

24.964

Phonetic Realization

Does Language-Specific Detail  
Affect Phonological  
Distribution?

Contour Tones

- Reading for next week:

Gordon (2002) A phonetically-driven account of syllable weight

## Zhang (2002, 2004)

- Argues that an analysis of the typology of the phonological distribution of contour tones must make reference to language-specific phonetic details concerning segment duration.

## Outline of Zhang (2004)

- Level and contour tones
  - lexical tones may involve approximate level  $f_0$  (H, M, L), or  $f_0$  movements (rising, falling).
  - generally, if a language has contour tones it also has level tones.
- Many languages with contour tones restrict them to certain positions, e.g. long vowels.

# Outline of Zhang (2004)

- Explanation for distributional restrictions:
  - Contour tones are realized by  $f_0$  movement
  - It takes time to produce and accurately perceive  $f_0$  movement
  - $f_0$  is best perceived in vowels and sonorants
  - so contour tones are restricted to syllables iwth longer sonorous rhyme durations.
    - i.e. contour tones are excluded from positions where they are harder to produce/identify.
- Language-specific variation in the duration of different rhyme types affects the distribution of contour tones.
  - an analysis of the phonological typology of contour tones needs to refer to phonetic details of segment duration.

# Outline of this lecture

- What is a contour tone?
- Phonetic bases for markedness of contour tones
  - perception
  - production
- The typology of distributional restrictions on contour tones
- Evidence for the role of sonorous rhyme duration.
- Evidence for the role of language-specific segment duration.

# What is a contour tone?

- Which are the contour tones?
- Level:
  - 1 (H)
  - 3 (M)
  - 6 (L/LM)
- Contour:
  - 2 (High rising)
  - 4 (Low falling)
  - 5 (Mid rising)

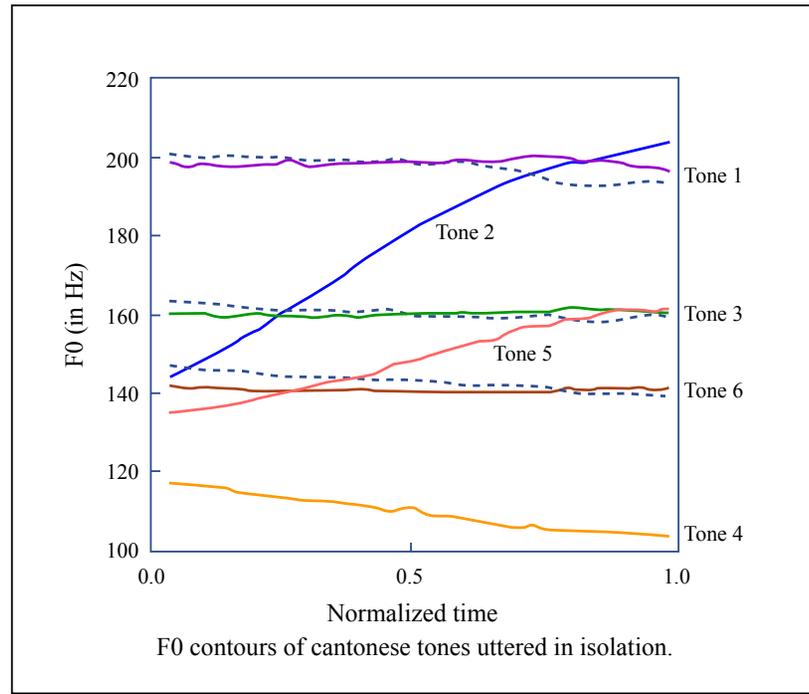


Image by MIT OpenCourseWare. Adapted from Li, Yujia, Tan Lee, and Yao Qian. "Analysis and Modeling of F0 Contours for Cantonese Text-to-Speech." *ACM Transactions on Asian Language Information Processing* 3, no. 3 (2004): 169-180.



