Contrastive Hierarchy Theory: An Overview

These are the combined slides presented at talks at the University of Connecticut, February 2015, and at the University of Massachusetts, Amherst, September 2015.

PART 2: Section 7 to end

B. Elan Dresher
University of Toronto

7.

Why Contrast Must be Computed Hierarchically

How do we establish contrasts?

Consider the typical sub-inventory /p, b, m/ shown below, and suppose we characterize it in terms of two binary features, [±voiced] and [±nasal].

In terms of full specifications, /p/ is [–voiced, –nasal], /b/ is [+voiced, –nasal], and /m/ is [+voiced, +nasal].

Which of these features is contrastive? Many people reason as follows:

	/p/	/b/	/m/
[voiced]	–	+	+
[nasal]	–	–	+

How do we establish contrasts?

We observe that /p/ and /b/ are distinguished only by [voiced]; so these specifications must be contrastive.

Similarly, /b/ and /m/ are distinguished only by [nasal]; these specifications must also be contrastive.

What about the uncircled specifications? These are predictable from the circled ones:

	/p/	/b/	/m/
[voiced]	(–)	(+)	+
[nasal]	–	(–)	(+)

How do we establish contrasts?

Since /p/ is the only [–voiced] phoneme in this inventory, its specification for [nasal] is predictable, hence redundant.

Similarly, /m/ is the only [+nasal] phoneme, so its specification for [voiced] is redundant.

This is a still-popular way of thinking about contrastive specifications; we can call it the 'minimal contrast' (MC) approach (Padgett 2003, Calabrese 2005, Campos-Astorkiza 2009, Nevins 2010 explicitly, and many others implicitly).

	/p/	/b/	/m/
[voiced]	⊖	⊕	■
[nasal]	■	⊖	⊕

Minimal Contrast (MC)

According to the definition proposed by Nevins (2010: 98), a segment S with specification [αF] is *contrastive* for F if there is another segment S’ in the inventory that is featurally identical to S, except that it is [–αF].

R	S		S′	T
[αE]	[αE]	=	[αE]	[–αE]
[αF]	[αF]		[–αF]	[–αF]
[–αG]	[αG]	=	[αG]	[–αG]
[–αH]	[αH]	=	[αH]	[–αH]

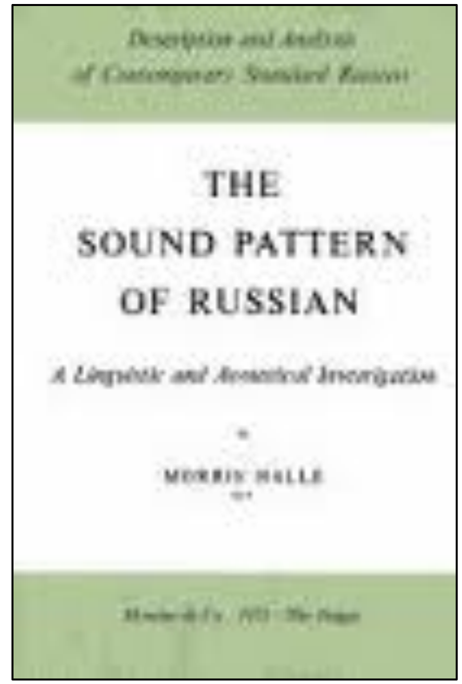
Minimal Contrast (MC)

According to the definition proposed by Nevins (2010: 98), a segment S with specification [αF] is *contrastive* for F if there is another segment S’ in the inventory that is featurally identical to S, except that it is [–αF].

In our example, the circled specifications are minimally contrastive, by the above definition, but the uncircled ones are not, because there is no voiceless nasal /m̥/ in this inventory.

	/p/	/b/	/m/
[voiced]	(–)	(+)	+
[nasal]	–	(–)	(+)

An Argument for Branching Trees



Halle (1959) argued that phonological features must be ordered into a hierarchy because this is the only way to ensure that segments are kept properly distinct.

The Distinctness Condition

Specifically, he proposed (1959: 32) that phonemes must meet the Distinctness Condition:

The Distinctness Condition

> Segment-type {A} will be said to be different from segment-type {B}, if and only if at least one feature which is phonemic in both, has a different value in {A} than in {B}; i.e., plus in the former and minus in the latter, or vice versa.

This formulation is designed to disallow contrasts involving a zero value of a feature, and it disallows specifications derived by MC.

The Distinctness Condition

Segment-type {A} will be said to be different from segment-type {B}, if and only if at least one feature which is phonemic in both, has a different value in {A} than in {B}; i.e., plus in the former and minus in the latter, or vice versa.

According to the Distinctness Condition, /p/ is 'different from' /b/, because /p/ is [–voiced] and /b/ is [+voiced].

	/p/	/b/	/m/
[voiced]	–	+	
[nasal]		–	+

The Distinctness Condition

Segment-type {A} will be said to be different from segment-type {B}, if and only if at least one feature which is phonemic in both, has a different value in {A} than in {B}; i.e., plus in the former and minus in the latter, or vice versa.

According to the Distinctness Condition, /p/ is 'different from' /b/, because /p/ is [–voiced] and /b/ is [+voiced].

Similarly, /b/ is 'different from' /m/, because /b/ is [–nasal] and /m/ is [+nasal].

	/p/	/b/	/m/
[voiced]	–	+	
[nasal]		–	+

The Distinctness Condition

Segment-type {A} will be said to be different from segment-type {B}, if and only if at least one feature which is phonemic in both, has a different value in {A} than in {B}; i.e., plus in the former and minus in the latter, or vice versa.

But /p/ is not 'different from' /m/: where one has a feature, the other has no specification.

Therefore, these specifications are not properly contrastive.

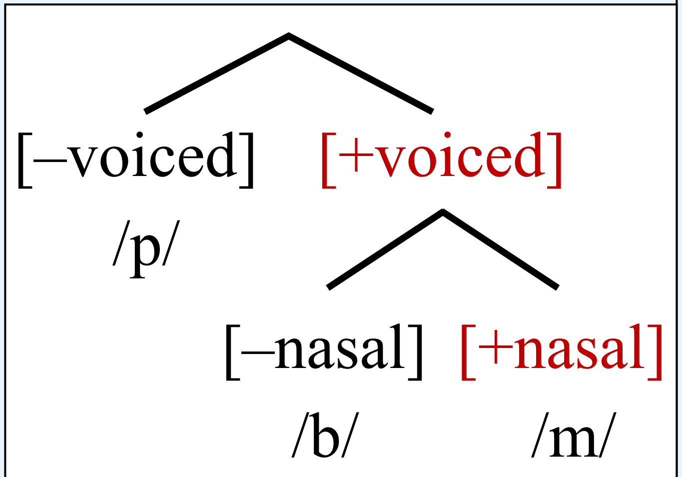
	/p/	/b/	/m/
[voiced]	–	+	
[nasal]		–	+

The Distinctness Condition

The specifications below violate the Distinctness Condition because no feature hierarchy yields this result.

If we order [voiced] > [nasal], we generate an extra specification on /m/.

	/p/	/b/	/m/
[voiced]	–	+	+
[nasal]		–	+



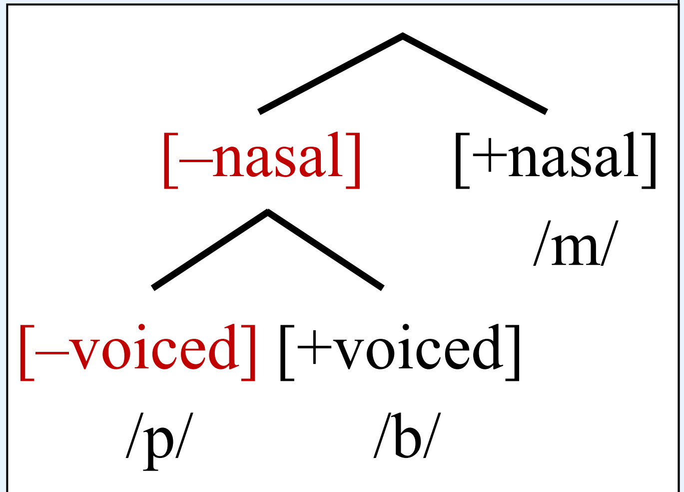
The Distinctness Condition

The specifications below violate the Distinctness Condition because no feature hierarchy yields this result.

If we order [voiced] > [nasal], we generate an extra specification on /m/.

If we order [nasal] > [voiced], we generate an extra specification on /p/.

	/p/	/b/	/m/
[voiced]	–	+	
[nasal]	–	–	+



Problems with Minimal Contrast

The Distinctness Condition is not some arbitrary formal condition that may be disregarded; as I document in Dresher (2009), MC's violation of the condition results in a variety of empirical and conceptual problems.

The main problem with MC is that fewer phonemes than we might think are 'featurally identical' with respect to *all* features that they might possibly possess.

