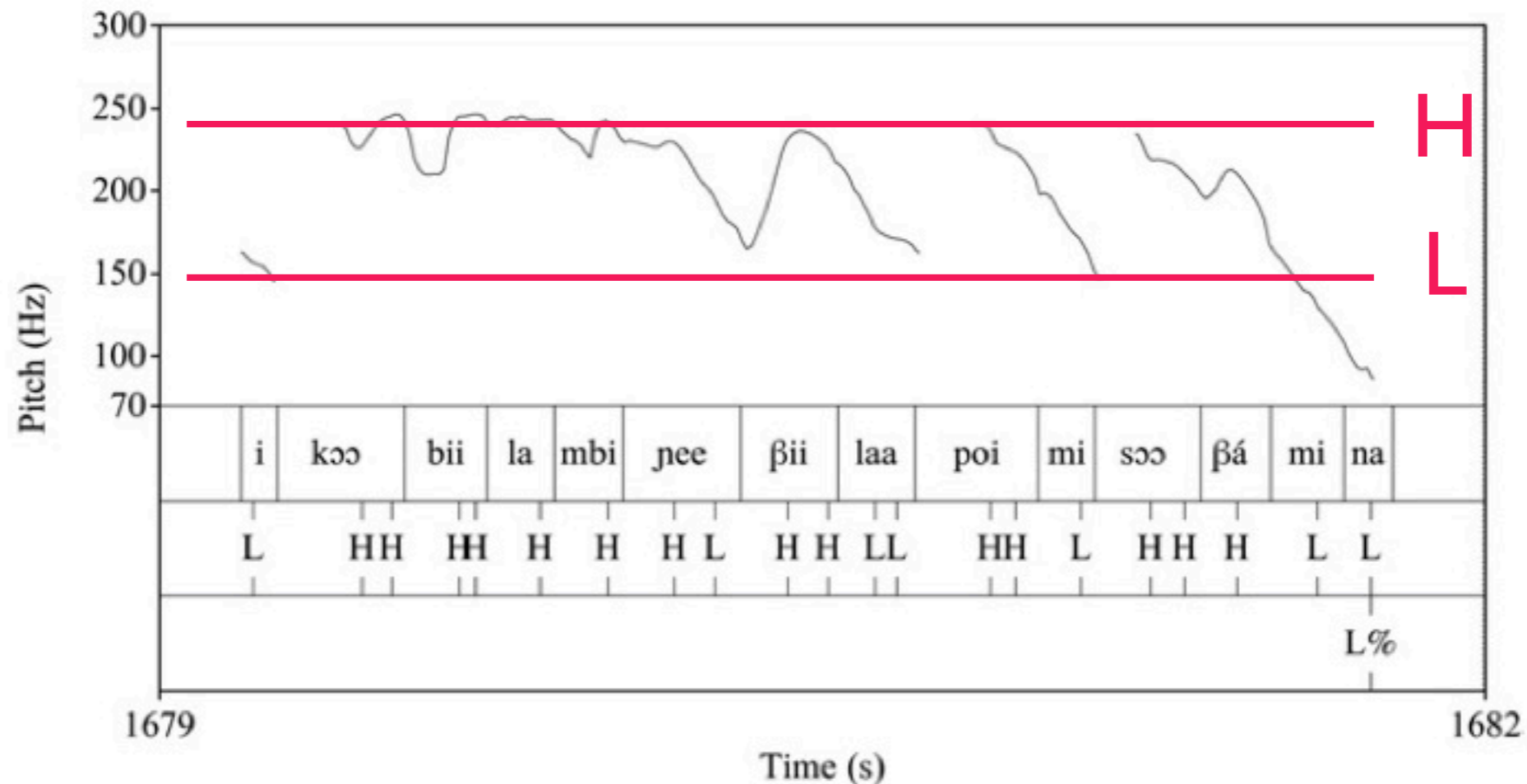


Figure 3: F0 curve of [ikóóbíílámbíjééβíílaapóimisóóβámina] "The manioc that Gneebii cooked yesterday is already toughened" (Speaker MEA)

Contours

- Multiple pitch gesture per syllable: contour tone
- Pitch gestures may not have their own syllable to be coupled to.
- Or, their coupled vowels may be elided in running speech when adjacent to another vowel.
- They can then be coordinated with a preceding or following syllable creating a tonal sequence.

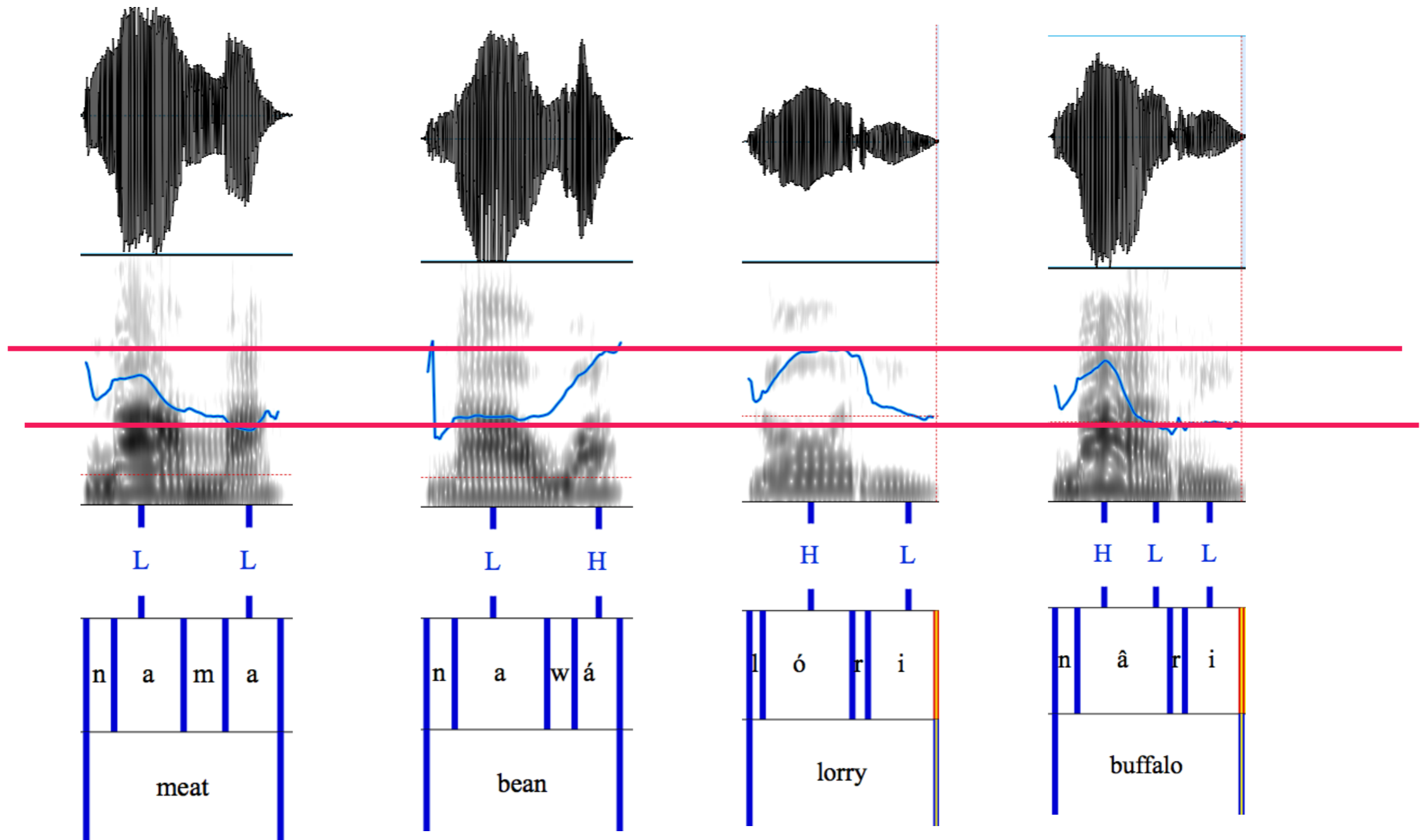
Etsako (Nigeria)

ò + ' + dé # àkpà --> [ǒdâkpà]
he PAST buy cup 'he bought a cup'

ò + ' + dé útékwĩ --> [òdútékwĩ]
he PAST buy chair 'he bought a chair'

Shekgalagari (Bantu, Botswana)

(Hyman & Monaka, 2011)

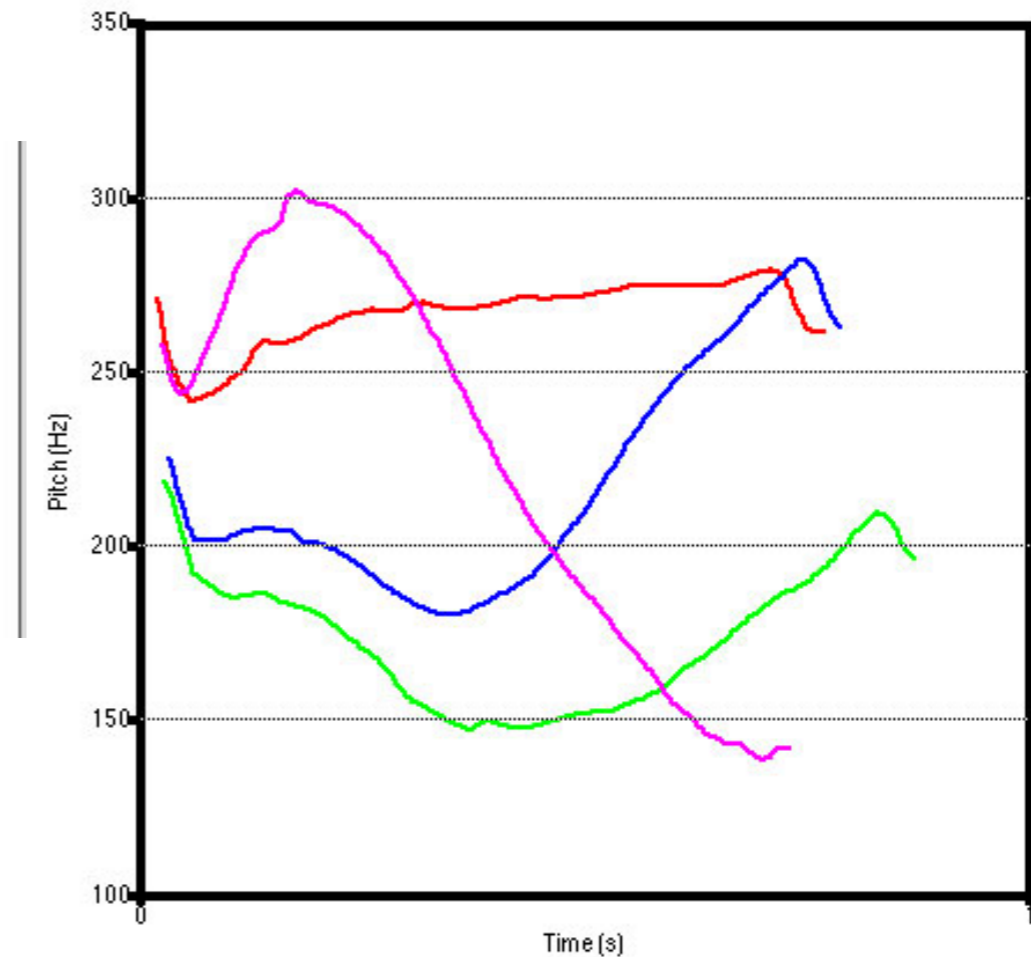


Assignment of Tone Sequences to Syllables: *Contour Tones*

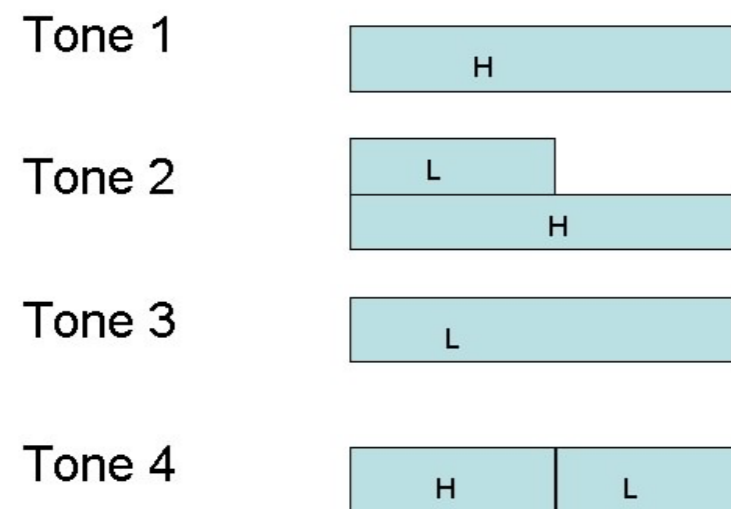
- Tonal sequence can contrast lexical items