1, 3, 6, 4, 2, 5 Listen

# What is a contour tone?

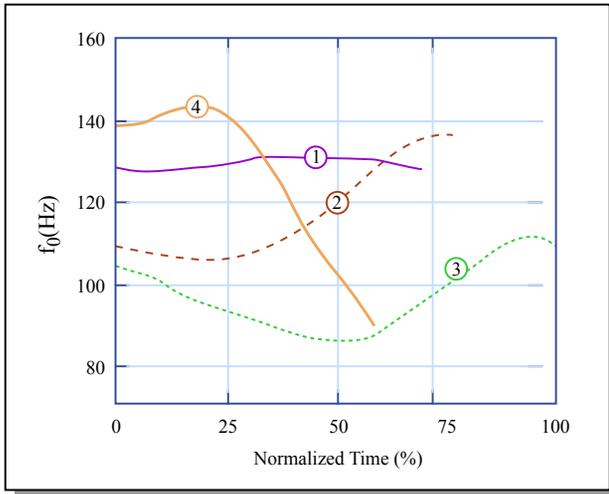


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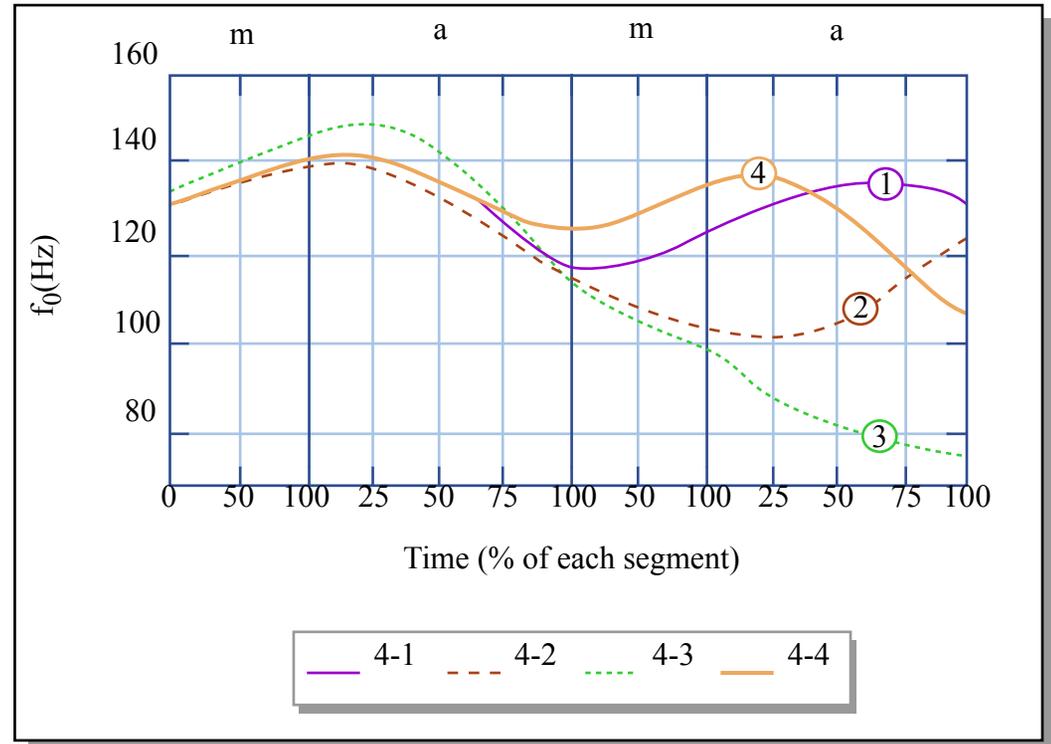


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## Mandarin (Xu 1997) J.Phon

- 1 = H, 2=R, 3=LF, 4=HF
- or: 1=H, 2=LH, 3=L, 4=HL

# What is a contour tone?

- Contour tones (in the relevant sense) are not just tones that involve (significant)  $f_0$  movement - as a result of tonal coarticulation, all tone types can appear to involve significant  $f_0$  movement.
  - e.g. Xu and Wang (2001) *Speech Comm.*
- Also 'level' tones may involve small pitch movements (cf. English diphthongs [eɪ vs. aɪ]).