More usually we ignore 'small' or 'irrelevant' features when assessing if two phonemes are minimally different.

Turkish Vowels

An example of the shortcomings of MC and how they are often tacitly set aside is Nevins's discussion of the Turkish vowel system (2010: 26).

In keeping with traditional analyses, Nevins observes that the features [high], [back], and [round] are sufficient to uniquely determine each of the eight vowels of Turkish.

	[–back]		[+back]	
	[–round]	[+round]	[–round]	[+round]
[+high]	i	ü	ɨ	u
[–high]	e	ö	a	o

Turkish Vowels

Nevins does not mention the feature [low], though it is one of the features commonly employed in vowel systems.

Limiting Turkish to a single height feature is crucial in achieving the elegant traditional classification of Turkish vowels.

	[–back]		[+back]	
	[–round]	[+round]	[–round]	[+round]
[+high]	i	ü	ɨ	u
[–high]	e	ö	a	o

Turkish Vowels

With just these 3 features, every feature specification is contrastive according to MC. Every vowel has 3 counterparts that differ from it with respect to exactly one feature.

	i	ü	ɨ	u	e	ö	a	o
[high]	+	+	+	+	–	–	–	–
[back]	–	–	+	+	–	–	+	+
[round]	–	+	–	+	–	+	–	+

Turkish Vowels

For example, consider /i/: it differs
from /ü/ only in [round],
from /ɨ/ only in [back],
and from /e/ only in [high].

	i	ü	ɨ	u	e	ö	a	o
[high]	+	+	+	+	–	–	–	–
[back]	–	–	+	+	–	–	+	+
[round]	–	+	–	+	–	+	–	+

Turkish Vowels

If we include [low], the vowel system would look different. Here not all pairs are minimal; MC would not give the desired results. Circled features are noncontrastive.

In particular, /ɨ/ is no longer contrastively [+high], /e/ is not contrastively [–back], and /o/ is not contrastively [+round]. /a/ has no contrastive features at all.

	i	ü	ɨ	u	e	ö	a	o
[high]	+	+	(+)	+	–	–	(–)	–
[back]	–	–	+	+	(–)	–	(+)	+
[round]	–	+	–	+	–	+	(–)	(+)
[low]	(–)	(–)	(–)	(–)	(–)	(–)	(+)	(–)

Against the MC Approach

Dresher (2009) argues that MC fails in many common situations to yield adequate contrastive representations.

This is hardly a surprise: Archangeli (1988) showed the same. In fact, *everybody* knows that MC does not really work.

A Simple Three-Vowel System

Consider a simple 3-vowel system with the feature specifications as below.

There are no minimal contrasts here at all. The 3 phonemes are too far apart in the $2^4 = 16$ slot feature space.

	i	a	u
[high]	+	–	+
[back]	–	+	+
[round]	–	–	+
[low]	–	+	–

A Simple Three-Vowel System

There are no minimal pairs, so MC would give no contrastive features at all.

This is not a good result. But most phonologists do not try to specify 4 features for a 3-vowel system, so this total failure of MC would not be noticed.

	i	a	u
[high]			
[back]			
[round]			
[low]			

A Simple Three-Vowel System

Even if we remove 1 feature MC still gives no results because there are still no minimal pairs.

The features [back] and [round] are getting in each other's way. We have to remove one of them.

	i	a	u
[high]	+	–	+
[back]	–	+	+
[round]	–	–	+

A Simple Three-Vowel System

Now MC *seems* to work: [high] distinguishes /a/ from /u/, and [back] distinguishes /i/ from /u/.

The other features are designated noncontrastive (circled). But I don't think that this is a proper contrastive specification.

	i	a	u
[high]	(+)	–	+
[back]	–	(+)	+

A Simple Three-Vowel System

Without the noncontrastive features, /i/ and /a/ are not properly in contrast.

Without the /u/, these ‘contrastive’ specifications would look absurd.

	i	a
[high]		–
[back]	–	

Contrast via hierarchy

Despite these considerable flaws, MC persists because it seems intuitive—there is indeed a sense in which contrast is minimal, almost by definition—and because phonologists tacitly help it out by discreetly removing 'extra' features and otherwise papering over awkward results.

Contrastive Hierarchy theory solves these problems, and is always able to arrive at properly contrastive specifications.

Moreover, decisions about the *relative scopes* of features are unavoidable, and are ubiquitous in phonological analyses.

Contrast: Relative Scopes of Features

For example, consider some analyses of Catalan vowel features:

Eastern Catalan (Crosswhite 2001)

	[+front]		[–front]
[+high]	i		u
[+ATR]	e		o
[–ATR]	ɛ		ɔ
[+low]		a	

In Crosswhite's (2001) analysis, [ATR] in Eastern Catalan is limited to the mid vowels. It has a narrow scope relative to [high] and [low].

Valencian Catalan (Walker 2005; Lloret 2008)

		[front]		[back]
[+ATR]	[high]	i		u
		e		o
[–ATR]		ɛ		ɔ
	[low]		a	

For Walker (2005) and Lloret (2008), Valencian Catalan [ATR] is contrastive over all vowels; it takes wide scope over the height features.

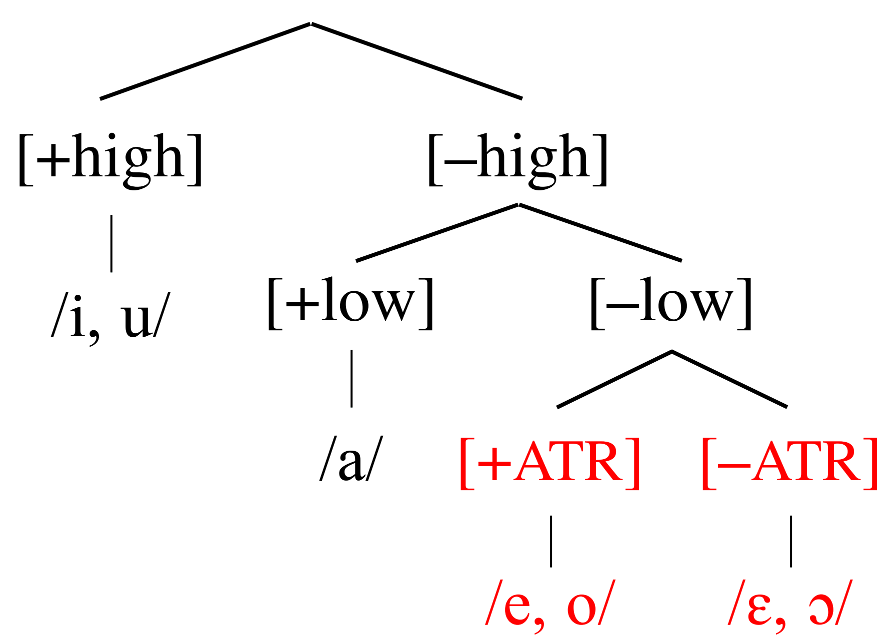
Relative Scope = Ordering

Another way to express this idea is in terms of *feature ordering*: a feature that is higher in the order takes wider scope than a lower-ordered feature.

Contrast: Relative Scopes of Features

Eastern Catalan (Crosswhite 2001)

	[+front]		[–front]
[+high]	i		u
[+ATR]	e		o
[–ATR]	ɛ		ɔ
[+low]		a	



The analysis of Eastern Catalan is tantamount to ordering the features [high] and [low] over [ATR].

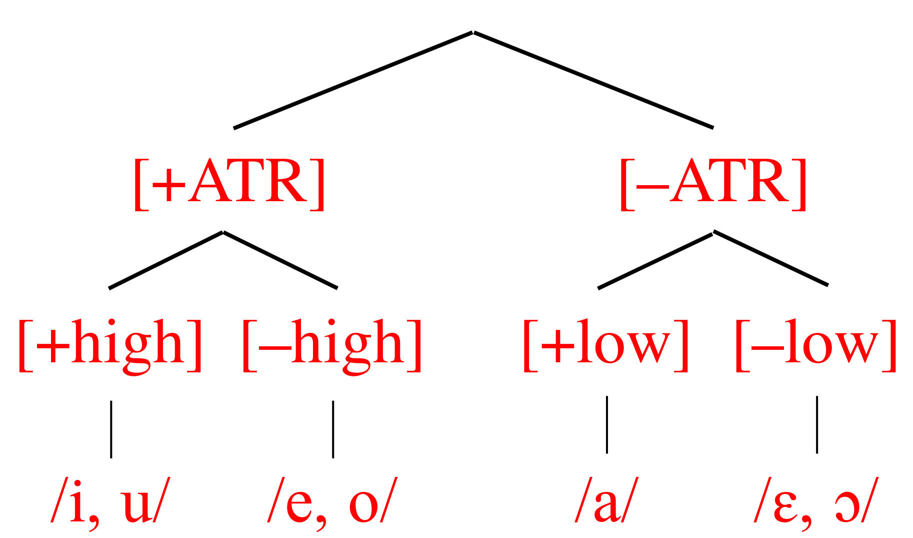
The tree diagram expresses the ordering:

[high] > [low] > [ATR]

Contrast: Relative Scopes of Features

Valencian Catalan (Walker 2005; Lloret 2008)

		[front]		[back]
[+ATR]	[high]	i		u
		e		o
[–ATR]		ɛ		ɔ
	[low]		a	



The analysis of Valencian Catalan is tantamount to ordering [ATR] over the height features.

