Consonant-Tone Interaction in Thai

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Phonology Forum 2014
University of Tokyo

Introduction: *What is Consonant-Tone Interaction?*

- Many tonal languages do not allow certain tones in syllables with certain consonants.
  - Coda-tone restrictions (e.g. * H–[+voice])
  - Onset-tone restrictions (e.g. * [+voice]–H)
- Cross-linguistically, we find certain combinations are (dis)favored:
  - Voiced C's and low tone are favored.
  - Glottalized C's and low tone are favored.
  - Glottalized C's and high tone are favored.

Why does Consonant-Tone Interaction Exist?

- Articulatorily, we use the same muscles to produce laryngeal contrasts in C's and tone in V's.
- **Diachronically**, tone contrasts can be reanalyzed as laryngeal C contrasts (and vice versa).
  - Tonogenesis: Tone contrast borne from C contrast (i.e. proto-Athabaskan)

Phonological Questions

- Consonant-Tone Interaction involves tonal autosegments interacting with segments.
  - This is an interaction *across tiers*.
  - Tonal tier was proposed because tones were thought not to interact with segments (*much*).
- Phonologists have tried to account for this interaction synchronically (in Thai: Lee 2008, Ruangjaroon 2006).
  - Perception Experiment for Thai suggests C-Tone interaction is grammaticalized.

Overview

- The goal: Use experimental evidence to assess the grammatical status of consonant-tone lexical gaps in Thai.
  - Lexical Frequency Statistics
  - Acoustic experiment
  - **Judgment experiment**
- Ultimately: The results of the experiments will inform a phonological account.

Part I – The Empirical Generalization

- A new observation concerning onset-tone restrictions in Thai is made.
  - **Rising tone**, in addition to high tone is ungrammatical following glottalized onsets.
- A judgment experiment is outlined that tests the grammatical status of onset-tone lexical gaps in Thai.

Contrastive Tones in Thai

Thai (CV: Syllables)				
high tone	[kʰáː]	'trade'	[kʰuáː]	
low tone	[kʰàː]	'galangal'	[kʰuàː]	
mid tone	[kʰaː]	'to obstruct'		
rising tone	[kʰǎː]	'leg'	[kʰuǎː]	
falling tone	[kʰâː]	'to destroy'		

Consonant Inventory of Thai

	Labial	Alveolar	Palatal	Velar	Glottal
Stop	pʰ p b	tʰ t d	t͡ɕʰ t͡ɕ	kʰ k	ʔ
Nasal	m	n		ŋ	
Trill		r			
Fricative	f	s			h
Glide	w		j		
Lateral Approximant		l			

Onset-Tone Interaction in Thai

- Certain consonants are not found preceding certain tones in unchecked syllables (Ruangjaroon, 2006; Lee 2008, 2011)
  - Thai (unchecked syllables):
    - Voiced Stop + High Tone — No
    - Unaspirated Stop + High Tone — No
    - Aspirated Stop + High Tone — Yes
    - Fricative + High Tone — Yes
    - Sonorant + High Tone — Yes
  - Low, mid, falling tone OK with all

Definitions: Syllables in Thai

- Unchecked Syllable:
  - No coda or sonorant coda
- Checked Syllable:
  - Obstruent coda
    - The only licit obstruent codas: [p], [t], [k]

Rising tone gap

- Previous accounts: high tone gap only (Ruangjaroon 2006; Lee 2008, 2011)
- Corpus (Kasuriya et al. 2003) & Dictionary (Slayden 2013) searches (shown below) confirm a rising tone gap in unchecked syllables.