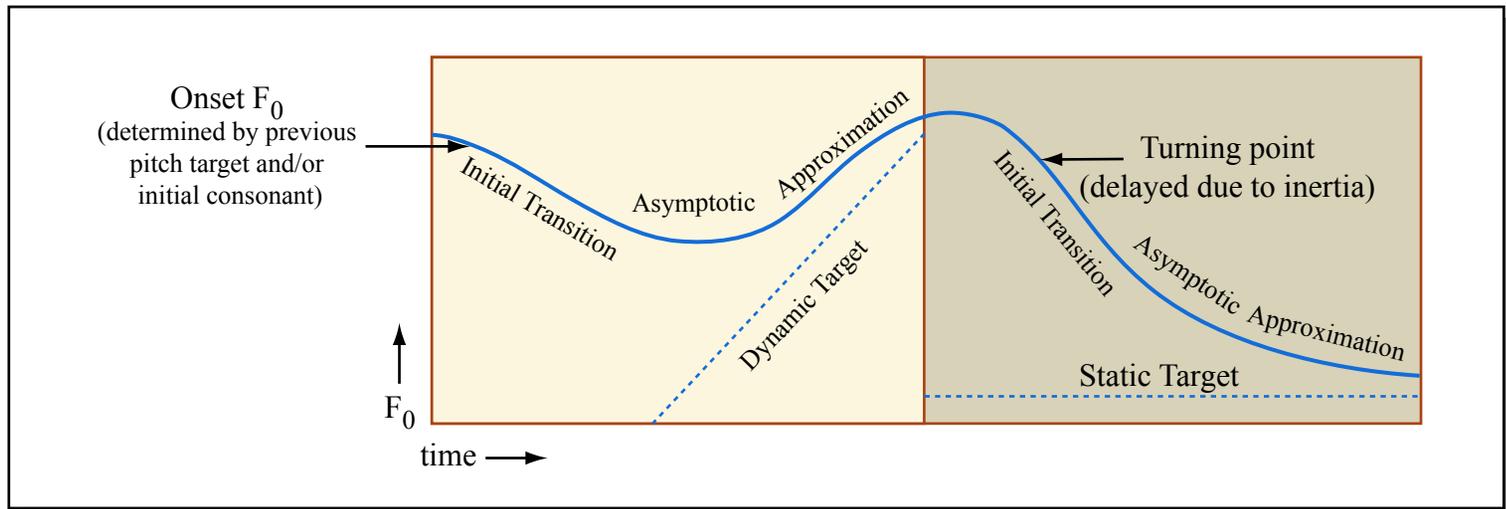


Image by MIT OpenCourseWare. Adapted from Xu, Y., and E. Wang. "Pitch Targets and Their Realization: Evidence from Mandarin Chinese." *Speech Communication* 33, no. 4 (2001): 319-337.

# What is a contour tone?

- What is crucial to Zhang's analysis is that contour tones take more time to realize clearly.
- Refinement: we probably need to talk about contrasts between level and contour tones.
  - e.g. small rise in H may not make it more marked as long as it doesn't contrast with level H.
  - $f_0$  movement is easier to produce than a steady state in some contexts, but the contrast may still be time consuming/difficult.
  - $f_0$  acceleration is hard, not just  $f_0$  change.

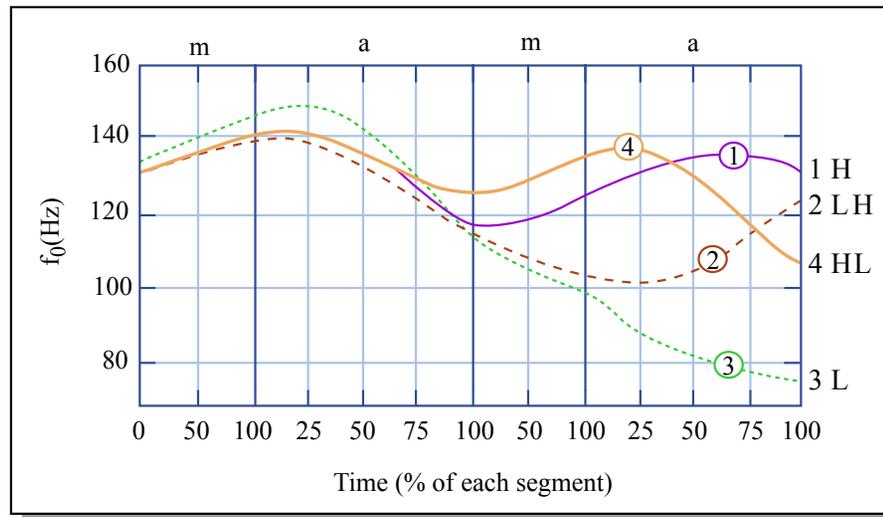


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# Perceptual factors behind restrictions on contour tones

- ‘main perceptual correlate of tone is fundamental frequency’
- ‘...the region containing the second, third and fourth harmonics is especially important in the perception of fundamental frequencies in the range of speech sounds’ (p.158) Plomp (1967, Ritsma 1967)
  - Referring to ‘dominance region’ for pitch perception.
  - variously characterized as lower harmonics, ‘resolved’ harmonics, harmonics nearest 700 Hz (e.g. Dai 2000, JASA).
  - This region dominates when there are conflicting indications of pitch (e.g. ‘mistuned’ harmonics).
  - It has not been shown that pitch discrimination is better with 3rd-4th harmonics as opposed to 1st-2nd which are generally strongest in voiced obstruents (as far as I know).

## Perceptual factors behind restrictions on contour tones

- Pitch discrimination is generally better with more harmonics (e.g. Fastl and Weinberger 1981)
- Pitch discrimination is better with more intense signal (up to a certain limit).
- So pitch perception should be facilitated by louder, harmonically richer sounds
  - vowels > sonorants > voiced obstruents
- Sufficient duration is required to perceive a pitch change (Greenberg and Zee 1979 estimate 90 ms).