The tree diagram expresses the ordering:

[ATR] > [high], [low]

Ordering in Turkish Vowels

Ordering is also implicit in the traditional analysis of Turkish vowels.

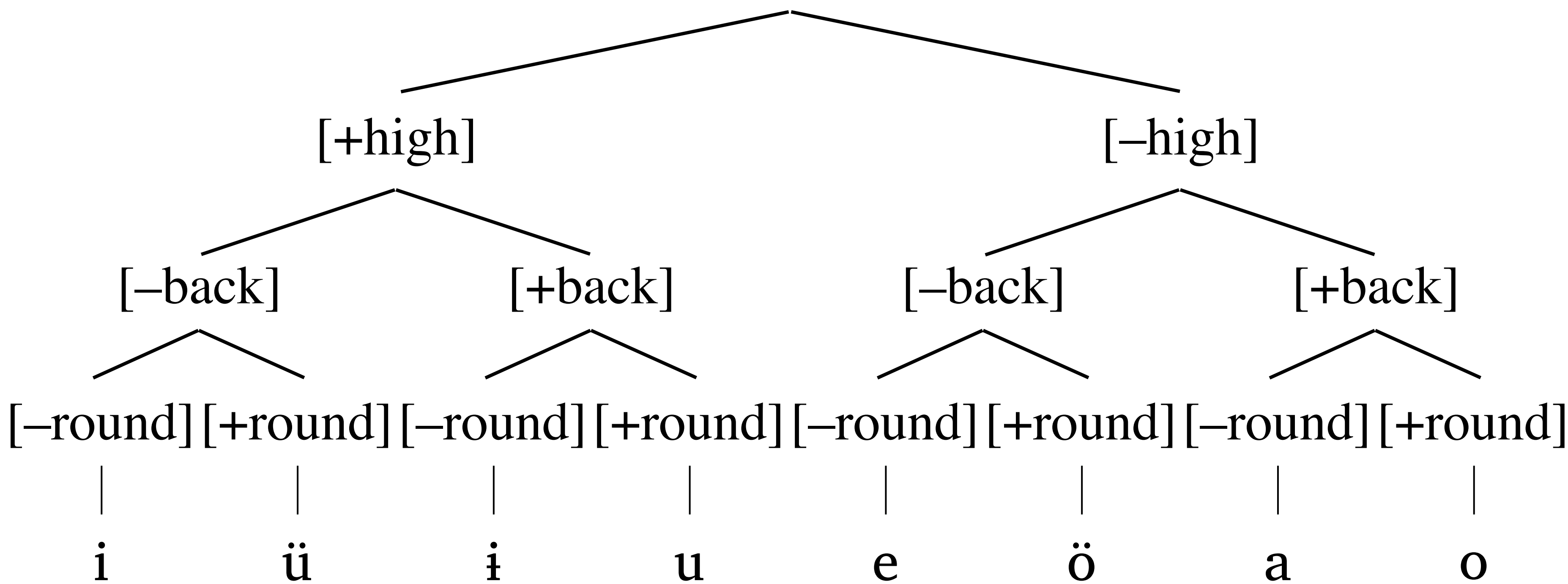
The features [high], [back], and [round] are ordered ahead of [low] and other possible features.

	[–back]		[+back]	
	[–round]	[+round]	[–round]	[+round]
[+high]	i	ü	ɨ	u
[–high]	e	ö	a	o

Ordering in Turkish Vowels

Once the top 3 features have applied, all vowels are contrastive and no further contrastive features can be assigned.

Ordering provides the *rationale* and *justification* for omitting [low] and [ATR] from the analysis of Turkish.



8-10

Contrast Shift and Diachrony

The notion that contrast shift is a type of grammar change has proved to be fruitful in the study of a variety of languages.

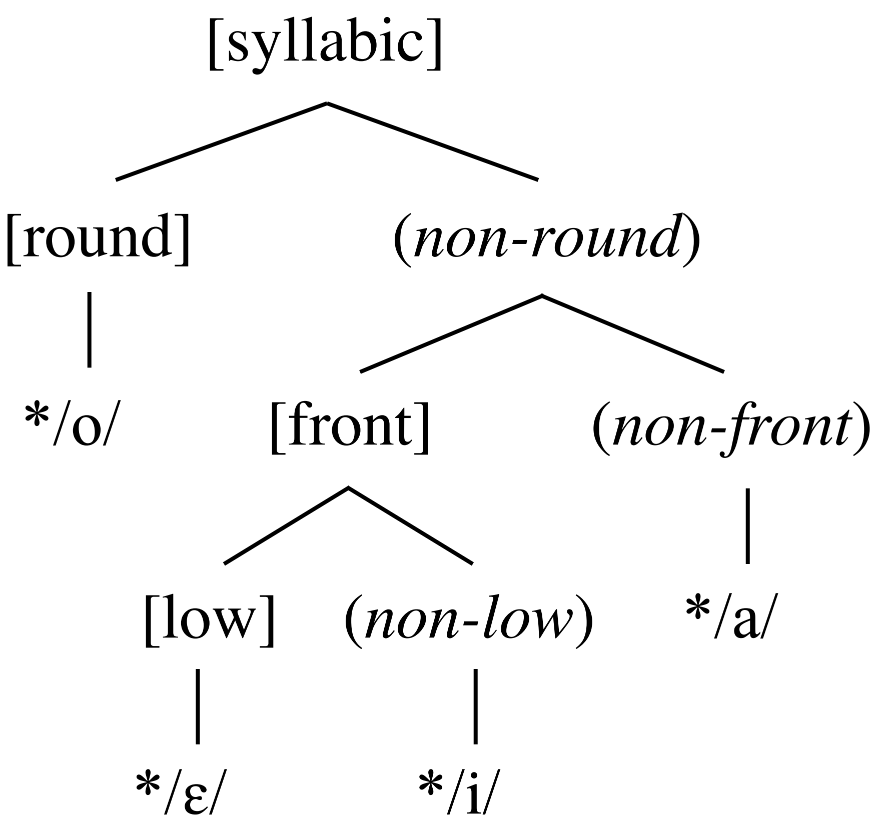
Examples include: Zhang (1996) and Dresher and Zhang (2005) on Manchu; Barrie (2003) on Cantonese; Rohany Rahbar (2008) on Persian; Dresher (2009: 215–225) on East Slavic; Compton & Dresher (2011) on Inuit; Gardner (2012), Roeder & Gardner (2013), and Purnell & Raimy (2013) on North American English vowel shifts; and large-scale studies by Harvey (2012) on Ob-Ugric (Khanty and Mansi), Ko (2010, 2011, 2012) on Korean, Mongolic, and Tungusic, and Oxford (2012, 2015) on Algonquian.

8.

From Proto-Algonquian to the modern Algonquian languages

In a survey of the historical development of Algonquian vowel systems, Oxford (2015) observes that a large set of separate changes can be understood if we posit a single contrast shift.

Contrastive hierarchy for Proto-Algonquian vowels (Oxford 2015) [round] > [front] > [low]



Oxford (2015) posits this feature hierarchy for Proto-Algonquian *(length contrast omitted for ease of exposition)*.