Initial Consonant	Mid Tone	Low Tone	Falling Tone	High Tone	Rising Tone
Others	34.1%	10.0%	21.7%	15.1%	19.0%
[p, t, t͡ɕ, k, ʔ]	43.5%	21.2%	23.2%	4.3%	7.7%
[b, d]	42.7%	21.6%	27.6%	3.8%	4.3%

Onset-Tone Interaction: The Generalization in Native Words

Initial Consonant	Mid Tone	Low Tone	Falling Tone	High Tone	Rising Tone
Others	✓	✓	✓	✓	✓
Unaspirated Obstruent	✓	✓	✓	✗	✗
Voiced Obstruent	✓	✓	✓	✗	✗

English loans – Exceptions I

- Dictionary search (unchecked syllables):
  - Unaspirated/voiced consonants & high tone OK!

Onset	Mid Tone	Low Tone	Falling Tone	High Tone	Rising Tone
Others	93.2%	0.6%	1.9%	4.3%	0.0%
[p, t, t͡ɕ, k, ʔ]	87.5%	0.0%	3.1%	9.4%	0.0%
[b, d]	82.5%	0.0%	7.5%	7.5%	2.5%

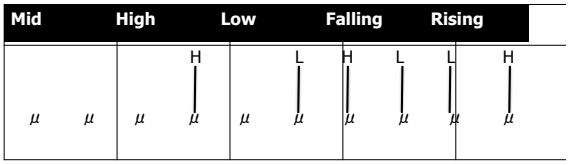
English loans – Exceptions II

- Loan vocabulary is often more permissive
  - E.g. Japanese: Lyman's Law relaxed in loanwords (Ito & Mester 1995, 1999)
  - E.g. Yorùbá: Vowel harmony seen in native words only, not in English loan words (Bamgboṣe 1967:273, Archangeli & Pulleyblank 1989: 182-183)

The Segmental Feature

- An acoustic study:
  - Voiced & Unaspirated stops are [+constricted glottis] in Thai.
  - Lowered F0 & spectral tilt
- A unified treatment:
  - *[+CG] – High/Rising
  - Note: High & Rising tones are phonetically rising in Thai (MH and LH respectively).

Moraic Representations (Morén & Zsiga 2006)



- Mid tone is unspecified.
- Tonal targets are late.
  - High tone is actually phonetically rising (MH)

Towards a Phonological Account

- An account that uses locality won't suffice (*[+CG] – H)
  - +CG - Falling tone (HL) is grammatical
  - +CG – High tone (MH) is ungrammatical
  - +CG – Rising tone (LH) is ungrammatical
- I depart from Lee (2008, 2011), who uses locality.
  - Aims to account only for H tone restriction.
  - Lee's High tone assumption: 

Judgment Experiment: Introduction

- Goal 1: To assess the grammatical status of the high- and rising-tone restrictions
- Goal 2: To assess whether there is a grammaticality difference in loan and native strata

Method

- Forced-Choice Judgment Task
- Nonce stimulus pairs presented aurally:
  - Varying tone
    - e.g. [tó:] vs. [tò:]
  - Varying onset manner
    - e.g. [tó:] vs. [t^hó:]
- Prediction: Participants will disprefer unattested onset-tone sequences

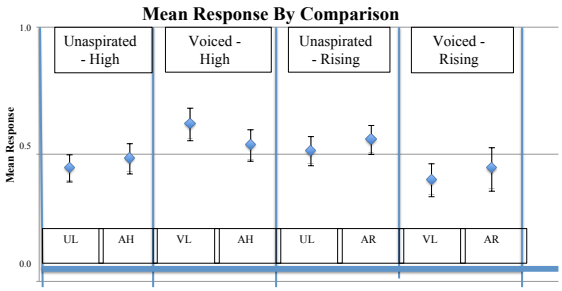
Grammaticality in Loan vs. Native Strata

- Loan vs. Native stratum difference
  - Experiment 1 (loan interpretation)
    - In U.S.A with English speaking experimenter
    - Instructions: "Choose which non-word sounds more Thai-like"
  - Experiment 2 (native interpretation)
    - In Thailand with Thai speaking experimenter
    - Instructions: "One of these two is ancient Thai, choose which one" (Vance, 1980; Kawahara, 2012)