## Articulatory factors behind restrictions on contour tones

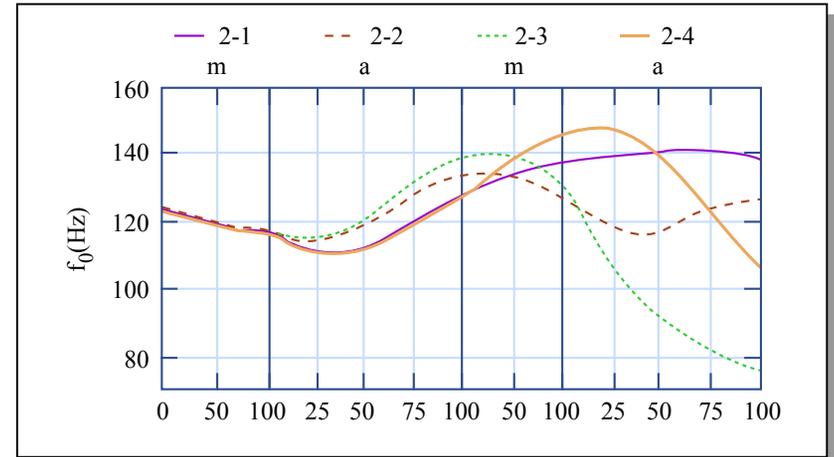
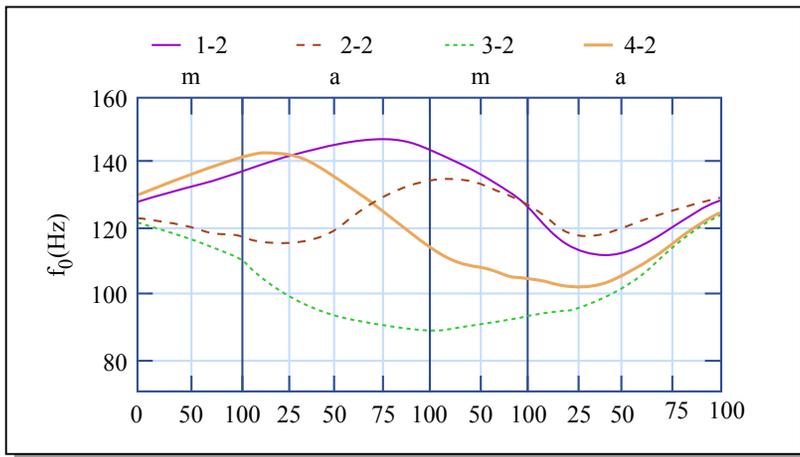
- It takes time to produce  $f_0$  change.
- Greater for rises than falls (Ohala 1978, Xu & Sun 2002)

### Conclusion:

- longer, more sonorous rhyme is more suitable for perceptible realization of contour tones.
- $C_{\text{CONTOUR}} = a \text{ Dur}(V) + \text{Dur}(R)$   
–  $a > 1$

# Why are onsets not relevant?

- Zhang (2002) cites work by Howie and Xu showing that, in Mandarin, the onset tends to be occupied with the transition from the preceding tone.
- This seems to be true of Thai and Cantonese also.
- Not clear why this organization is adopted - perhaps because onsets characteristically have low sonority?
  - applies even with initial glides (Xu).
  - Note: House (1990) was contradicted by House (1996).



Images by MIT OpenCourseWare. Adapted from Xu, Y. "Contextual Tonal Variations in Mandarin." *Journal of Phonetics* 25 (1997): 61-83.

## Predictions

- Syllables with greater  $C_{\text{CONTOUR}}$  should license greater tonal complexity.

Factors that affect  $C_{\text{CONTOUR}}$ :

- Segmental composition of syllable
- Stress
- Phrase-final position
- Number of syllables in word

# Survey

- Cross-linguistic survey of restrictions on the distribution of contour tones.
- E.g. Navajo - contour tones on CVV(X) only

	H	L	ĤL	L̂H
CV	sání 'old one'	ḡtḡa 'you're crying'	—	—
CVO	tíníʔḡḡʔ¹ 'I'm looking'	pìtìł 'his blood'	—	—
CVR	hááʔáłt'èʔ 'exhumation'	pìkʰìn 'his house'	—	—
CVV	tíí 'this'	ḡikài 'white'	sáànìì 'old woman'	hákdónèèʔ 'let's go'
CVVO	łóóʔ 'fish'	pìnììʔ 'his face'	tʰáàʔtì 'three times'	tèłḡnìíłton 'they shot at him'
CVVR	àstsáán 'woman'	pìjììn 'his song'	tàtínììłʔḡḡł 'we'll look at him'	tèìłʔá 'they extend'

Image by MIT OpenCourseWare. Adapted from Zhang, Jie. *The Effects of Duration and Sonority on Contour Tone Distribution: A Typological Survey and Formal Analysis*. New York, NY: Routledge, 2002.