*/**o**/ is [round]: triggers rounding

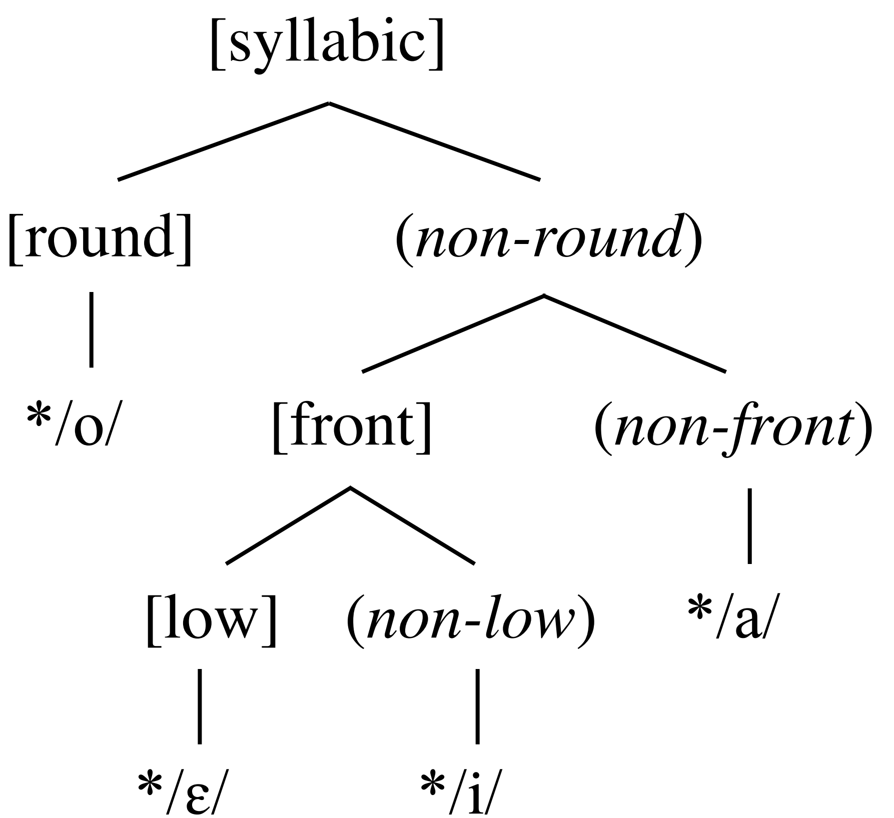
*/**i**/ is [front]: triggers palatalization

*/**i, ɛ**/ sisters: partial neutralization

*/**a**/ has no marked contrastive features: is never a trigger

Contrastive hierarchy for Proto-Algonquian vowels (Oxford 2015)

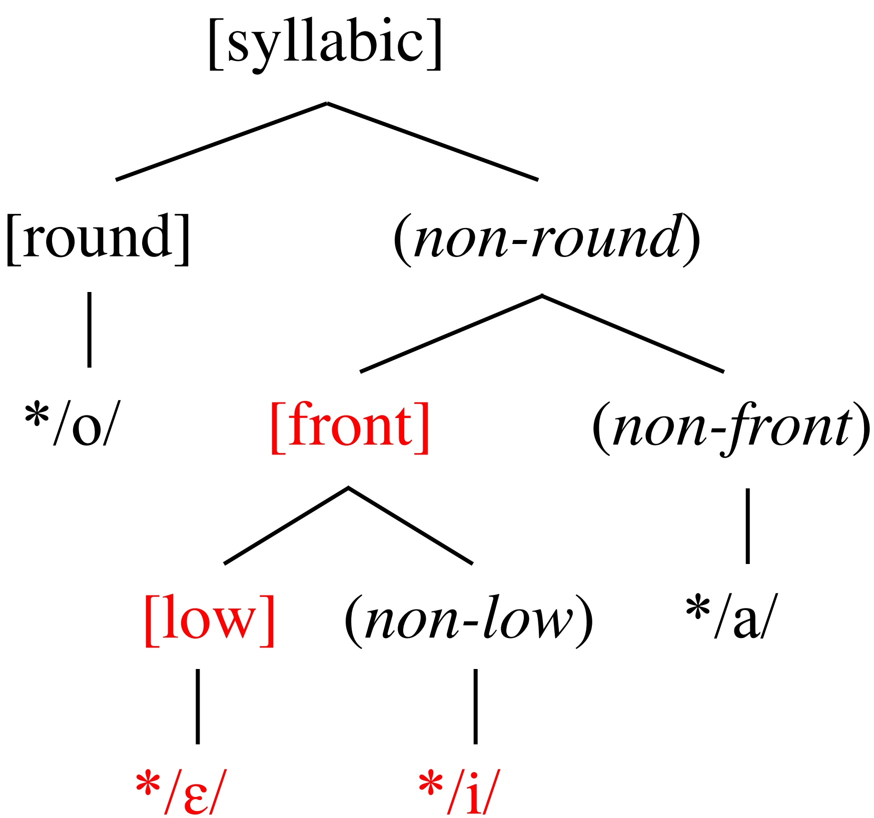
[round] > [front] > [low]



The PA hierarchy continues unchanged in the Central Algonquian languages and in Blackfoot.

It accounts for two recurring patterns:

Contrastive hierarchy for Central Algonquian and Blackfoot [round] > [front] > [low]



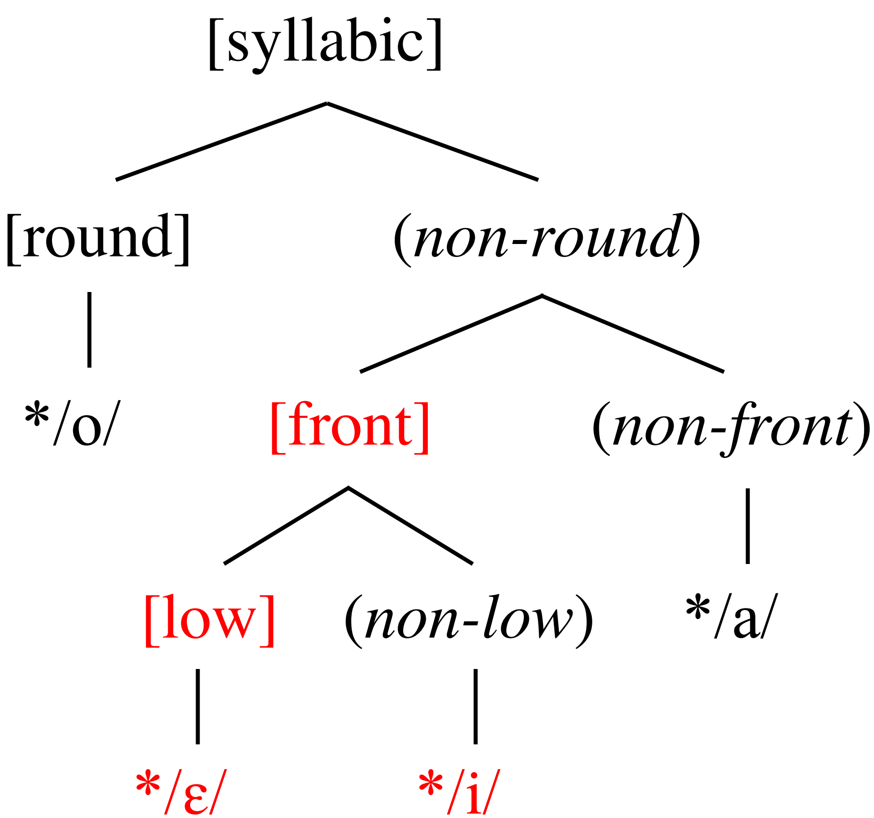
1. Palatalization always includes */i/ as a trigger

PA */t, θ/-palatalization is triggered by */i, iː/

Innu */k/-palatalization is triggered by */i, iː, ɛː/

Betsiamites Innu /t/-palatalization is triggered by /iː/

Contrastive hierarchy for Central Algonquian and Blackfoot [round] > [front] > [low]