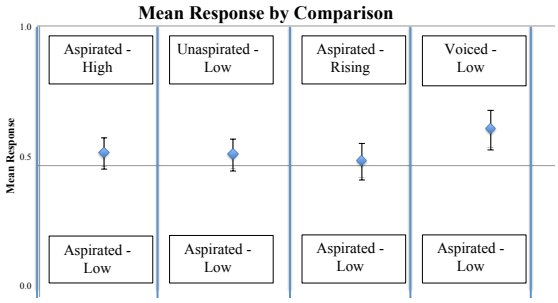
Experiment Details

- Experiment 1: 14 Participants
- Experiment 2: 16 Participants
  - Mixed Range of English fluency in both groups (fluency had no effect)
- SuperLab software (laptop)
- 234 Stimulus Items per Participant
  - 20-30 minutes each

Experiment I Results



Preferences between grammatical stimuli



A Markedness Effect

- A preference for a voiced-low sequence is unsurprising.
  - Voiced stops have an affinity for low tone cross-linguistically (Bradshaw 1998, Lee 2008, Tang 2008)
  - A low-ranked markedness constraint (*If L then [+voi]*) prefers voiced-low over aspirated-low.
- This constraint is not crucial in learning Thai.

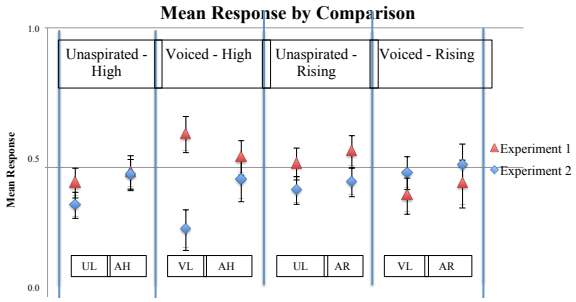
Conclusion – Experiment I

- Only voiced-rising sequences are ungrammatical in the loan stratum.
- A preference for voiced-low sequences indicates activity of low-ranked markedness constraints.

Experiment II

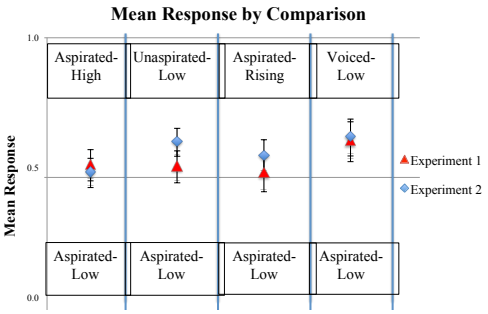
- Native interpretation of stimuli
- Expectation: All four unattested onset-tone sequences should be dispreferred
  - The dispreferences in Experiment II should be more significant than in Experiment I.

Experiment II Results



Preferences between grammatical items

- Low tone preferred with glottalized consonants



Discussion: The Voiced-Rising Flip

- The voiced-rising sequence is exceptional:
  - Experiment I: strongly dispreferred
  - Experiment II: marginally dispreferred only in comparisons varying tone
- 1. Voiced-rising sequences have a [+CG]-L tone sequence.
- 2. Experiment 2: There is a preference for [+CG]-L sequences.

The Voiced-Rising Flip II: Markedness Constraint Effects

- [+CG]-L: "One violation for an L tone segment that isn't preceded by [+CG]".
  - *Voiced-rising > Aspirated-rising*
  - *Voiced-low = Voiced-high = Aspirated-high*
  - *Voiced-low, Unaspirated-low > Aspirated-low*
- A single explanation for:
  - 1. the preferences between grammatical items
  - 2. the voiced-rising flip

Discussion: Tone Confusability

- Comparisons varying onset introduce increased probability of tone confusion.
  - Post-experiment tone ID task:
    - 10 of 35 high tone stimuli were misidentified as rising tone.
    - 6 of 45 rising tone stimuli were misidentified as high tone.
- If tone is varied, tone confusion is less likely.
  - L tone alternative provides a tonal benchmark.