# Survey

- Observed restrictions:
  - ‘more freely’ = contour tones occur only there, or more contour tones occur there.

Contour tones occur more freely:

- a. on CVV in 38 languages (e.g. Somali, Navajo, Ju|’hoasi)
- b. on CVV and CVR in 66 languages (Kiowa, Nama, Fuzhou Chinese)
- c. on stressed syllables in 21 languages (Xhosa, Jemez, Lango)
- d. on the final syllable of words or utterances in 45 languages (Etung, Luganda, Beijing Chinese)
- e. on syllables in shorter words in 19 languages (Mende, Ngamambo, Shanghai Chinese)

# Survey

Implicational universals:

A  $\rightarrow$  B = if A can carry a contour tone then B can carry contour tones of equal or greater complexity

- CV  $\rightarrow$  CVV
- CVO  $\rightarrow$  CVR, CVV
- unstressed  $\rightarrow$  stressed
- non-final syll in prosodic domain  $\rightarrow$  final syll
- in  $n$  syllable word  $\rightarrow$  in  $n-1$  syllable word
  
- All of the ‘stronger licensors’ are positions that are typically associated with greater sonorous rhyme duration.

# Possible analyses of contour tone distribution

1. ‘Generalized licensing’ - there is a general purpose strong licensing positions that can allow a greater range of contrasts of all kinds (Smith 2002?).
2. Structure-based, contrast-specific licensing
  - There are specific positional markedness constraints on contour tones (and universal rankings).
  - Constraints are formulated in terms of standard phonological representations (no direct reference to duration, no language-specific phonetic detail).
3. Phonetic licensing - markedness constraints on contour tones refer directly to  $C_{\text{CONTOUR}}$ .
  - sensitive to language-specific phonetic detail.

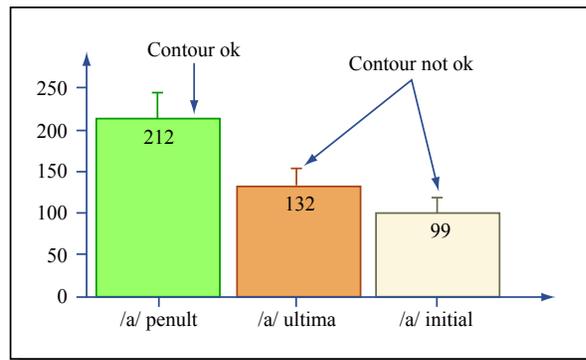
## Evidence against generalized licensing

- Initial position licenses other contrasts (e.g. vowel contrasts - Turkish, Shona), but not contour tones.
  - no initial lengthening
- Phrase-final syllables and syllables in short words license contour tones, but do not generally license other contrasts.
  - phrase-final syllables can resist vowel reduction (Barnes 2002).
- See Steriade (1999, 2001 etc) for evidence that licensing positions are contrast-specific in general.

# Evidence for a role for $C_{\text{CONTOUR}}$

- Two languages in which stress licenses more (complex) contours than final position: Xhosa, Beijing Chinese.
- In each case stressed rhymes are longer than final rhymes (with some complications in Beijing Chinese).
- Xhosa: open syllables only, H, L, HL.
  - HL on stressed (penult) only.
- A counter-example to the direct relevance of  $C_{\text{CONTOUR}}$  would be a language with contour tones on stressed syllables only where final rhymes are longer.
  - more examples need to establish a universal.
- If it is universal, could posit a universal ranking:

$*\text{CONTOUR}(\neg\text{stress}) \gg * \text{CONTOUR}(\neg\text{final})$



# Evidence for a role for language-specific phonetic detail

- Contrast between Standard Thai & Cantonese vs. Navajo:
  - all have long vowels, sonorant and obstruent codas.
  - in Thai and Cantonese, contour tones are licensed on CV, CVR, but not CV(V)O.
    - phonological vowel length is irrelevant.
  - in Navajo, contour tones are licensed in CVV(X), not on CV(X) (including CVR).
    - sonorancy of coda is irrelevant.
  - in ‘phonological’ terms, implies opposite rankings of \*Contour(¬long), \*Contour(obstruent coda)
- Durational patterns correlate with distribution of contour tones in all cases.

# Thai

Tonal Distribution in Standard Thai (Gandour 1974):					
	H	M	L	HL	LH
CV	+	+	+	+	+
CVN	+	+	+	+	+
CVVN	+	+	+	+	+
CVVO	(+)	—	+	+	—
CVO	+	—	+	(+)	—

Image by MIT OpenCourseWare. Adapted from Zhang, Jie. *The Effects of Duration and Sonority on Contour Tone Distribution: A Typological Survey and Formal Analysis*. New York, NY: Routledge, 2002. Based on Gandour, Jackson T. "The Glottal Stop in Siamese: Predictability in Phonological Description." *UCLA Working Papers in Phonetics* 27 (1974): 84–91.