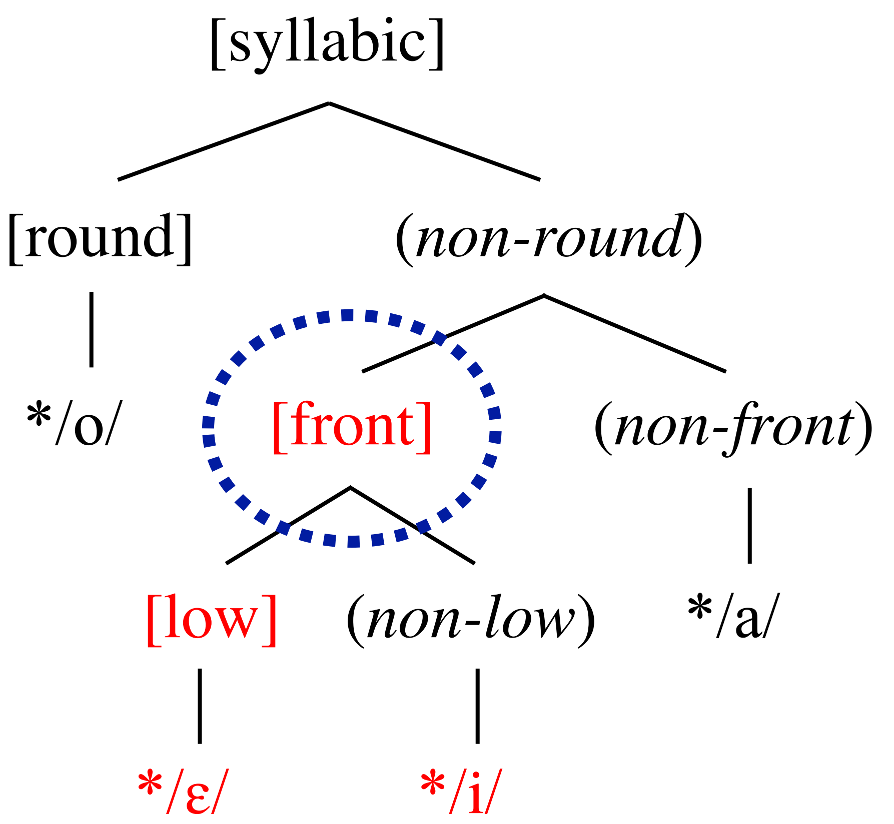


1. Palatalization always includes */i/ as a trigger

Blackfoot */k/-assibilation is triggered by PA */i, iː/

Blackfoot /t/-assibilation is triggered by Blackfoot /i, iː/

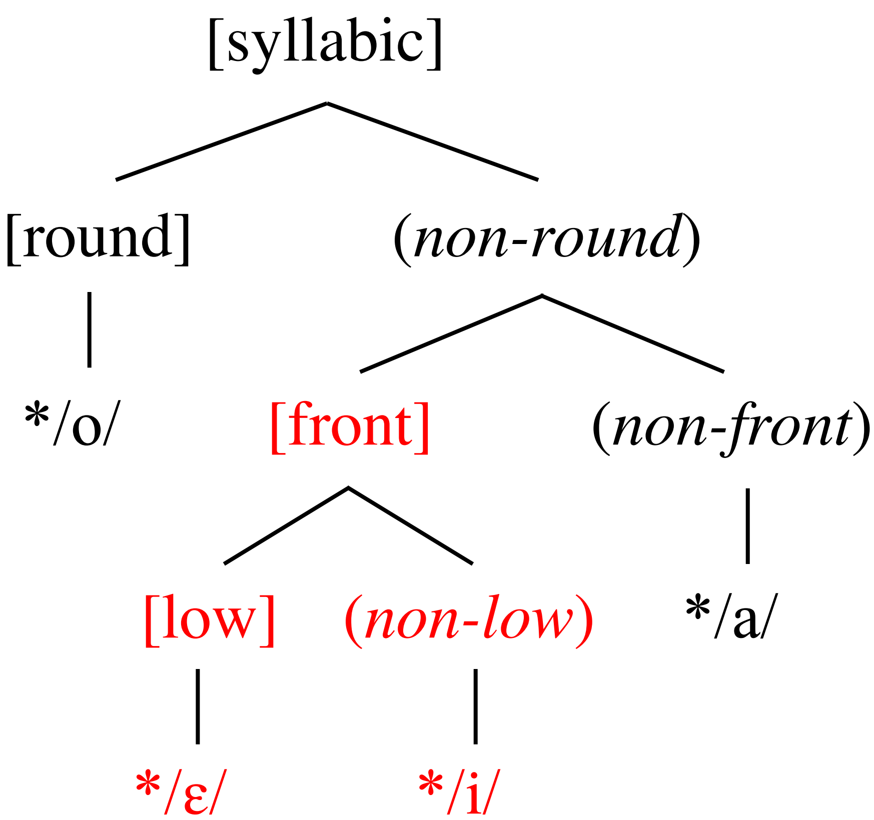
Contrastive hierarchy for Central Algonquian and Blackfoot [round] > [front] > [low]



1. Palatalization always includes */i/ as a trigger

These patterns support the view that palatalization is triggered by a contrastive [front] feature, and favours vowels that are (*non-low*).

Contrastive hierarchy for Central Algonquian and Blackfoot [round] > [front] > [low]

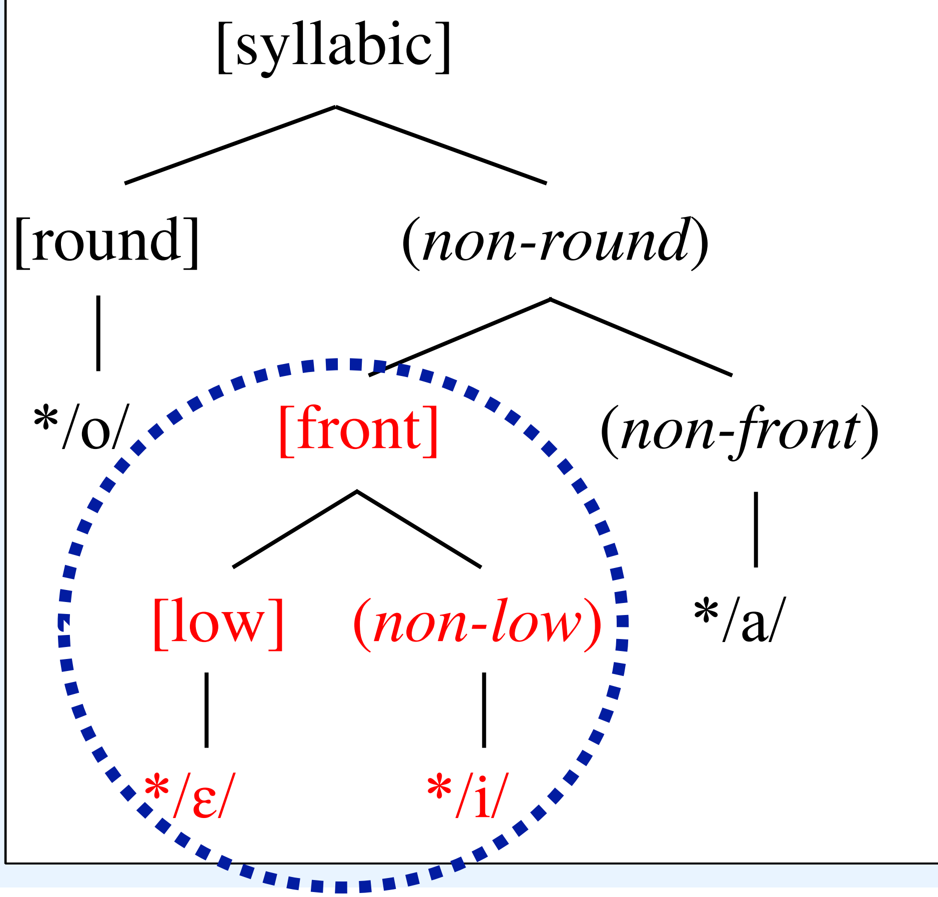


2. */ɛ/ regularly merges with */i/

Partial or complete mergers of short */ɛ/ > /i/ occur in Fox, Shawnee, Miami-Illinois, Cree-Innu, Ojibwe, and Blackfoot

Long */ɛː/ > /iː/ in Woods Cree, Northern Plains Cree, and Blackfoot

Contrastive hierarchy for Central Algonquian and Blackfoot [round] > [front] > [low]

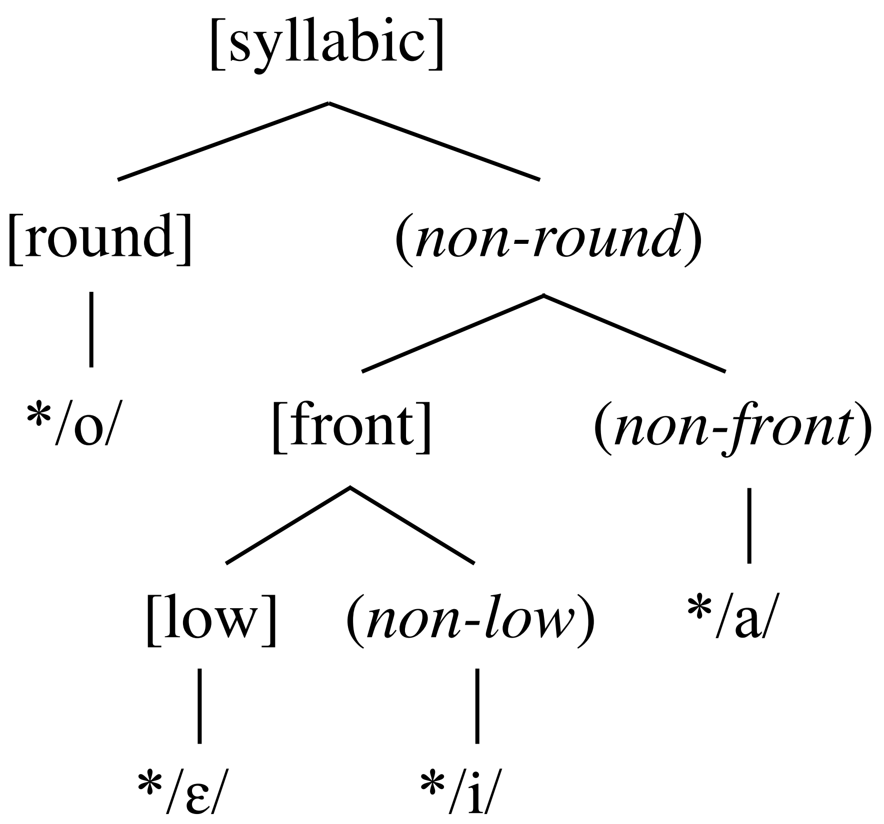


2. */ε/ regularly merges with */i/

These mergers are consistent with the idea that merger will tend to involve terminal nodes in the feature tree.