Conclusion – Judgment Experiments

- All four consonant-tone restrictions are grammaticalized in native Thai.
  - *[+CG] – high, *[+CG] – rising
- Only voiced-rising restriction grammaticalized in loan stratum.
  - Loan stratum is more permissive than native stratum.

Part 2 – An OT Account

- 1. An OT account (Prince & Smolensky 1993/2004) of onset-tone interaction
  - Assumes Morén & Zsiga's (2006) analysis of coda-tone interaction as a starting point
- 2. Loan vs. native stratum differences
- 3. A task-specific weighted constraint model

Onset-Tone Interaction in unchecked syllables

- Rising & high tone are ungrammatical following [+CG] onsets.
  - Both tones have a 2nd mora that is H tone.
- *[+CG]-[H] μ 2
  - "Incur one violation per H tone autosegment that is linked to the 2nd mora in a syllable that has a [+CG] onset."
  - Motivation: Tonal information is usually carried late in the syllable, as opposed to early in it (Cutler & Chen 1997; Xu 1999, 2004).

The high tone restriction

- Underlying high tone surfaces as falling tone:

/pá:/	*[+CG]-[H] μ 2	*L	*CONTOUR	ALIGN-TONE-R
a. pá: (MH)	*!			
☞ b. pâ: (HL)		*	*	*

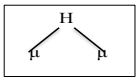
The rising tone restriction

- Underlying rising tone surfaces as falling tone

/pǎ:/	*[+CG]-[H] μ 2	LINEARITY
a. pǎ:	*!	
☞ b. pâ:		*

A doubly-linked H tone candidate

- A doubly-linked H tone candidate does not violate *[+CG]-[H] μ 2:
  - Yet it is ungrammatical.



- *[μ μ]T – "two moras within the same tonal domain are prohibited" (called MONO-SPAN by Bickmore (1996), *MULTIPLE LINK, *SHARE, *SPREAD)" (Morén & Zsiga 2006:140)

A doubly-linked H tone candidate II

/pá:/ H	*[μμ]T	*L	*CONTOUR	ALIGN-TONE-R
a. pá: (H shared)	*!			
☞ b. pâ: (HL)		*	*	*

A ranking contradiction!

- Align-Tone-R must dominate *[μ μ]T to account for doubly-linked H tone in checked syllables with short vowels (Morén & Zsiga 2006:150 ex. 41)

	/lak-H/ "to steal"	REALIZETONE	ALIGN-Right	*[μμ]T
a.	H, μμ, l a k²	*!		
b.	H, μμ, l a k²		*!	
☞ c.	H, μμ, l a k²			*

- H tone is pronounced with a late target so candidate (c) should be optimal.

Alignment reformulated

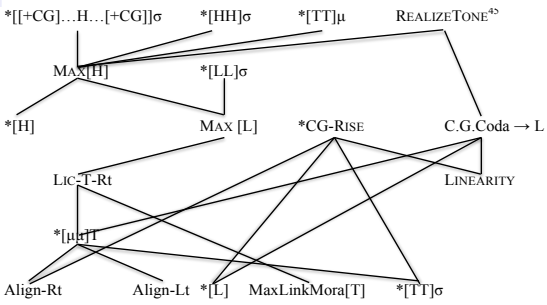
- Goal: A constraint that is violated by HM, but not HL.
- Lic-T-Rt – "Assign one violation for a syllable associated with a tone, but whose rightmost mora is not associated to a tone (*HM, LM)."
  - Contour tones – no violations
  - Unmarked tone (mid tone) – no violations
- Motivation: Tonal targets tend to be realized late (Yip 2002:83,147; Xu 1999).