Standard Chinese

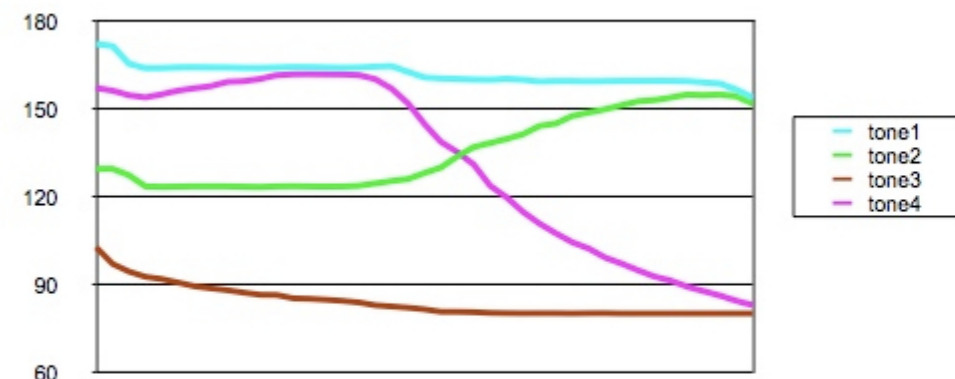
High level	妈	ma	55	˥	'mother'
High rising	麻	ma	35	˨˨˥	'hemp'
Low falling-rising	马	ma	214	˨˨˨˥	'horse'
High falling	骂	ma	51	˥˨	'scold'



Gestural Scores of Mandarin Tones



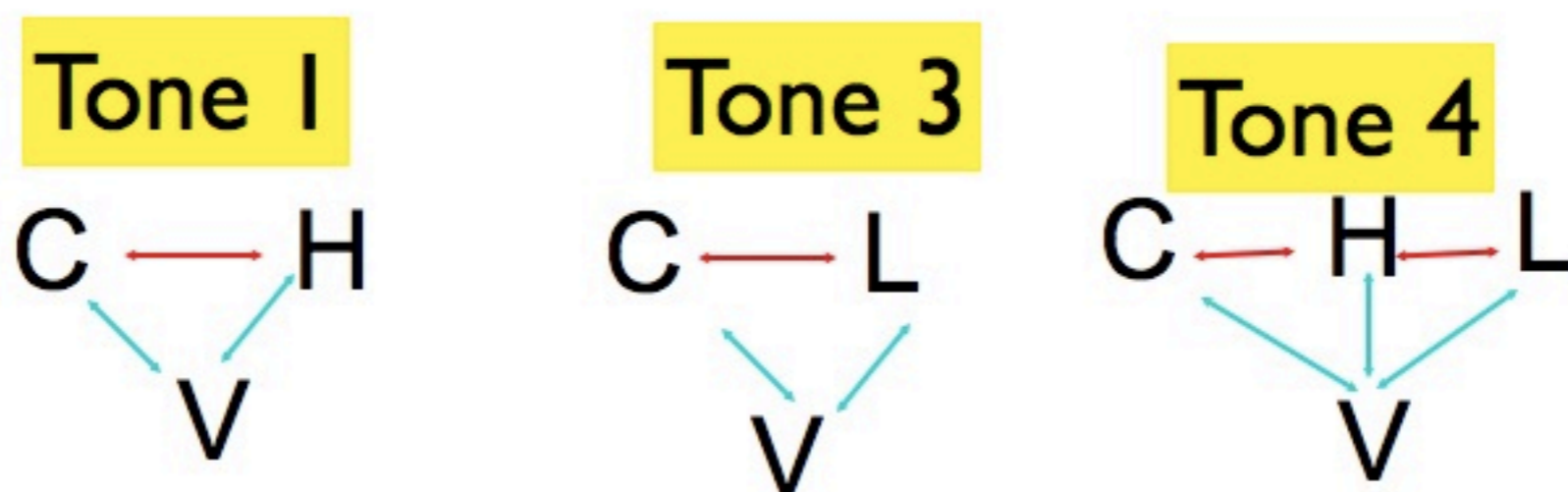
Gao (2006)



Pitch contours output by Task Dynamic Model (Nam et al., 2005)

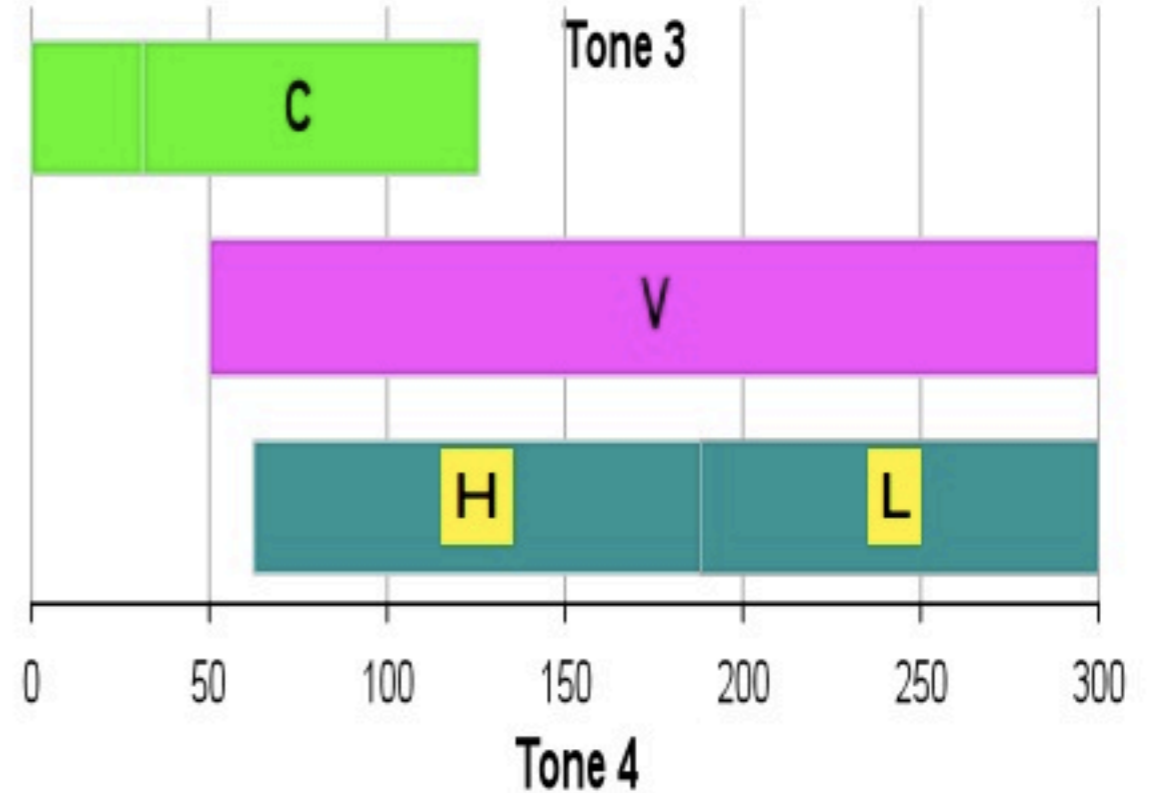
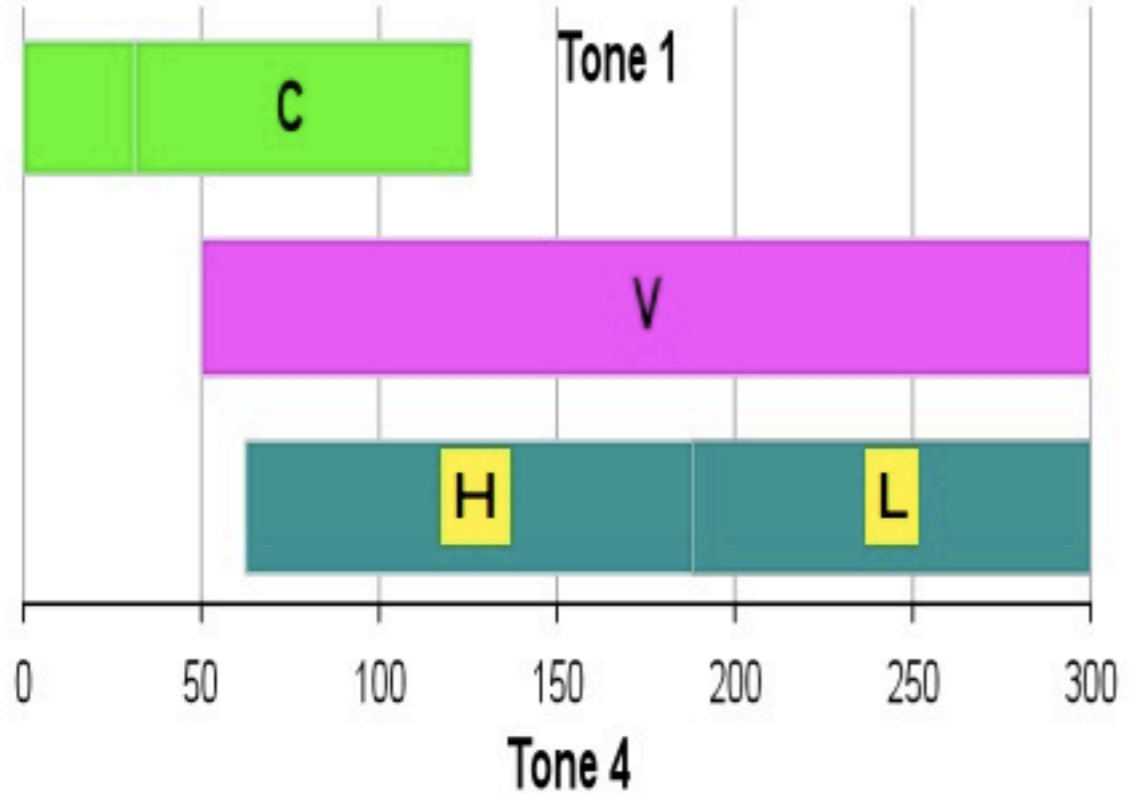
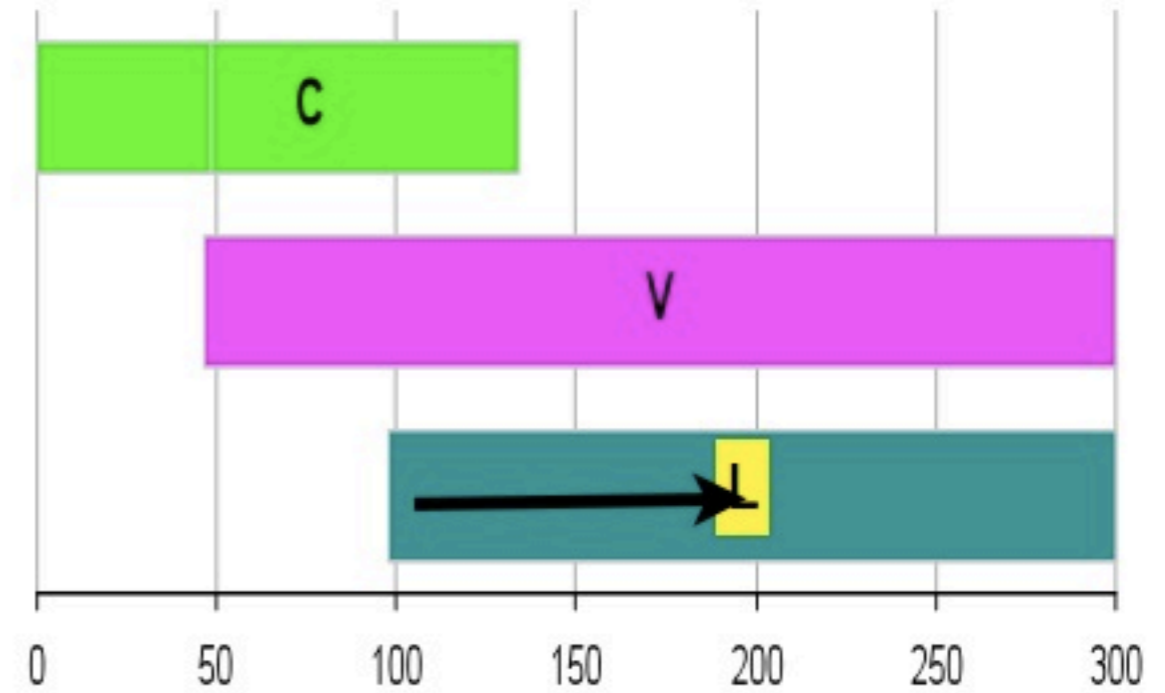
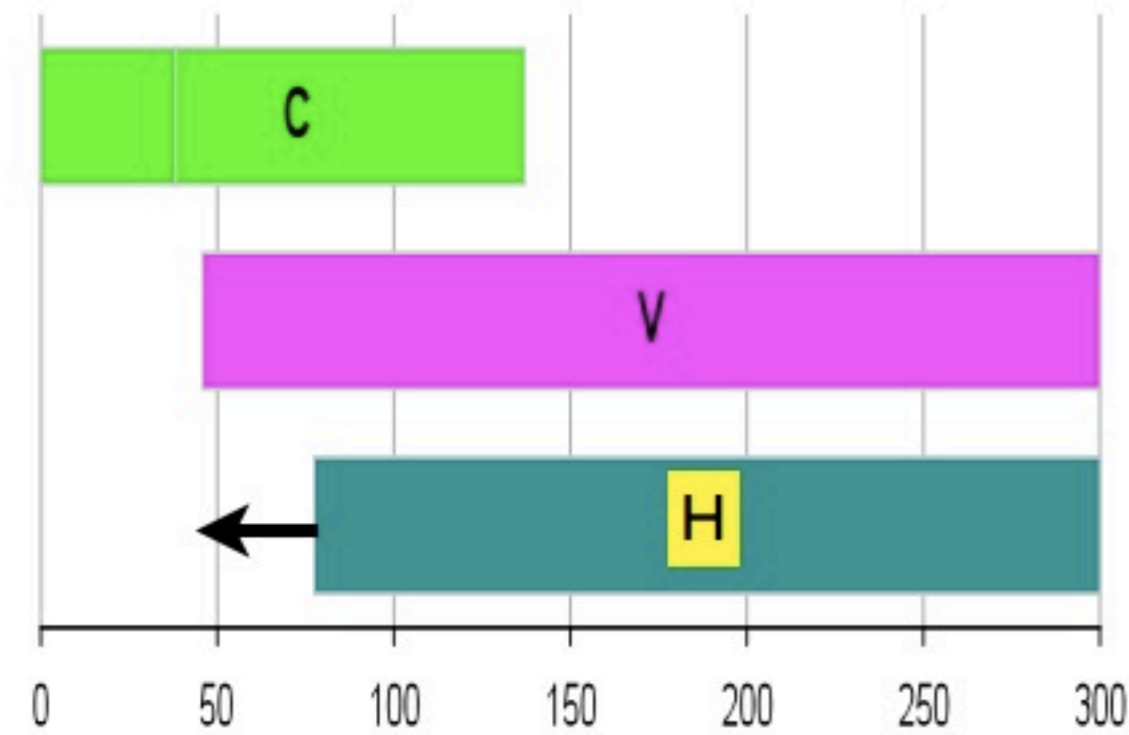
Mandarin Coupling Graphs