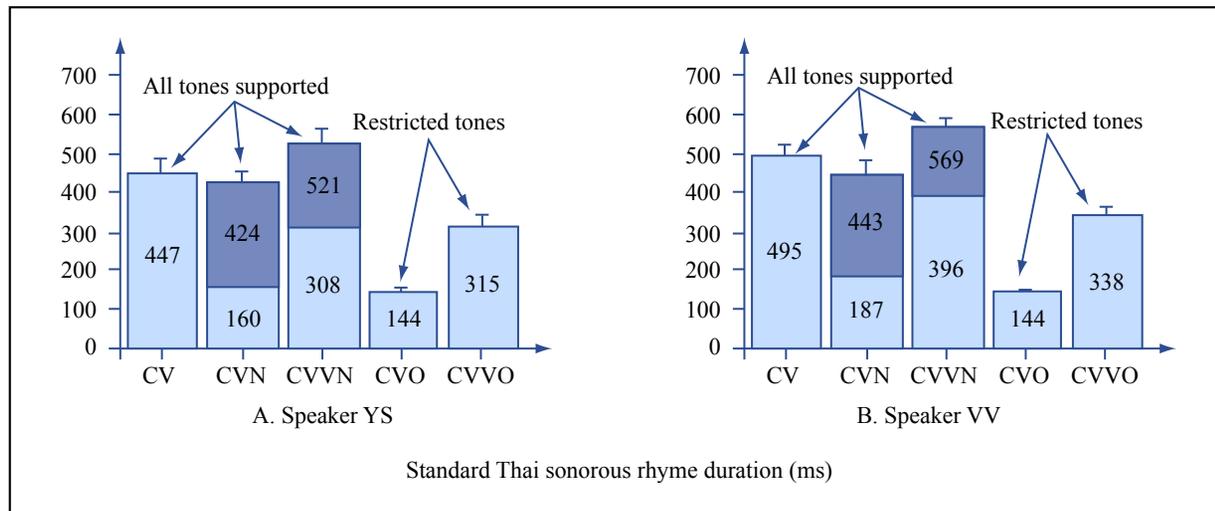


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- All syllables contain /a/, level tones (L or M)

# Thai

- Similar patterns of duration for two speakers in Morén and Zsiga (2006).
- Morén and Zsiga (2006) observe that all tones other than M look like contour tones, even in citation form.
- Looks like initial  $f_0$  is mid-range, resulting in movement towards tone (cf. Mandarin tonal coarticulation).
- Greater duration is required to distinguish L from R.
- Exclusion of H

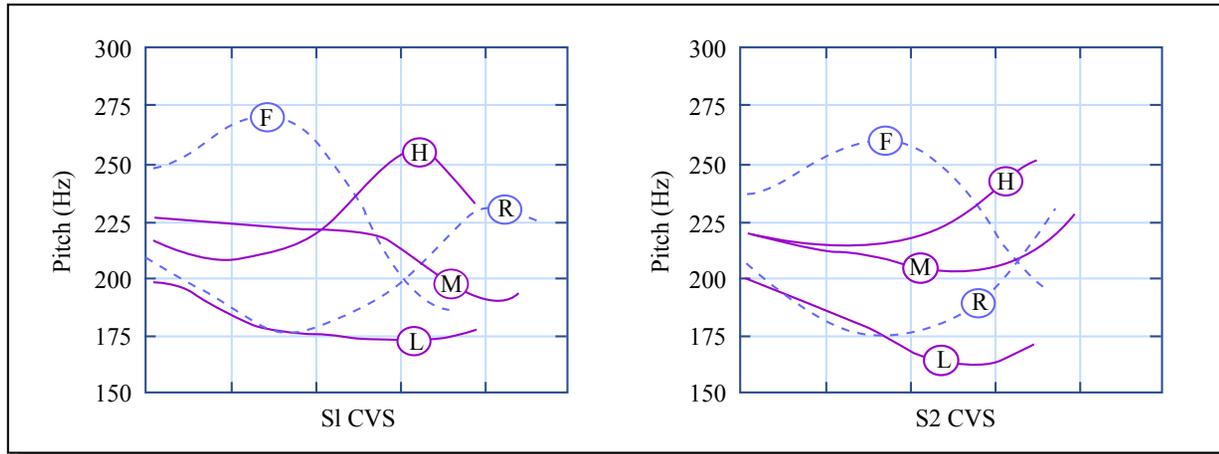


Image by MIT OpenCourseWare. Adapted from Morén, B., and E. Zsiga. "The Lexical and Post-lexical Phonology of Thai Tones." *Natural Language and Linguistic Theory* 24 (2006): 113-178.