Eastern and Western Algonquian

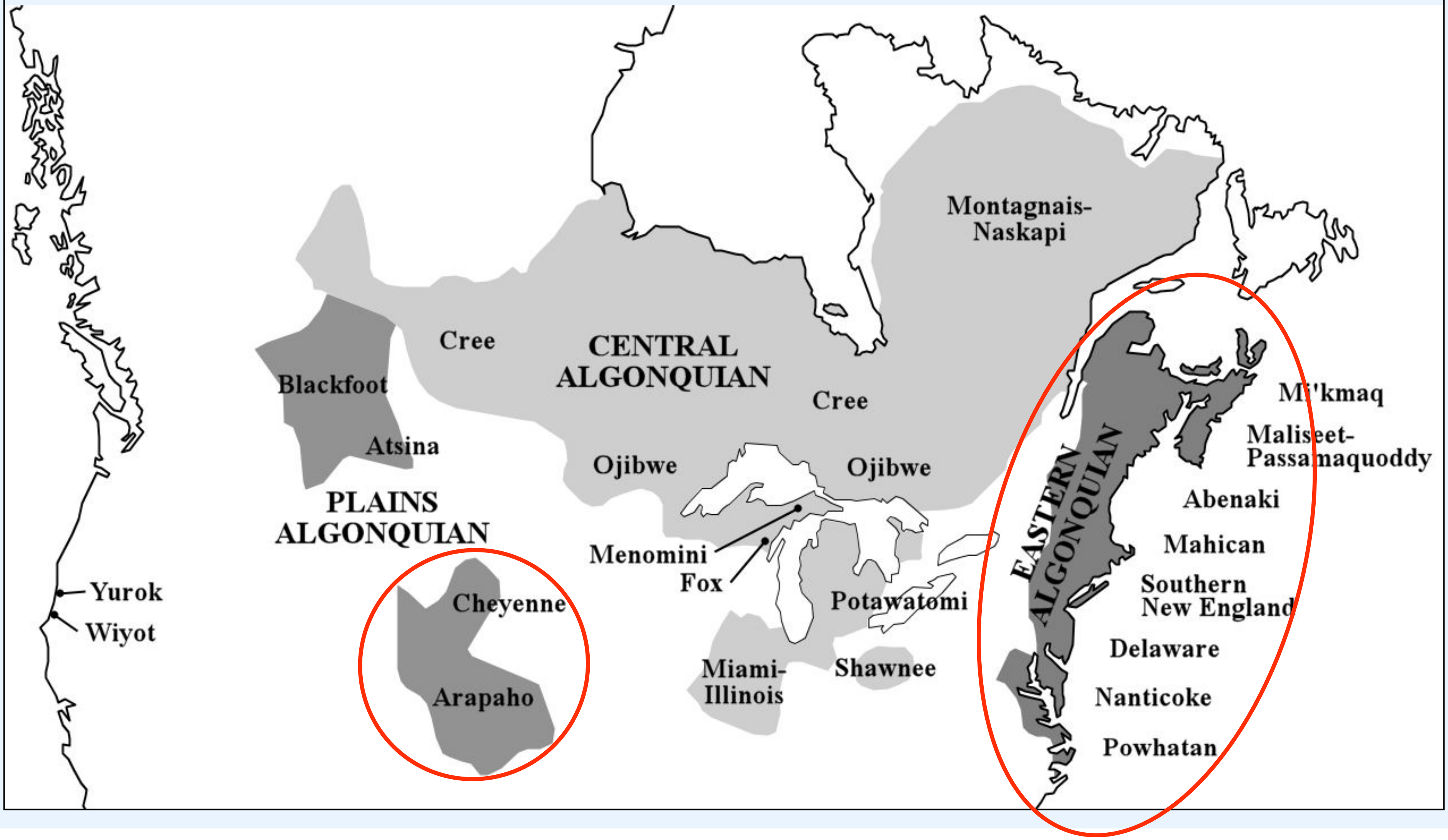
[round] > [front] > [low]



On the eastern and western edges of the Algonquian area, developments diverge from the predictions of the PA hierarchy.

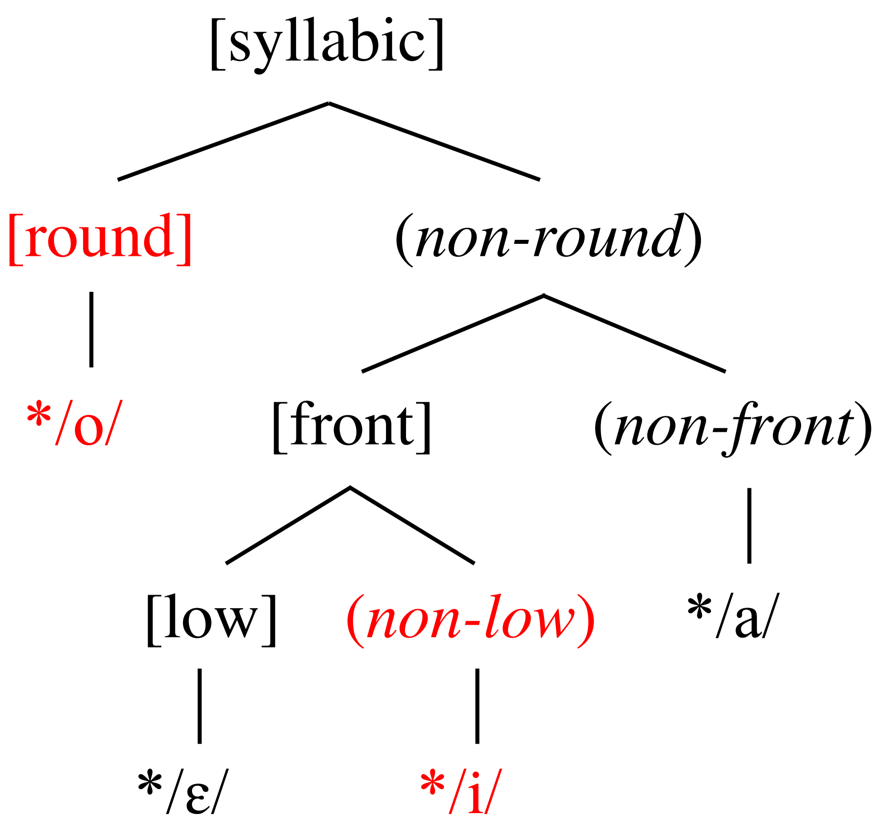
Map of Algonquian languages

Eastern and Western (Cheyenne-Arapaho) are circled in red



Eastern and Western proto-languages

[round] > [front] > [low]



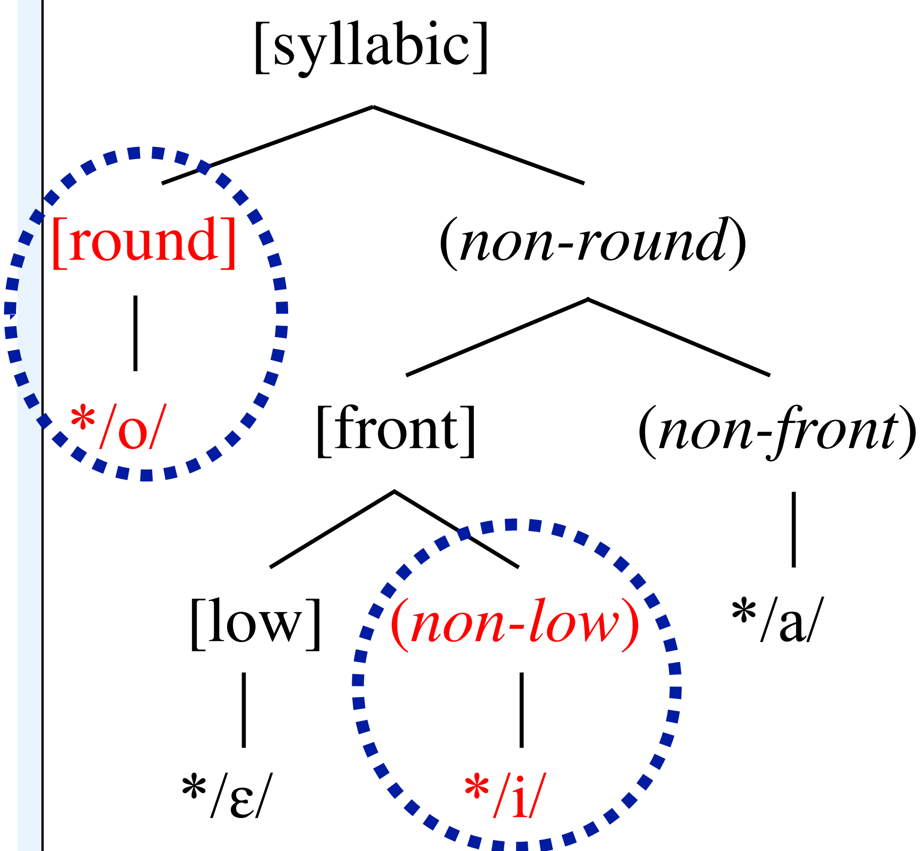
The high vowels begin to pattern together