- Gao (2008) measured
 - onset of C,V gestures (using EMMA)
 - onset of pitch gesture (from turning point in f0)
- The relative timing of C,V, and Tones shows the pattern predicted by the competitive coupling of onset Cs.



- Thus, the Mandarin tones are behaving like onset Cs, at least with respect to their timing.

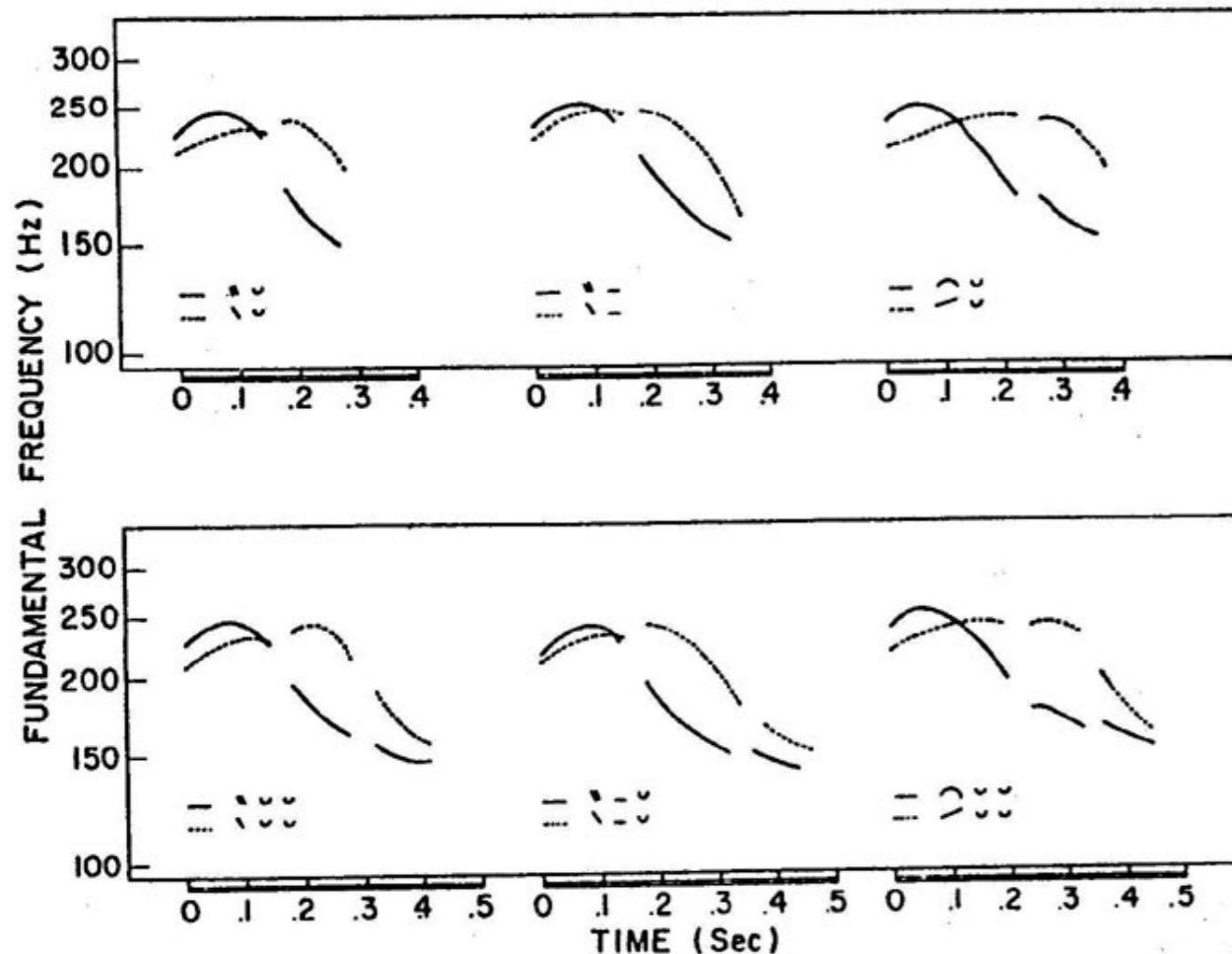
Coordination of Mandarin Tones with C,V



Assignment of Tone Sequences to Words: *Pitch Accents*

- Words can contrast in terms of pitch gestures assigned to them, but not every syllable can independently bear pitch gestures.

Croatian



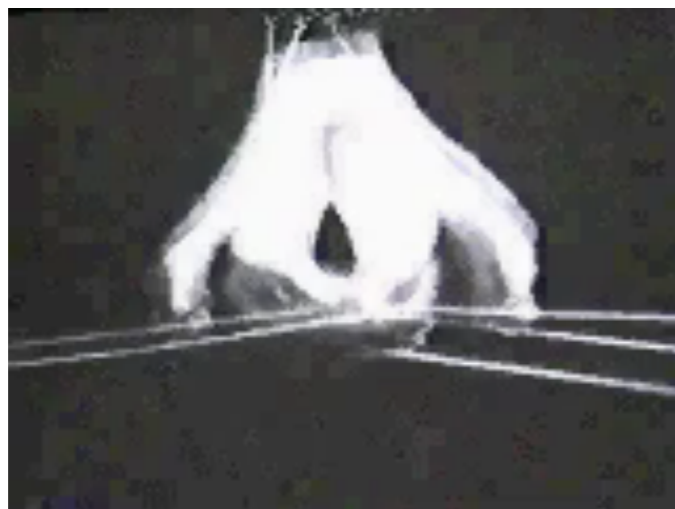
- Words contrast in accent type: 2 sequences of pitch gestures.
- Early rise ($L+H^* L-L\%$) /mlada/ 'the bride'
- Late rise ($L^*+H L-L\%$) /mara/ proper name ('Mara')
- Patterns are "strung out" over words of 2- or 3- syllable words.
- In a syllable tone language, there could be 8 contrastive tonal patterns on 3-syllable words. In Serbo-Croatian, there are only

Tone Gesture Control

- Gestures are defined by tasks and the articulators that produce them.
- Tasks: F0 value (H or L)
- Articulators:

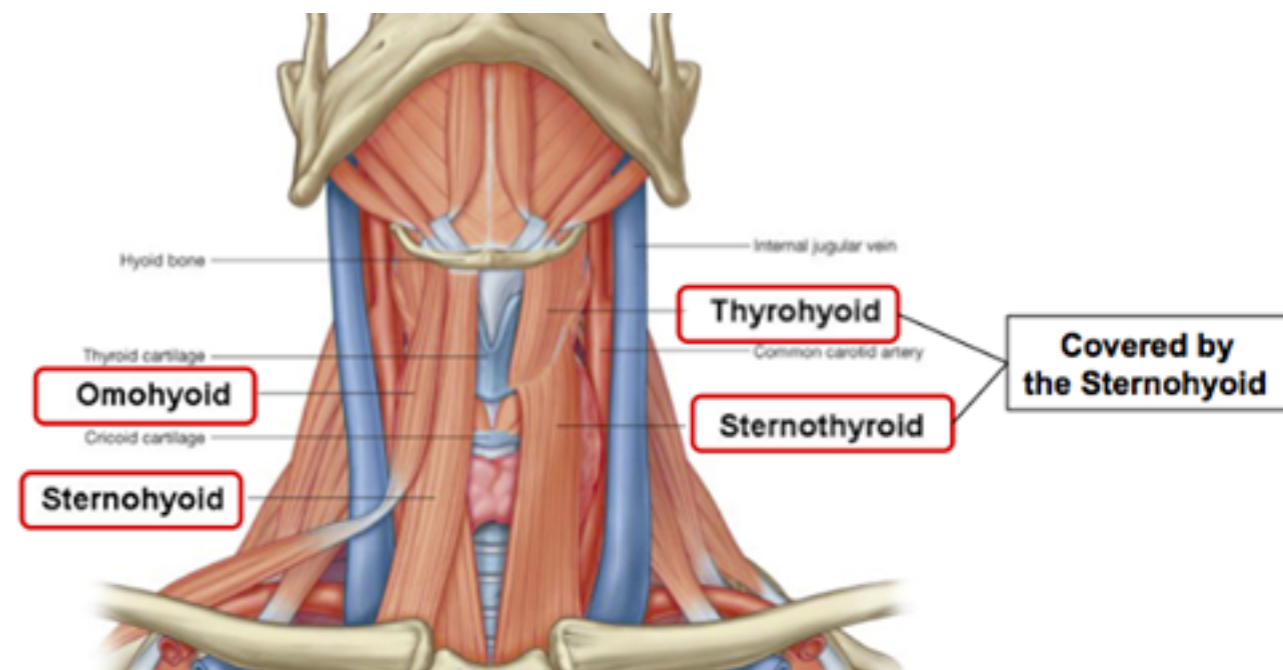
H

- Increase in longitudinal tension
- Produced by increasing angle between cricoid and thyroid cartilages
- Action of crico-thyroid muscles



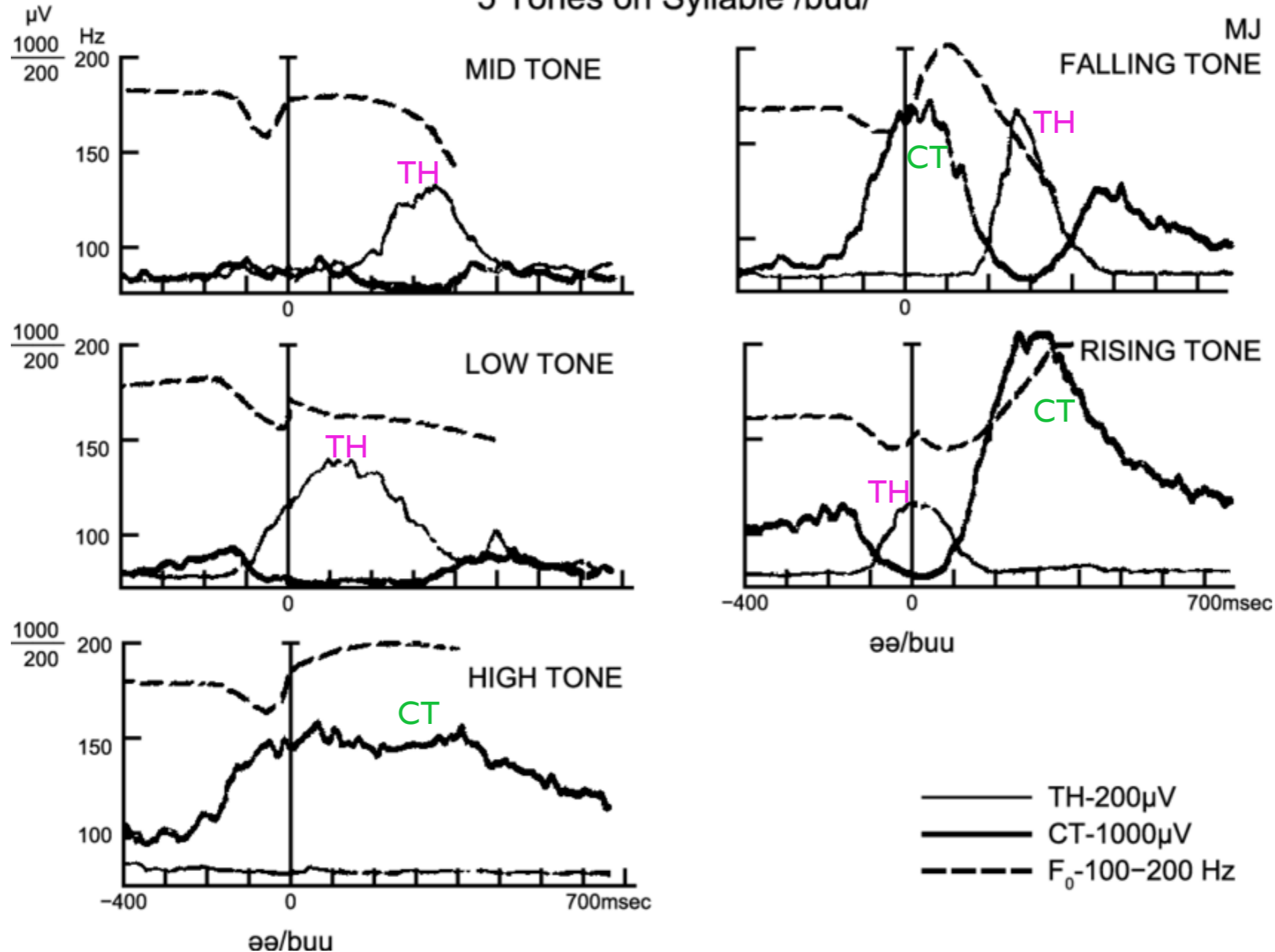
- Decrease in vertical tension produced by lowering entire larynx.
- Action of the strap muscles: sterno-hyoid, thyrohyoid