LIC-T-Rt allows [+CG]-falling tone sequences

/pá:/ H	LIC-T-Rt	*[μμ]T	*L	*CONTOUR	ALIGN-TONE-R
a. pá: (H shared)		*!			
☞ b. pâ: (HL)			*	*	*
c. pá: (HM)	*!				*

- Lic-T-Rt is the relevant right-alignment constraint, not Align-Tone-R.

Final Ranking – Consonant-Tone Interaction in Thai



Native vs. Loan stratum Differences

- Judgment Experiments:
  - Any [+CG] preceding a tonal rise (high/ rising tone) is ungrammatical in native Thai words.
  - [+voice] preceding rising tone is ungrammatical in English loans.
- The loan stratum is more permissive.

Relativized Faithfulness

- There is a cross-linguistic tendency for loan strata to be more permissive. Ito & Mester (1995, 1999, 2001)
  - Ito & Mester: A single relative ranking of markedness constraints across strata.
    - Faithfulness constraints are relativized for each stratum:
  - M1 >> Max-$F_{\text{Stratum A}}$ >> M2 >> Max-$F_{\text{Stratum B}}$
    - Stratum A is more permissive than stratum B.

An OT account for onset-tone interaction in English Loans

- Rising tone can occur following unaspirated stops

/pǎ:/	LINEARITY$_{\text{Loan}}$	*[+CG]-[H]μ2
a. pâ:	*!	
☞ b. pǎ:		*

Voiced-rising sequences are ungrammatical in Loans

- A specific constraint militating against voiced-rising sequences is needed:
  - *[+voice] LH

/bǎ:/	*[+voice] LH	LINEARITY$_{\text{Loan}}$	*[+CG]-[H]μ2
☞ a. bâ:		*	
b. bǎ:	*!		*

- Ranking for Onset-Tone Interaction:
  - *[+voice] LH >> Linearity$_{\text{Loan}}$ >> *[+CG]-[H]μ2 >> Linearity$_{\text{Native}}$

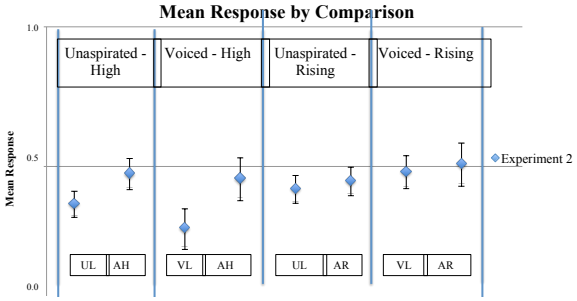
OT Account Summary

- *[+CG]-[H]μ2, Lic-T-Rt are required to capture the onset-tone restrictions.
- Relativized Faithfulness accounts for loan vs. native differences in onset-tone interactions.

Sub-grammatical preferences: A weighted constraints model

- OT Account can explain:
  - Dispreference for [+CG]-high & rising sequences
- OT Account doesn't explain:
  - [+CG]-low tone preference
  - High-tone effect > Rising-tone effect
- Hypothesis: Competition between low-ranked markedness constraints is relevant.

Experiment II Results



Outline of Model

- The ranking in the grammar (from the OT account) can capture these finer-grained results.
  - This task involves judgment of two stimuli based on markedness constraints only.
  - Faithfulness is irrelevant (input undefined).
- Constraints are weighted.
  - Higher ranked constraints → larger weighting
  - Lower ranked constraints → smaller weighting

Predicted Response Score

- Goal: For each stimulus comparison, a predicted response mean, ranging from 0 to 1.
  - Comparable to actual response means.
  - Value comes from violation profile & constraint weightings.