# Thai duration patterns

- Open syllables have long vowels (non-contrastive)
- Codas are longer where V is short (obstruents also - Morén and Zsiga 2006).
- Closed syllable shortening of long V
- Net effect: all rhyme types are quite similar in duration in spite of large differences in V durations.

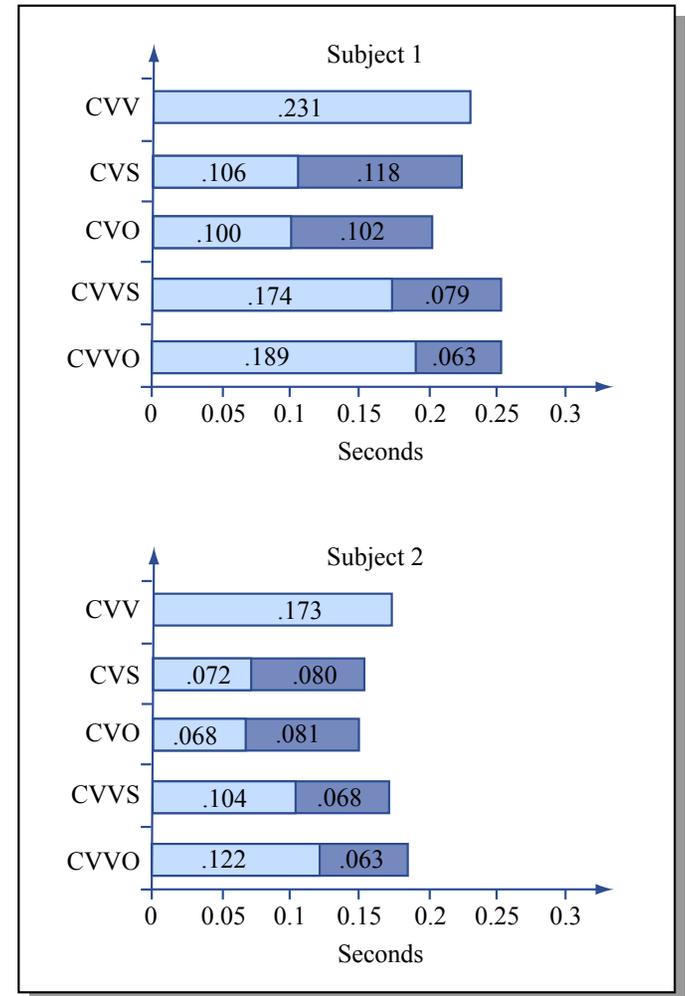


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# Cantonese (Gordon 1998)

- CV, CVN, CVVN, CVO, CVVO (O = stop).
- no contour tones on CV(V)O, OK on CV, CV(V)N
  - contrastive vowel length irrelevant.
- Again: nasal coda is longer after short V, closed syllable V shortening.  
Also pre-obstruent shortening. (cf. Zee 2002). □ □  
sonorous rhyme VN > V:O

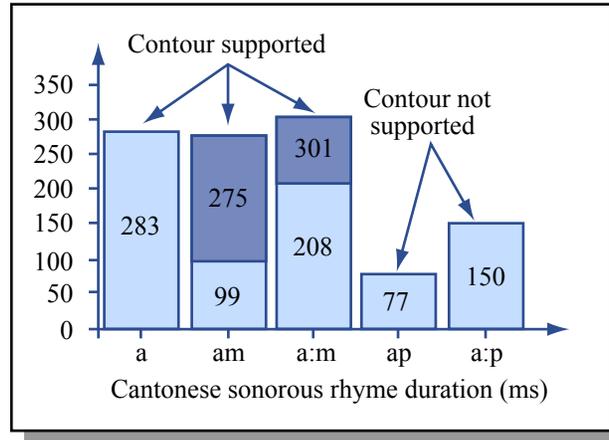


Image by MIT OpenCourseWare. Adapted from Zhang, Jie. "The Role of Contrast-Specific and Language-Specific Phonetics in Contour Tone Distribution." *Phonetically-Based Phonology*. Edited by Robert Kirchner, Bruce Hayes, and Donca Steriade. New York, NY: Cambridge University Press, 2004.

# Navajo

Tonal Distribution in Navajo				
	H	L	HL	LH
CV	+	+	-	-
CVO	+	+	-	-
CVR	+	+	-	-
CVV	+	+	+	+
CVVO	+	+	+	+
CVVR	+	+	+	+

- 1 speaker
- sonorant duration must be discounted relative to vowel duration for  $C_{\text{CONT}}(\text{CVV}) > C_{\text{CONT}}(\text{CVR})$
- No closed syllable shortening - consistent long/short V durations across syllable types.