L

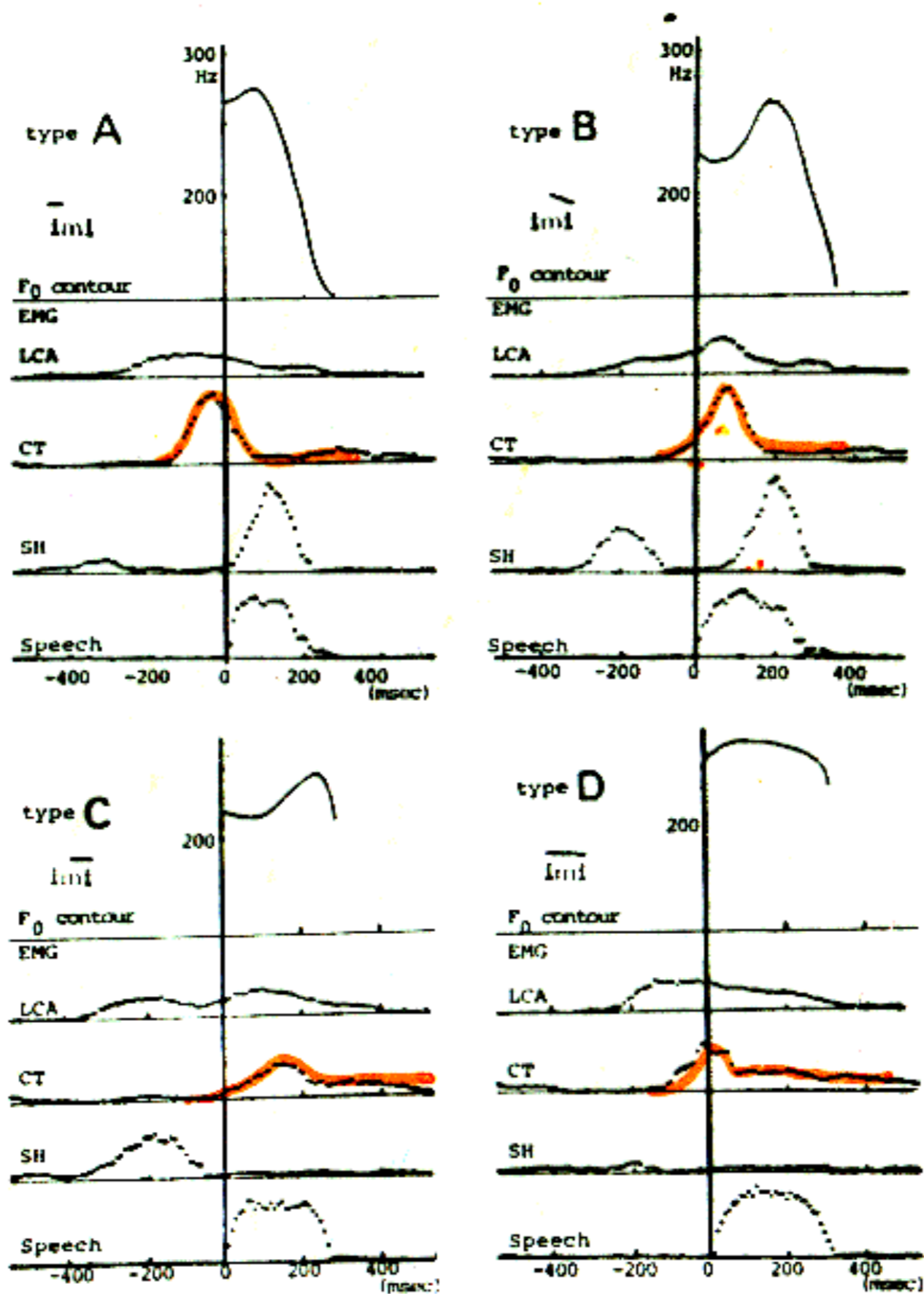


EMG of Thai tones (Erickson, 2011)

CRICOTHYROID, THYROHYOID, and F_0 Data
5 Tones on Syllable /buu/

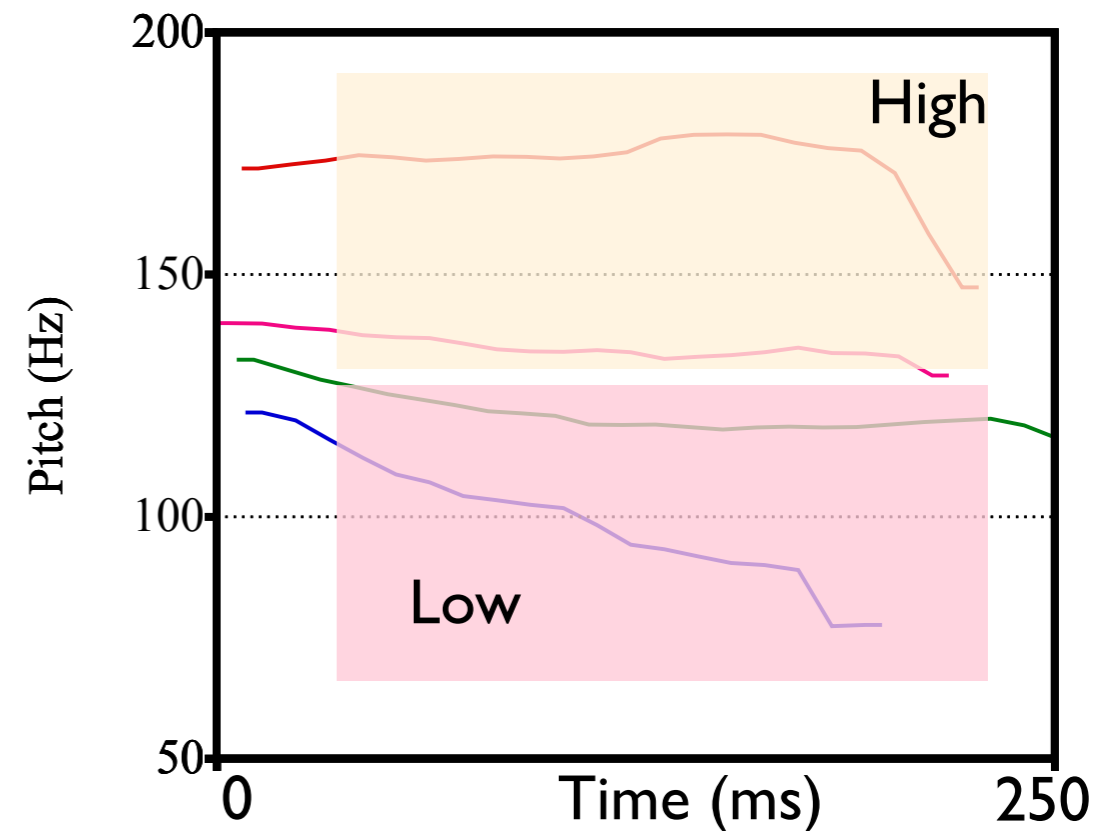


Accent Patterns in Kinki Dialect of Japanese



Cantonese Tones

- Four pitch levels
- Nissenbaum (2010) hypothesized they are produced with a 2x2 combination of
 - Larynx Height (SH) (“register”)
 - CT Stretching



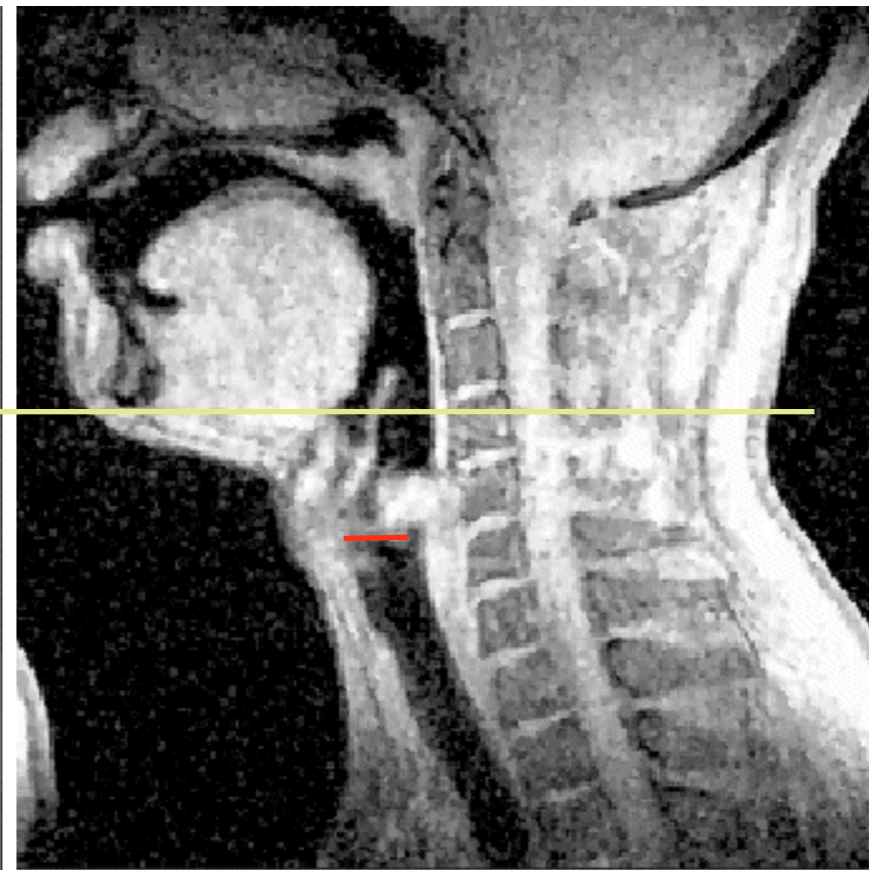
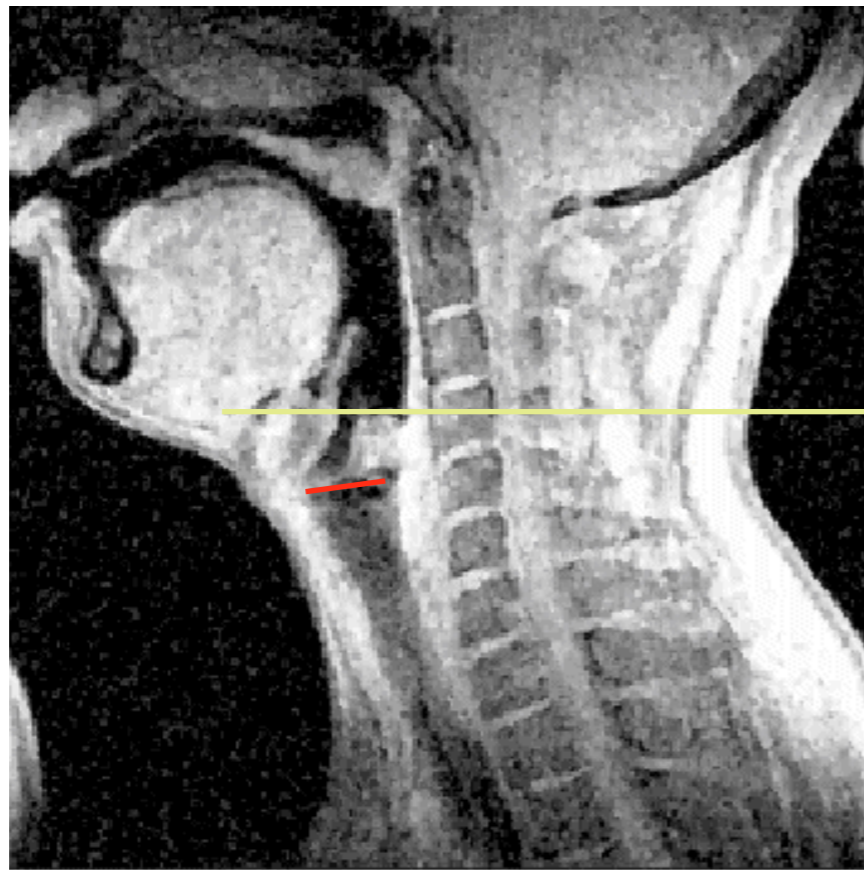
Cine-MRI evidence: extreme tones