Markedness Constraint Inventory

- Relevant Markedness constraints:
  - *[+CG]-[H] μ 2 & *[+voice] LH
  - Constraints banning marked consonant-tone sequences:
    - *[+CG]-H; *[+Voice]-H; *[+SG]-L
  - Constraints requiring unmarked consonant-tone sequences:
    - [+CG]-L; [+voice]-L; [+SG]-H
  - Basic markedness constraints
    - *H, *L, *LH, *Contour

Constraint Weightings

- Weights (k_i) are determined by position in ranking strata.
  - A ranking stratum is determined via BCD (Prince & Tesar 2004):
    - Stratum 1 (k = 8): *[+voice]-LH, *[[+CG]…H…[+CG]] σ, Lic-T-Rt, *[+CG]-[H] μ 2, …
    - Stratum 2 (k = 7): Max[L]
    - Stratum 3 (k = 6): Max[H]
    - Stratum 4 (k = 5): *H, *[CG]…H, C.G.Coda → L, *[+voice]…H
    - Stratum 5 (k = 4): *[TT] σ, *L, *[μ μ]T, Align-Rt, *[+SG]…L
    - Stratum 6 (k = 3): Align-Lt, [+voice]-L, [+CG]-L
    - Stratum 7 (k = 2): Linearity
    - Stratum 8 (k = 1): *LH, [+SG]-H

Violation Profiles

- For a given comparison, a violation profile (ERC) is computed.
- A constant, "c" encodes the violation information for each constraint as it evaluates each comparison.
- E.g. Unaspirated-High vs. Unaspirated-Low
  - *[+CG]-[H] μ 2: UL > UH
    - UL is the "0" response (c = 0)
  - *L: UH > UL
    - UH is the "1" response (c = 1)
  - *[voice]LH: UL = UH
    - The constraint is not decisive (c = 0.5)

Calculating the Predicted Response Mean

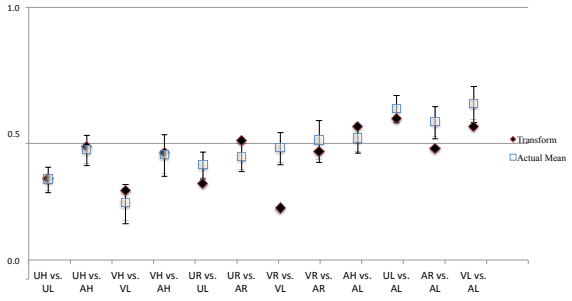
- Continuing the Unaspirated-High vs. Unaspirated-Low example:
  - 1. For each constraint, multiply c by the weight, k.
  - 2. Add all of these up.
  - 3. Divide by the sum of the weights to get a number between 0 and 1.
    - c * k for *CG-Rise = 0 * 8 = 0
    - c * k for *L = 1 * 4 = 4
    - c * k for *[+voice] LH = 0.5 * 8 = 4
    - If we had just these 3 constraints:

      Mean Response Score = (0+4+4) ÷ (8 + 4 + 8) = 0.4

Adjustments to the predicted mean responses

- Responses in comparisons varying manner were closer to random.
  - Higher probability of misperception.
  - A scaling factor, h, takes this into account.
- Cross-linguistically, H tone is more marked than L tone (Yip 2002:41):
  - *L plays no crucial role; perhaps it does not exist.
  - Removing *L improved the fit of the model.

Weighted Constraint Model vs. Experiment 2 Results



Conclusion

- An OT account that utilized two new constraints, *[+CG]-[H] μ 2 & Lic-T-Rt captured the consonant-tone restrictions in Thai.
- A weighted constraint model based on the phonological grammar approximates finer-grained results.

Thank you!

I'd like to thank my dissertation committee Shigeto Kawahara, Akin Akinlabi, Bruce Tesar & Elizabeth Zsiga for their support and guidance. Additional thanks to Seunghun Lee, Paul de Lacy, Alan Prince, Doug Pulleyblank, Gunnar Hansson and James Kirby. Special thanks to Sugunya Ruangjaroon, Thanawath Kaewtongprakham, Anna Phuwarat, Art Chaovalitwongse and many more for their help with the experiments. Thanks also to the friendship and support of all my fellow graduate students at Rutgers.