In the east: Proto-Eastern Algonquian lost the length contrast only in the high vowels (reflexes of */o/, */i/)

In the west: Proto-Arapaho-Atsina and Pre-Cheyenne merge */o, o:/ with */i, i:/

Eastern and Western proto-languages

[round] > [front] > [low]

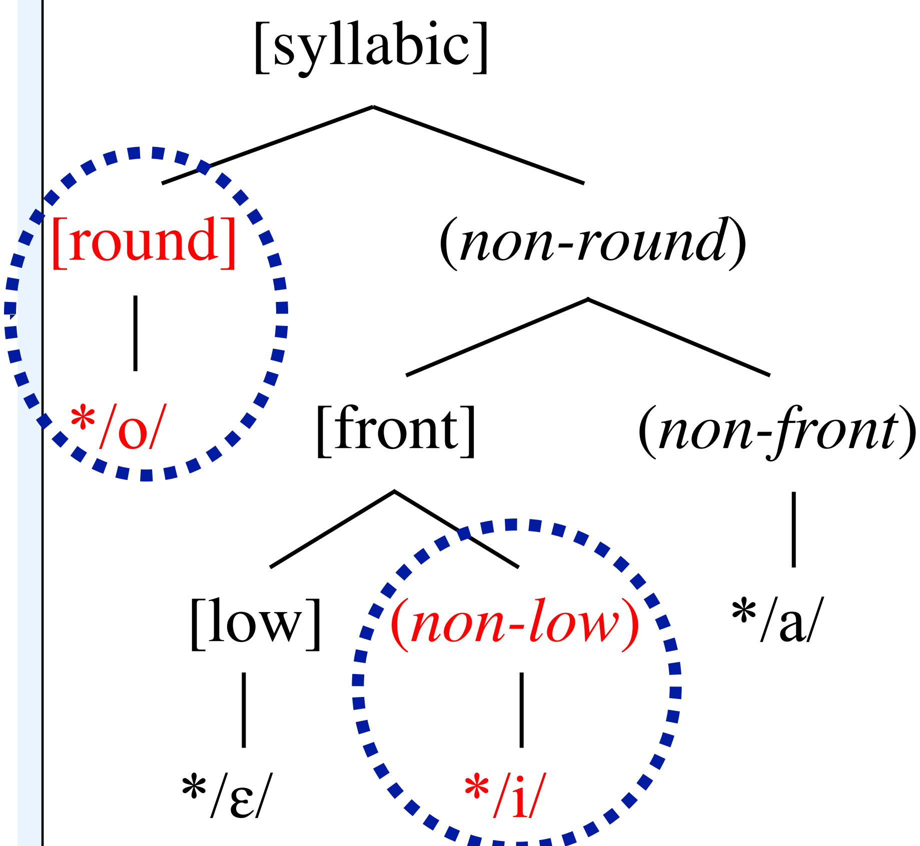


The high vowels begin to pattern together

But under the hierarchy inherited from PA, the high vowels are not a natural class!

Eastern and Western proto-languages

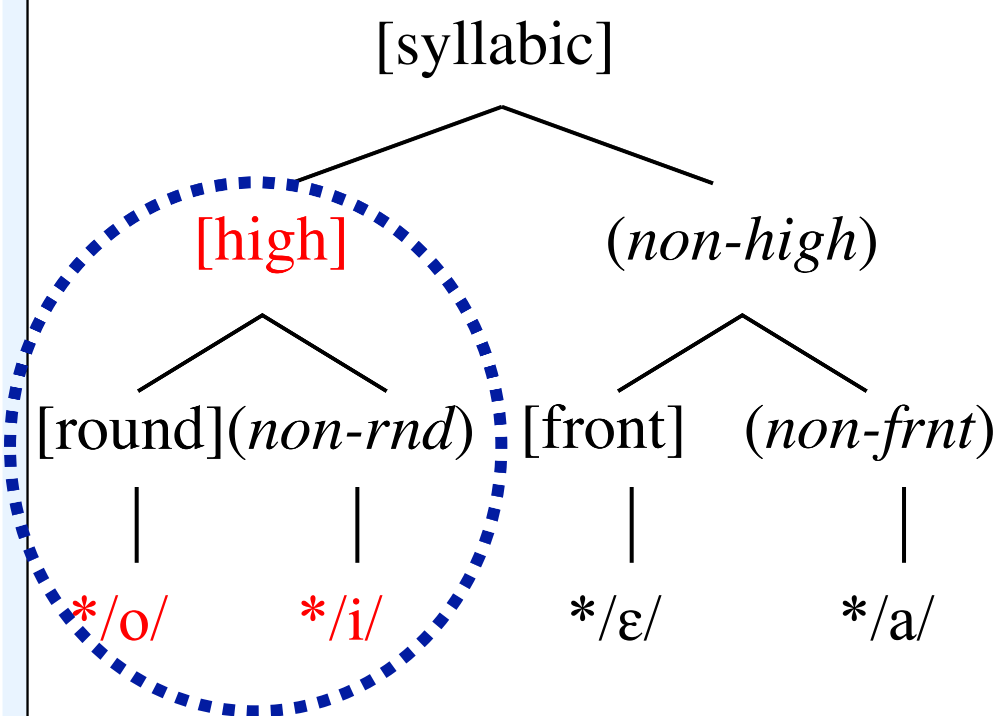
[round] > [front] > **[high]**



If the hierarchy constrains patterning, then the **height contrast** (reinterpreted as [high]) must have come to **outrank place contrasts**

Eastern and Western proto-languages

[high] > [round] > [front]

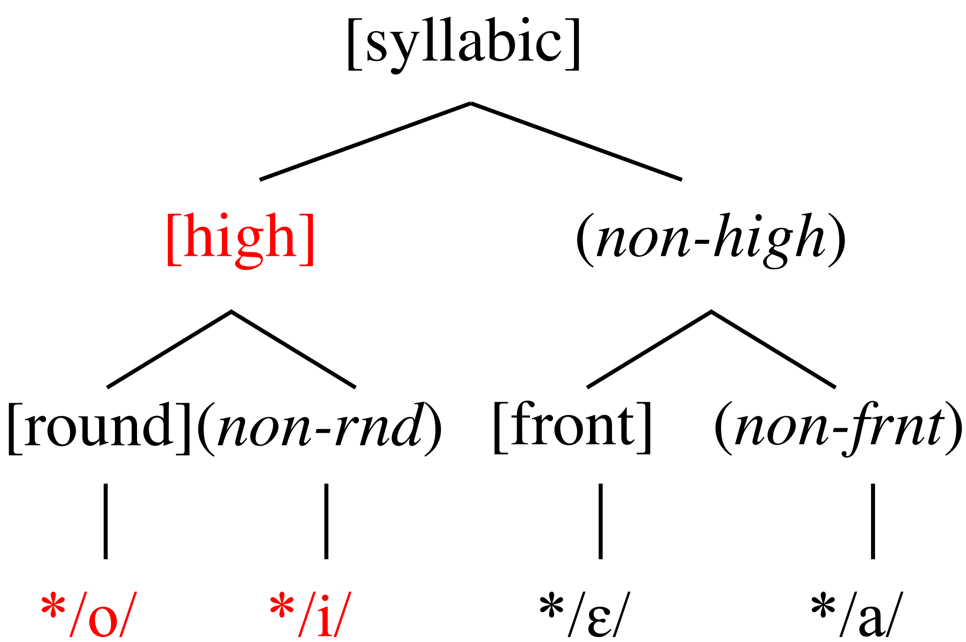


If the hierarchy constrains patterning, then the **height contrast** (reinterpreted as [high]) must have come to **outrank place contrasts**

That is, the feature [high] moves to the top of the hierarchy.