Male speaker age 20

Upper and Lower extreme tones

UPPER register, HIGH tone

LOWER register, LOW tone



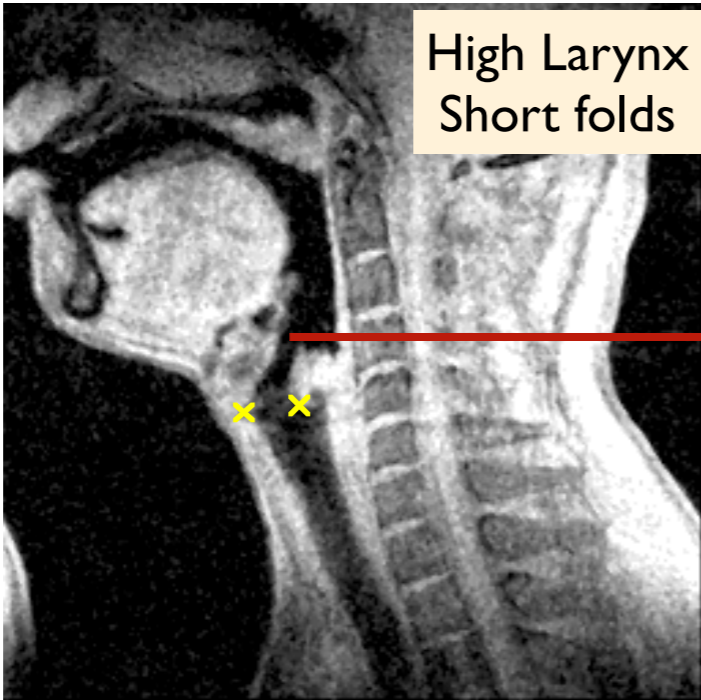
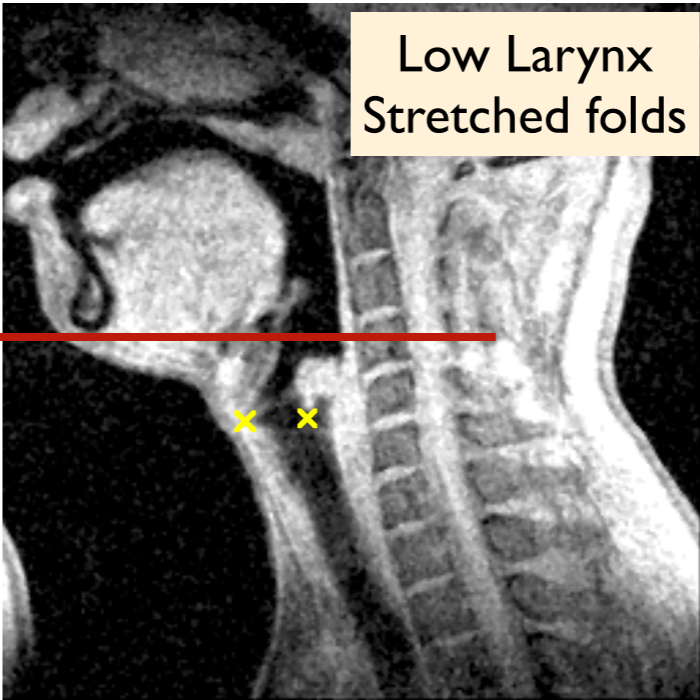
Hi Larynx
Stretched

Lo Larynx
Short Folds

Mid tones

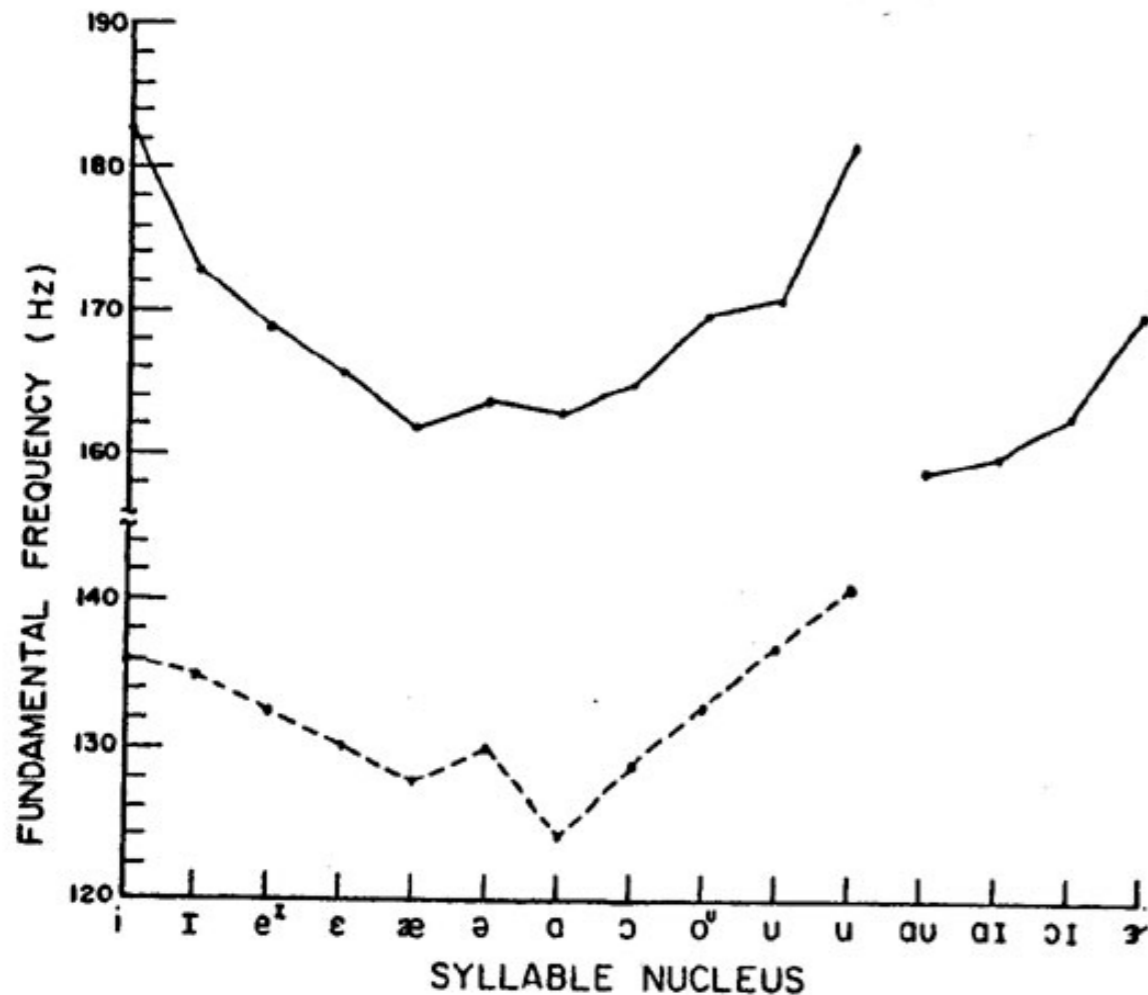
- In running speech, the f_0 of the two middle tones are not distinct, but they are produced with distinct gesture combinations.

Mid tones

<p>/u³/ UPPER mid-tone</p> <p>vocal fold length = 17.7 mm posterior vertical dist. from top = 127.7 mm</p> 	<p>/u⁶/ LOWER mid-tone</p> <p>vocal fold length = 19.7 mm posterior vertical dist. from top = 132 mm</p> 
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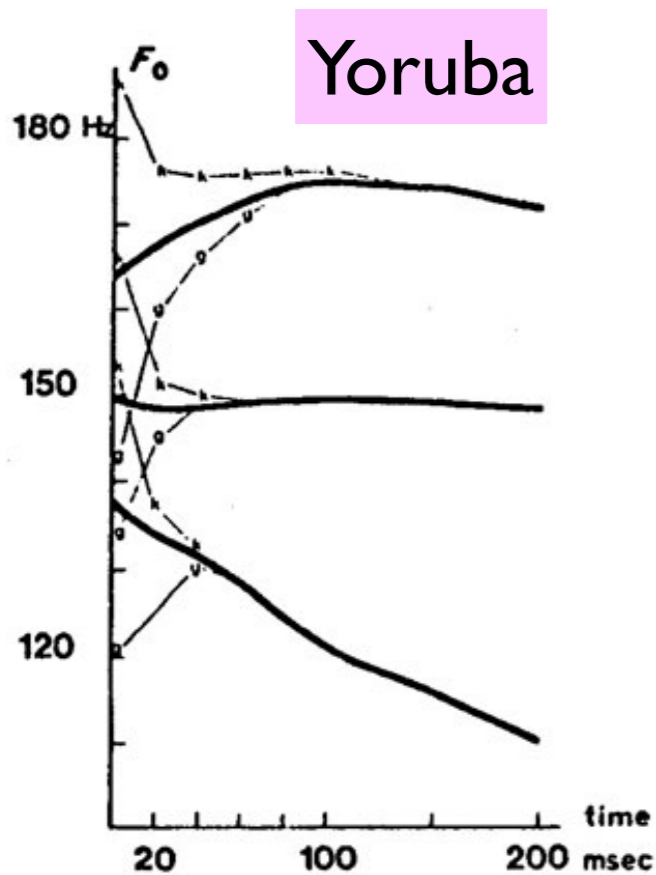
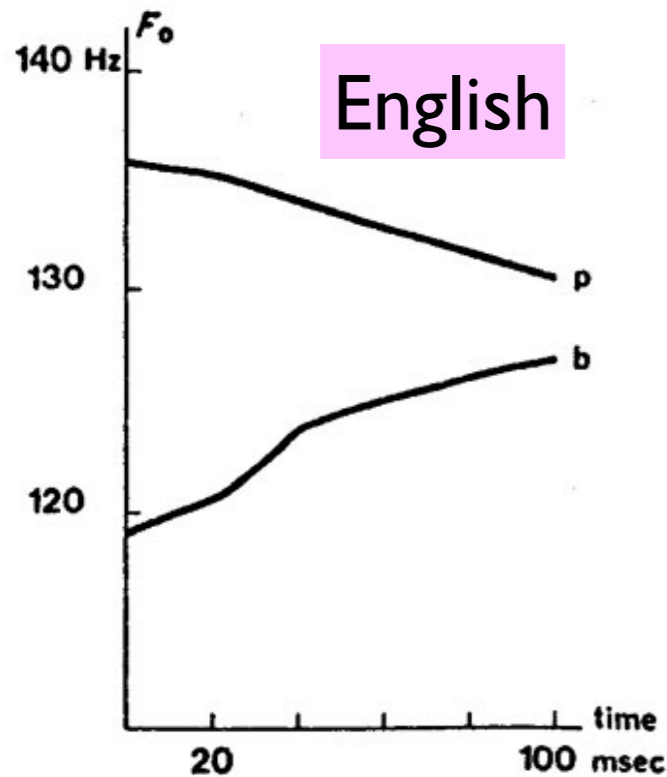
- Difference in vocal fold length between tones 3 and 6 for this subject is 2 mm (i.e. vocal folds are 11% longer at onset of tone 6 than at onset of tone 3)
- Difference in vertical position is 4.3 mm (i.e. larynx lowers by nearly 1/2 cm for tone 6)

Intrinsic f0



- High vowels have higher F0 than low vowels (31 languages in Whalen & Leavitt, 1995).
- Effect has been considered universal and a “mechanical” effect of vowel production.
- Mechanism? Low vowels pull the hyoid bone down, which also lowers the larynx.
- Counter-evidence to “mechanical” :
 - Effect is neutralized in Mambila, a 4-tone African language (Connell, 2002).
 - Regional variation in size of the effect in English (Jacewicz & Fox, 2015).

Voicing and F0



Hombert (1978)

- Near-universal effect of voicing in stops and fricatives on f0
- F0 is high and falling after voiceless stops and fricatives.
- F0 is low and rising after voiced stops and fricatives.
- Mechanism unclear
 - LH for voiced stops causes lower F0 (but implosives may not have effect)
 - CT for voiceless stops contributes to devoicing.
 - Inconsistent patterns for nasal and pre-nasalized stops, murmured stops (Chibelli, 2015).
- Tonogenesis (Hyman, 1976)
 - Tone contrasts can develop and replace voicing contrast

Assignment of Tones & Sequences to Phrases: *Intonation*

- Functions
 - Sentential meaning (speech-act)
 - assertion, question, command
 - Information structure, e.g., focus

What about Manny? Who came with him?
Anna came with Manny.