Image by MIT OpenCourseWare. Adapted from Zhang, Jie. "The Role of Contrast-Specific and Language-Specific Phonetics in Contour Tone Distribution." *Phonetically-Based Phonology*. Edited by Robert Kirchner, Bruce Hayes, and Donca Steriade. New York, NY: Cambridge University Press, 2004.

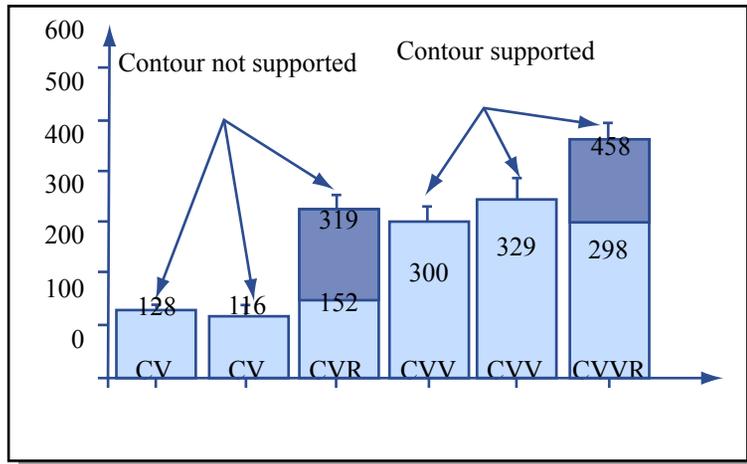


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# Evidence for a role for language-specific phonetic detail

- Zhang's analysis:

\* $C_{\text{CONTOUR}}(x_i) - C_{\text{CONTOUR}}(y_j)$ :

no contour tone  $x_i$  is allowed on a syllable with the  $C_{\text{CONTOUR}}$  value of syllable  $y_j$  or smaller.

– Direct reference to  $C_{\text{CONTOUR}}$ , i.e. phonetic duration.

- Ranked according to tonal complexity and  $C_{\text{CONTOUR}}$  values.
- Faithfulness to tone specifications
- Constraints on segment duration - penalize deviation from target duration.

\* $DUR(\tau)$ : for a rime in a prosodic environment, the cumulative duration in excess of the minimum duration for each segment cannot be  $\tau$  or more.

# Evidence for a role for language-specific phonetic detail

- In each case, the syllables that license (more) contour tones have greater  $C_{\text{CONTOUR}}$  in spite of variation in the syllable types that license contour tones (CVR vs. CVVO).
- Prediction: no language could have the Thai pattern of tone distribution and the Navajo pattern of duration, or vice versa.
- Although the studies are striking confirmations of the prediction, evidence for the universal is limited:
  - three languages
  - few speakers (esp. Navajo - other results are supported by independent studies).

## Alternatives

- Assuming the result holds up, it cannot easily be reanalyzed as an effect of phonology on phonetic realization.
  - Note that all duration patterns apply in the absence of contour tones.
  - Duration patterns appear to have an internal coherence.
- There are reported to be cases in which vowels lengthen to accommodate contour tones (Zhang cites Mitla Zapotec, Wuyi Chinese, Hausa and Gã), but this results in relatively free distribution of contour tones.
- Could the pattern be analyzed as an effect of phonetic realization on constraint ranking?

# Phonetic/phonological typology

Outputs of $T_{\Delta f} R_d$ generated by the factorial typology:		
Output	Constraint ranking	Example languages
A. Faithful: $\Delta f, d$	PRES(T), *DUR ↓ *T-R	Lalana Chinantec, !Xũ, ‡ Khomani
B. Partial Contour Reduction: $\Delta f-f_0, d$	*DUR, *T-R ↓ some PRES(T)	Pingyao Chinese
C. Complete Contour Reduction: $0, d$	*DUR, * $\delta$ -R ↓ PRES(T, $i$ )	Xhosa, Beijing Chinese
D. Non-neutralizing Lengthening: $\Delta f, d+d_0$	PRES(T), *T-R ↓ some *DUR	Mitla Zapotec, Wuyi Chinese
E. Neutralizing Lengthening: $\Delta f, 2d$	PRES(T), *T-R <sub>2d-\delta</sub> ↓ *DUR( $d$ )	Gã
F. Reduction and Lengthening: $\Delta f-f_1, d+d_1$	some *DUR, some PRES(T), *T-R ↓ some other *DUR, some other PRES(T),	Hausa

Image by MIT OpenCourseWare. Adapted from Zhang, Jie. *The Effects of Duration and Sonority on Contour Tone Distribution--A Typological Survey and Formal Analysis*. New York, NY: Routledge, 2002.

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