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Appendices

Coda-Tone Interaction

- In checked syllables, tonal contrast is reduced (Morén & Zsiga 2006; Ruangjaroon 2006)

Onset	Mid Tone	Low Tone	Falling Tone	High Tone	Rising Tone
C_{else} & long V	✗	✓	✓	✗	✗
C_{else} & short V	✗	✓	✗	✓	✗
Unaspirated	✗	✓	✗	✗	✗
Voiced	✗	✓	✗	✗	✗

Low tone-coda affinity

- Paradox: Mid tone is unmarked but it's ungrammatical in checked syllables.
  - Low tone is relatively marked, but is grammatical in checked syllables.
  - Codas are always [+CG] in Thai.
- C.G.Coda → L: "Constricted glottis coda segments must be associated with low tone" (Morén & Zsiga 2006)

Low tone-coda affinity in OT

- C.G.Coda → L >> *L (from Morén & Zsiga 2006:146 ex. 32)

	/la:k/ 'various'	C.G.Coda-->L	*[L]
☞ a.	L | μμ \/\ l a k$^{?}$		*
b.	μμ \/\ l a k$^{?}$	*!	

Falling tone with long vowels

- Max-H >> C.G.Coda → L
  - Underlying H tone surfaces as HL tone to satisfy C.G.Coda → L with long vowels.

/p^{h}á:t/	MAX-H	C.G.Coda → L	*L
a. p^{h}á:t		*!	
☞ b. p^{h}à:t			*
c. p^{h}à:t	*!		

High tone with short vowels

- Short vowel: 2nd mora is not vocalic

- Realize-Tone: "Tones must be associated to a segment that can support vocal fold vibration." (Morén & Zsiga 2006: 148 ex. 37)
  - L tone cannot be inserted to satisfy C.G.Coda → L

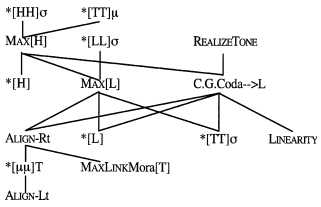
High tone with short vowels II

- Max-H, Realize-Tone >> C.G.Coda → L

/pʰât/	REALIZE-TONE	MAX-H	C.G.Coda → L	*L
☞ a. pʰát			*	
b. pʰât	*!			*
c. pʰàt		*!		

Coda-Tone Interaction - Summary

- Morén & Zsiga's (2006) final ranking for coda-tone interaction:



[+CG] in coda and onset

- Only low tone can surface in checked syllables with [+CG] onsets.
  - But falling tone is grammatical with [+CG]
    - With onsets: [+CG] HL is grammatical
    - With codas: HL [+CG] is grammatical
- Generalization: When *both* the onset and coda are [+CG], H is deleted.

[+CG] in coda and onset II

- *[[+CG]…H…[+CG]]σ (Chen 2007)

/pá:t/	*[[+CG]…H…[+CG]]σ	MAX[H]	C.G.Coda → L
a. pá:t	*!		
☞ b. pà:t		*	
c. pa:t		*	*!

Checked syllables in loans: A markedness reversal

- High tone is grammatical in checked syllables in English loans:

/pʰât/	*[TT]σ	ALIGN-Rt	C.G.Coda → L
a. pʰâ:t	*!	*	
☞ b. pʰá:t			*

  - Native Items:

/pʰá:t/	C.G.Coda → L	*[TT]σ	ALIGN-Rt
☞ a. pʰâ:t		*	*
b. pʰá:t	*!		

- C.G.Coda → L is violated in loans.

A markedness reversal II

- Contra Ito & Mester, markedness constraints must be ranked differently in loan and native strata.
- No relativized faithfulness constraint can achieve this.
  - Dep[Tone]: Favors mid tone

/pʰaːt/	C.G.Coda → L	DEP[TONE]
☞ a. pʰàːt		*
b. pʰaːt	*!	