What about Anna? Who did she come with?
Anna came with Manny.

- Syntactic parsing

"light-house keeping" vs. "light house-keeping"

"1 + (3 * 2)" ... = 7

"(1 + 3) * 2" ... = 8

ToBI system of Intonation description

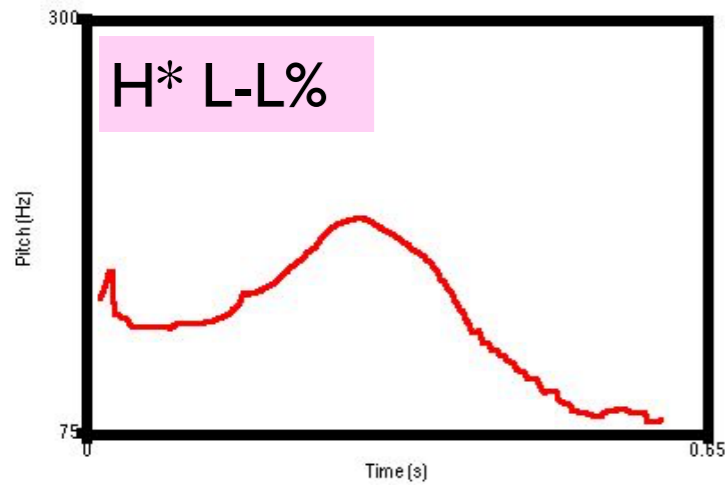
- Pitch accents (tones & sequences):
Every phrase has at least one.
- Final one is called the "nuclear" accent.
- (Partial) Inventory of pitch accents:
 - starred tone is coordinated with stressed vowel
 - !H means lowered H
- Phrase accents
Can be added to the "nuclear" accent.
- Boundary tones
 - Final rising or falling pitch

H*
L*
L+H*
L*+H
H + !H*

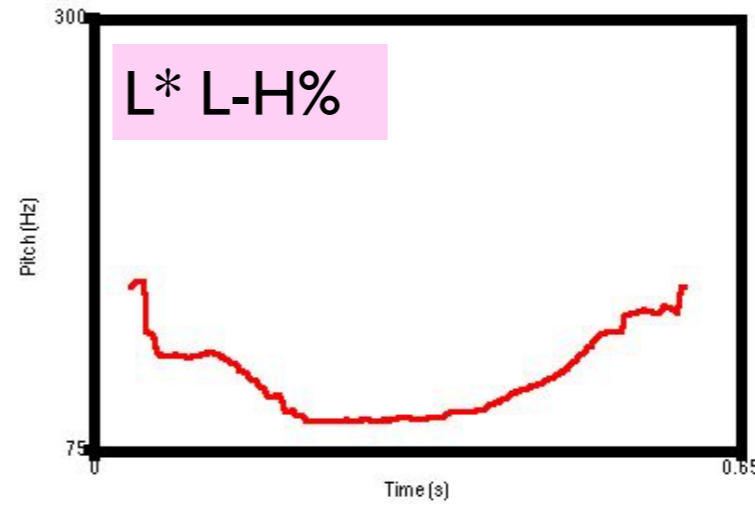
H-
L-

H%
L%

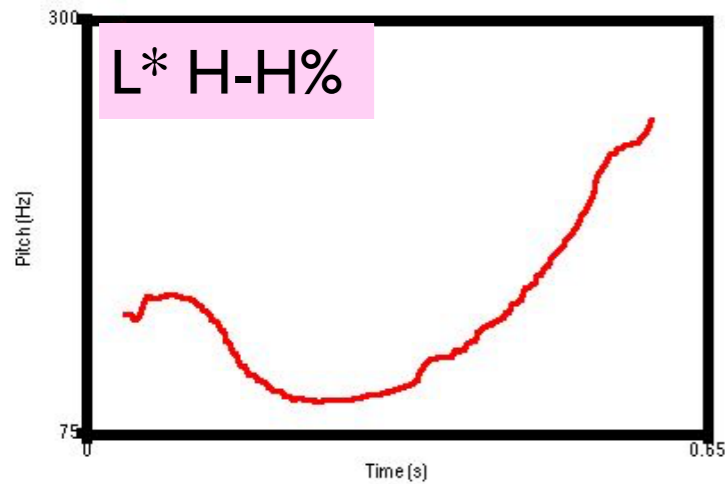
Example of ToBI



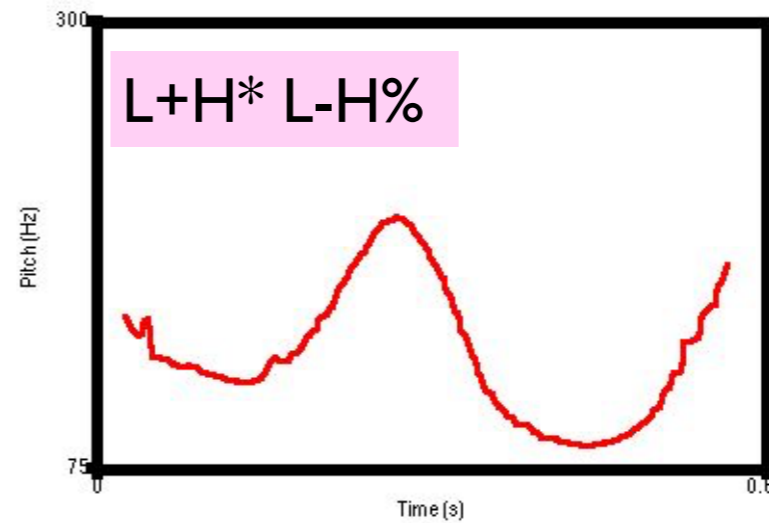
statement



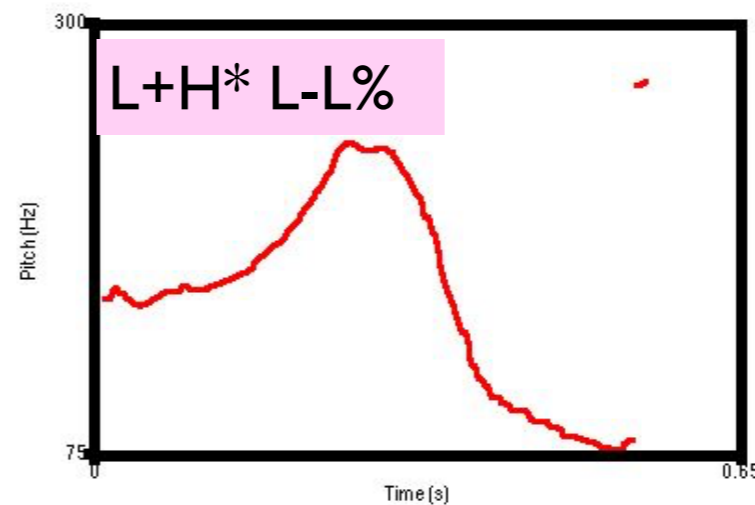
address



question



puzzlement



reprimand

Prominence and Focus

Question: What about Manny? Who came with him?
 Answer: Anna came with Manny.

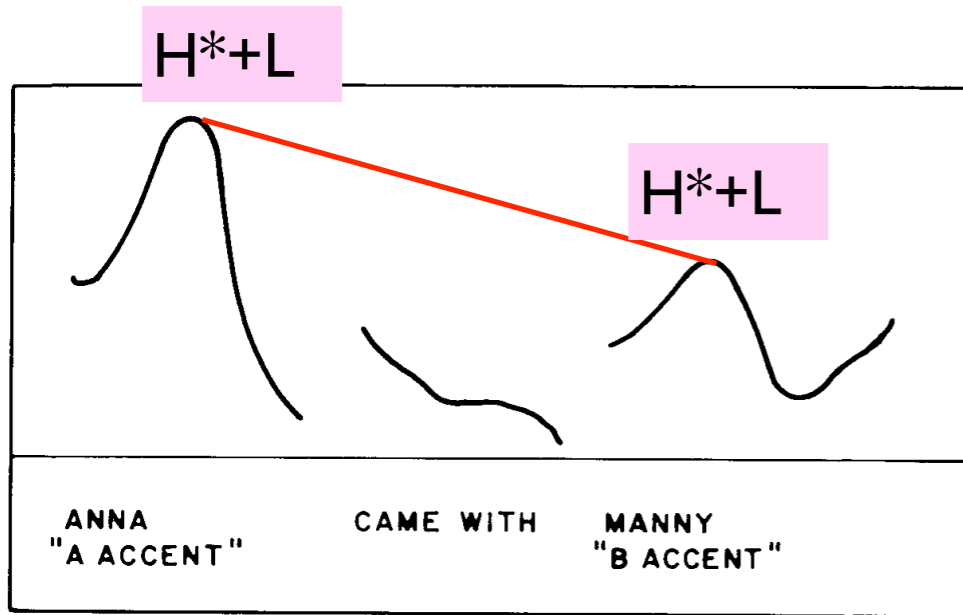


Figure 9
 An F0 contour for *Anna came with Manny*, produced as a response to *What about Manny? Who came with him?*

Question: What about Anna? Who did she come with?
 Answer: Anna came with Manny.

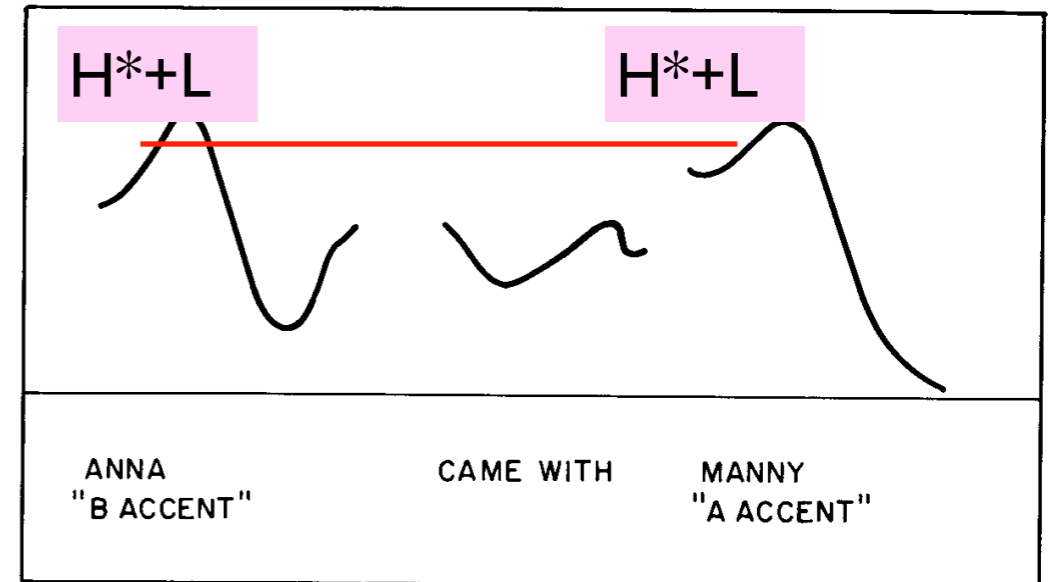
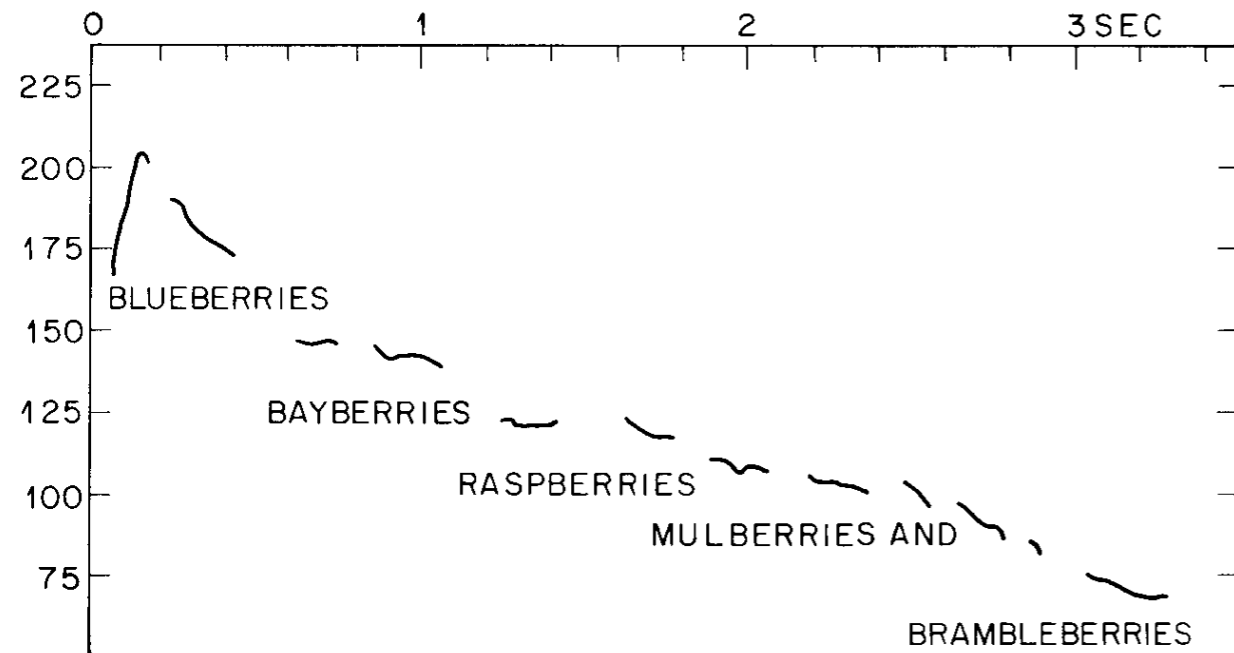


Figure 10
 An F0 contour for *Anna came with Manny*, produced as a response to *What about Anna? Who did she come with?*

- Hypothesis (Lieberman & Pierrehumbert, 1984)
- Prominence relation between (B and A) is invariant (across positions and and pitch range) though obscured by **downstep** and **final lowering**.
- Recording of these sentences under 10 degrees of “overall emphasis” (to vary pitch range).

Downstep



- Recording of lists: 2-5 items
- Three levels of pitch range

- Hypotheses
- Downstep is can be modeled by an exponential decay function (first-order dynamical system with “goal” at bottom of pitch range).
- Downstep is invariant across pitch range changes (when a reference level is incorporated that can vary across pitch ranges)

Results

- Results support exponential decay
- But final position is particularly low

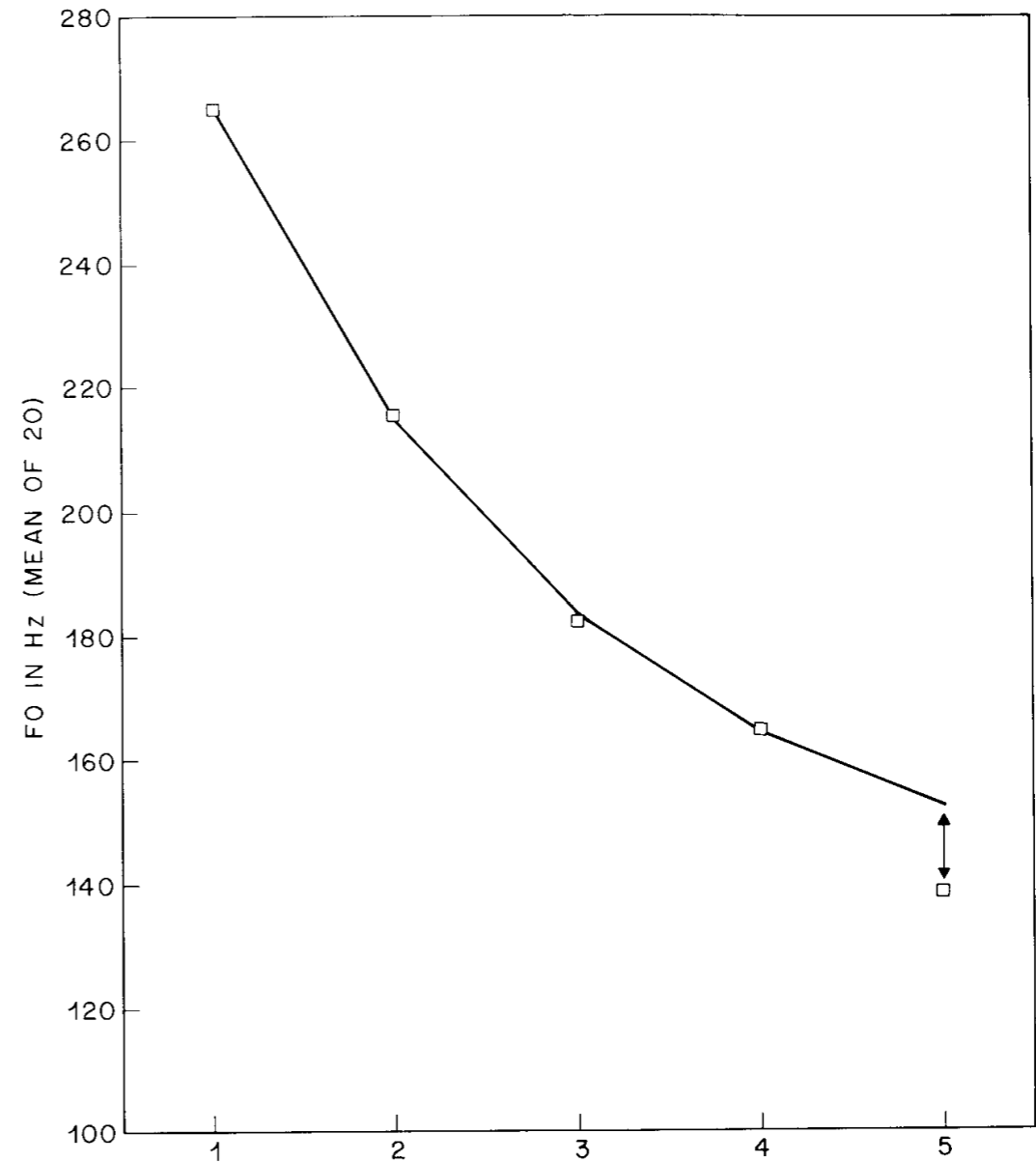
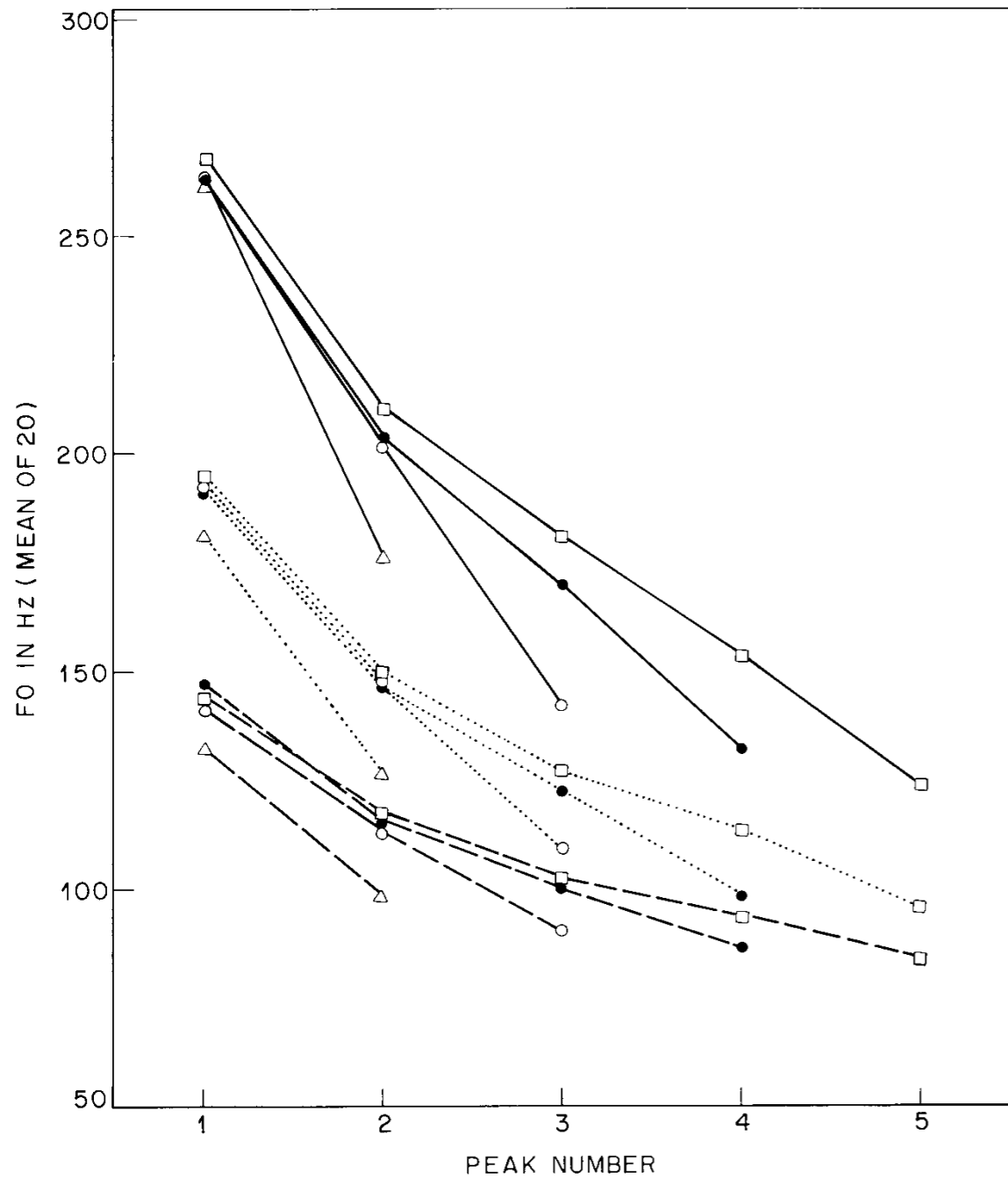


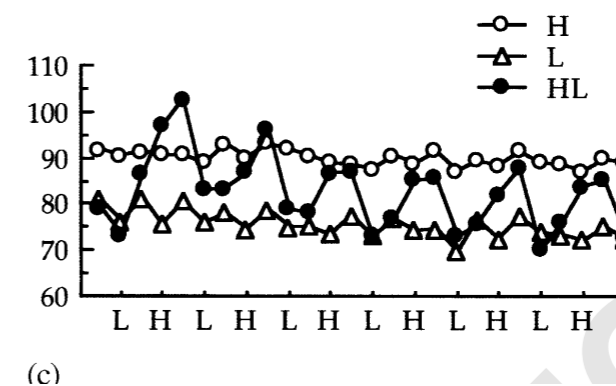
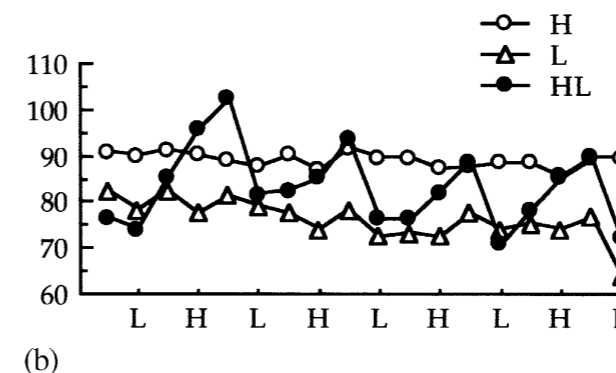
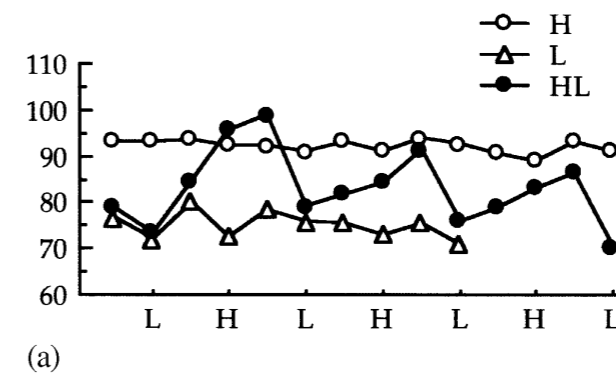
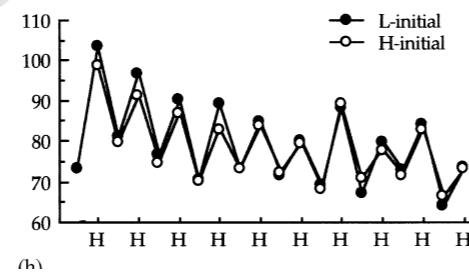
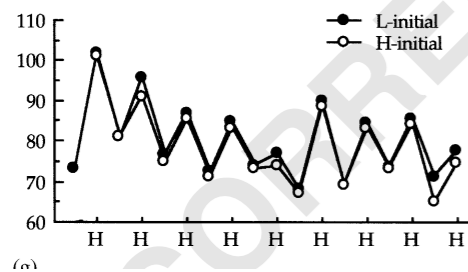
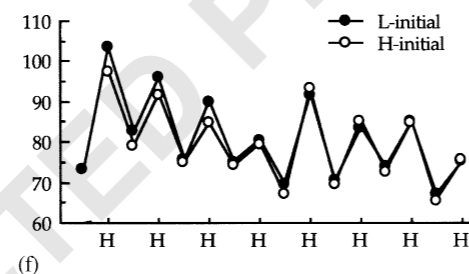
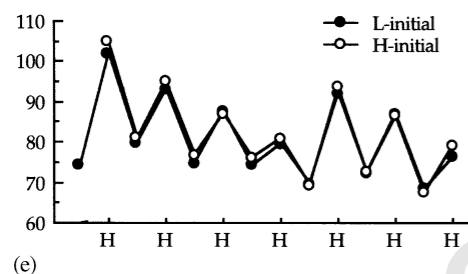
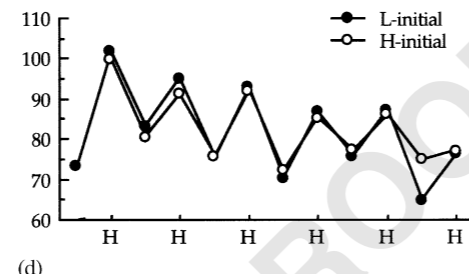
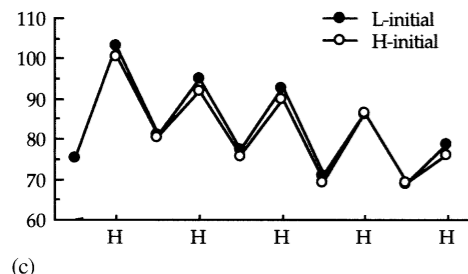
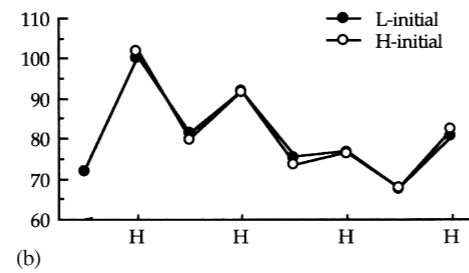
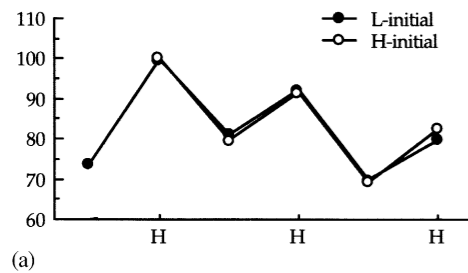
Figure 21
Pitch range 3, length 5 data for subject DWS. The solid line is a decaying exponential fit to the first four points of the five-item list. The arrow indicates how far the fifth data point falls below the value predicted by this exponential.

Intonation in Lexical Tone Languages

- Theoretical problem: how are functions of intonation expressed in the presence of lexical tones
 - Morphemes
 - Intonational tone gestures that blend with lexical tone gestures
 - Pitch range
 - downstep or declination

Downstep

- Successive H tones (separated by L) are lowered
- Can be modeled with an attractor to a low level at phrase end, with resets if the f0 gets too low

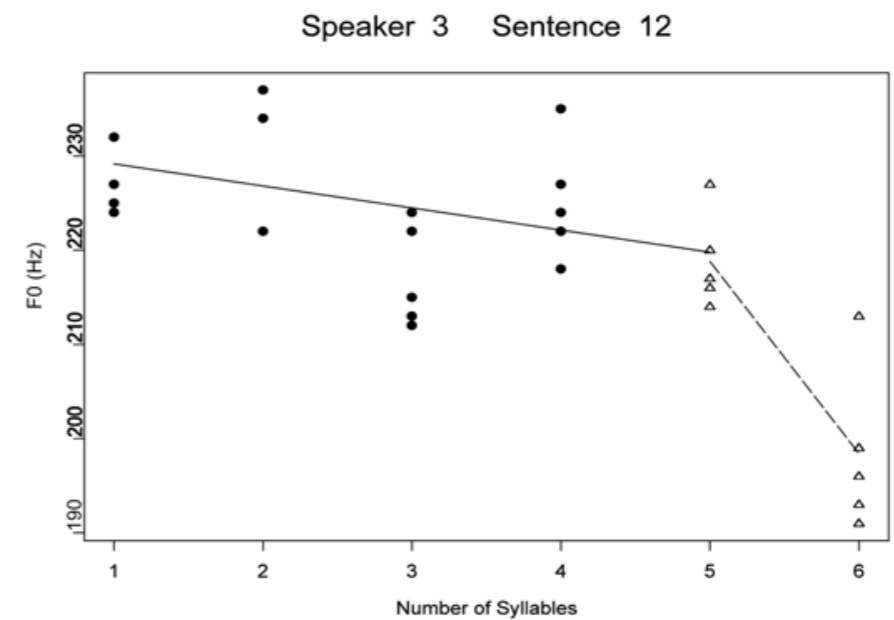
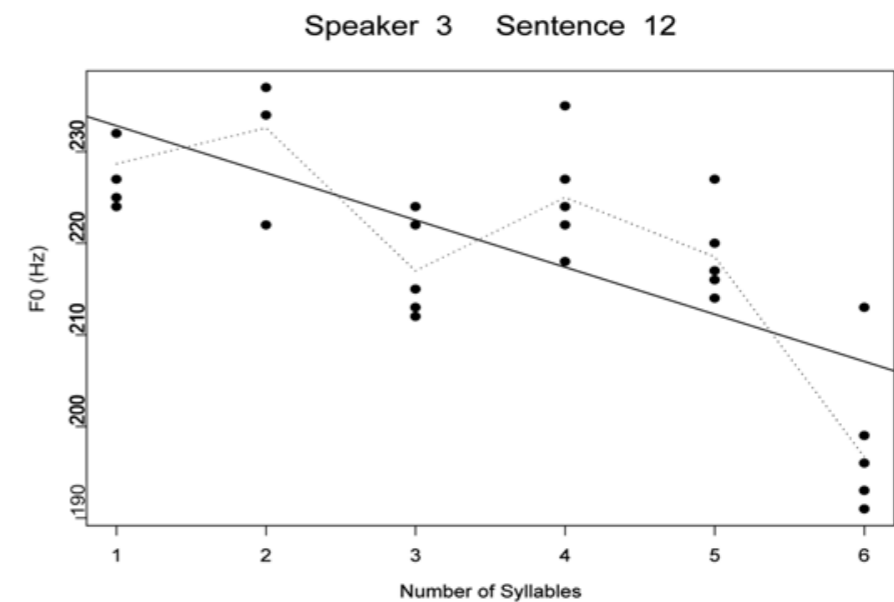


Yoruba

Laniran & Clements (2003)

Declination in Mambila (Connell, 2016)

- 4 level tones
- f0 lowers over time, even for same-tone sequences
- T1 (H) lowers least
- T4 (L) lowers most



Bemba (Zambia)

Kula & Hamann (2016)

- Both Declaratives and Yes/no Questions have final L%.
- Declaratives exhibit downstep over the entire utterance
- Yes/No Questions suspend downstep.

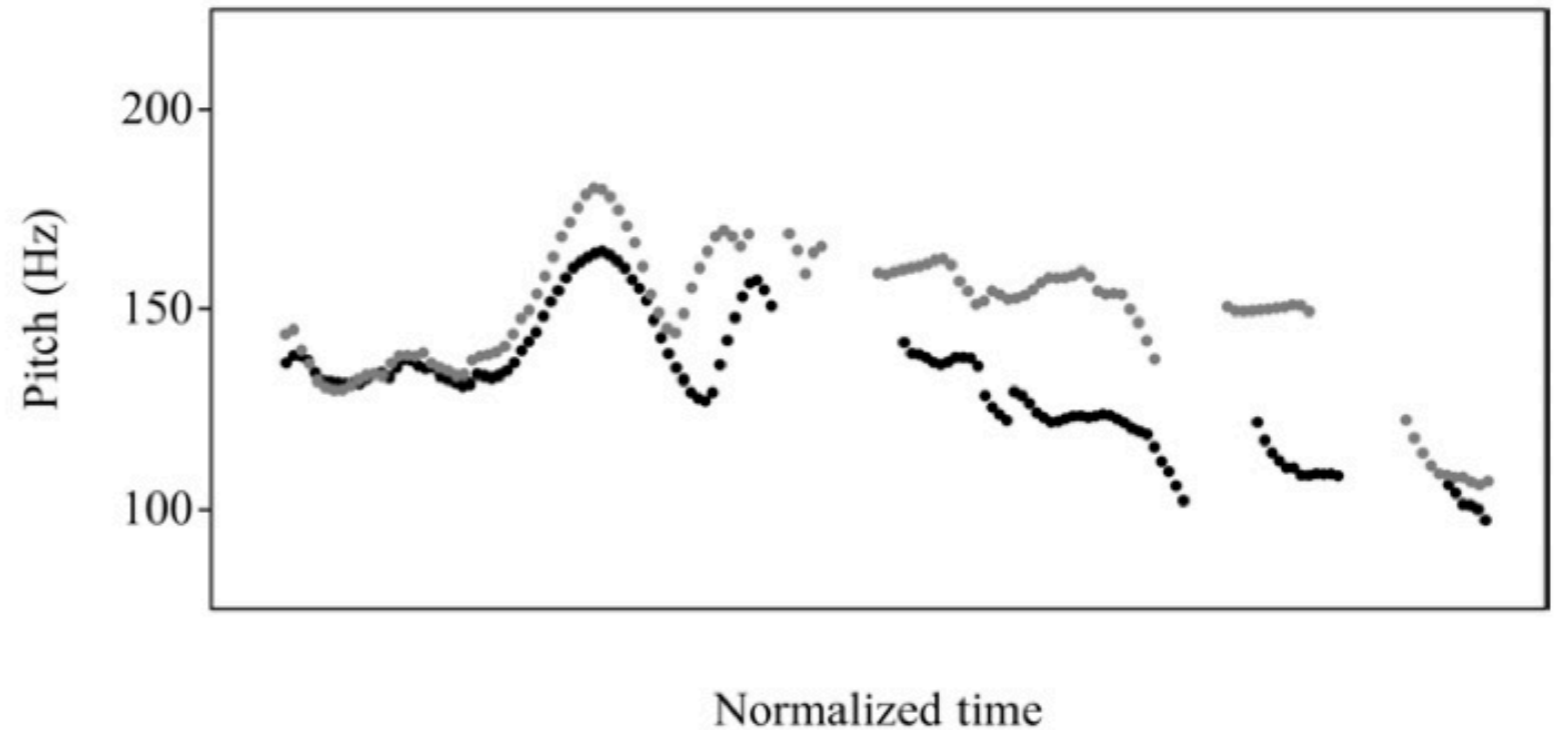
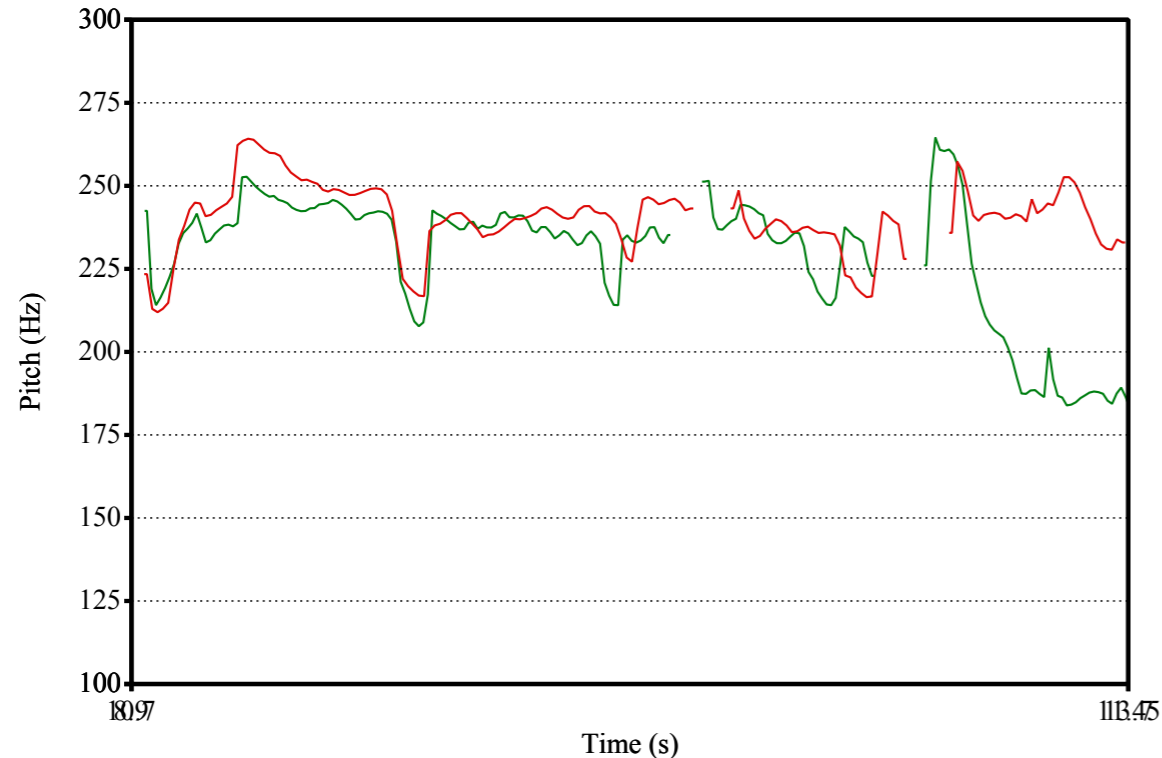


Figure 13: Pitch tracks of a declarative sentence (black) and the corresponding polar question (grey) (16)

(16) bànàmáàyó bá-ká-'pél-à úmu'kááte
2woman 2SM-FUT3-give-FV 3bread
'The women will give the bread?'

Shekgalagari

- Declaratives have final lowering over the penultimate and final syllables (L%), that is suspended in YNQ.



mulimi ubanelava kana bitari

Does the farmer want to leave?