Eastern and Western daughter languages

[high] > [round] > [front]

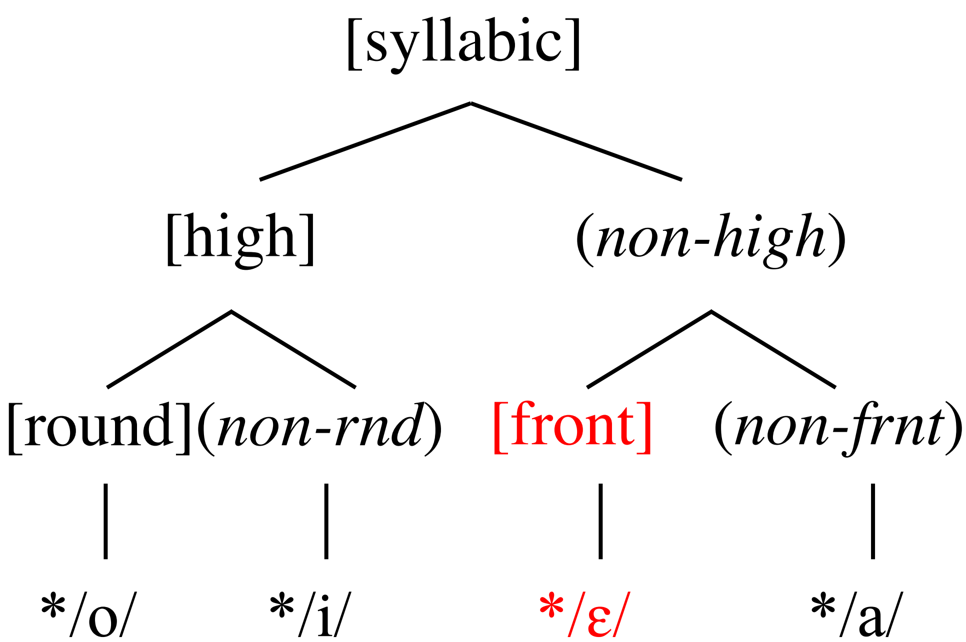


Subsequent developments in the eastern and western daughter languages follow the predictions of the new hierarchy.

The patterns consistently differ from those of Central Algonquian:

Eastern and Western daughter languages

[high] > [round] > [front]



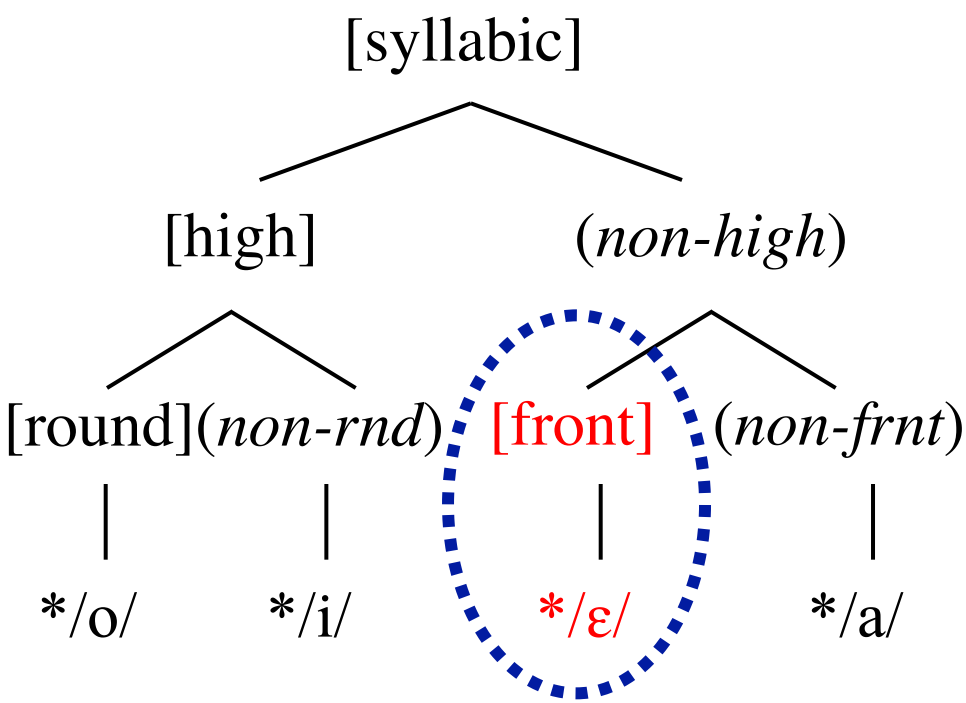
1. Palatalization is triggered by */ε/ but **excludes** */i/

Massachusett */k/-palatalization is triggered by PEA */εː/ but not /iː/

Cheyenne "yodation", where */k/ > /kj/, is triggered by */ε(ː)/ only

Eastern and Western daughter languages

[high] > [round] > [front]



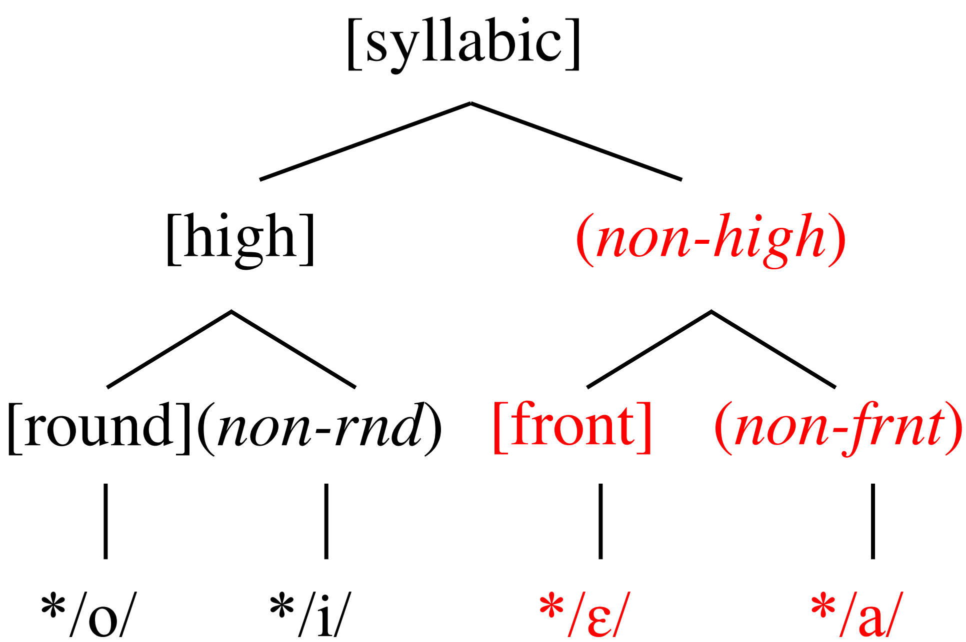
1. Palatalization is triggered by */ɛ/ but **excludes */i/**

Again, these patterns support the view that palatalization is triggered by a contrastive [front] feature.

Only /ɛ/ is contrastively [front] in these languages.

Eastern and Western daughter languages

[high] > [round] > [front]



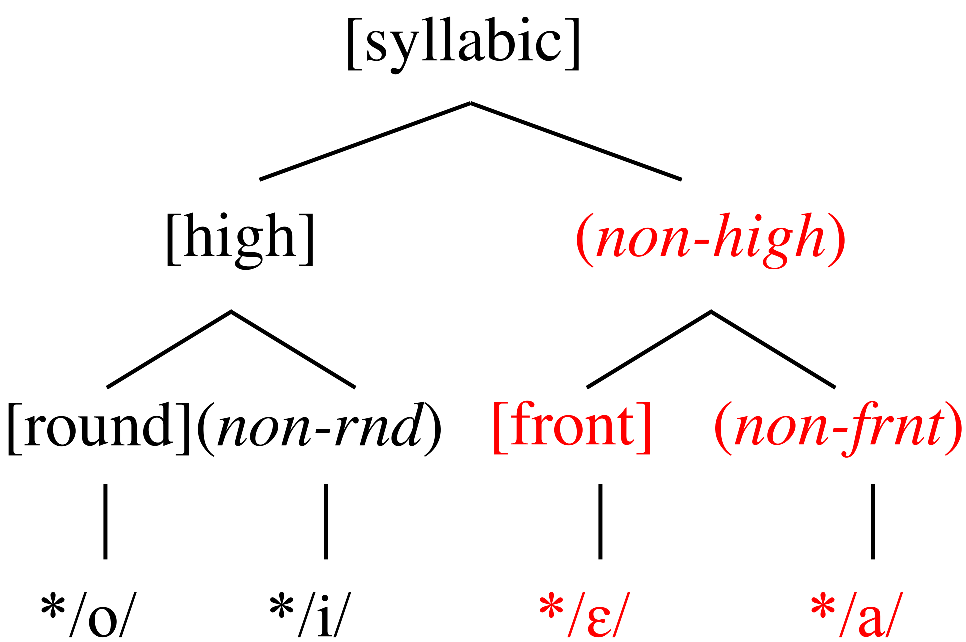
2. */ɛ/ merges with or shifts to */a/

Partial or complete mergers of PA short */ɛ/ with */a/ occur in Abenaki, Mahican, Mi’kmaq, and Maliseet-Passamaquoddy

PEA long */ɛː/ shifts to /aː/ in Massachusett and merges with */a/ in Western Abenaki

Eastern and Western daughter languages

[high] > [round] > [front]



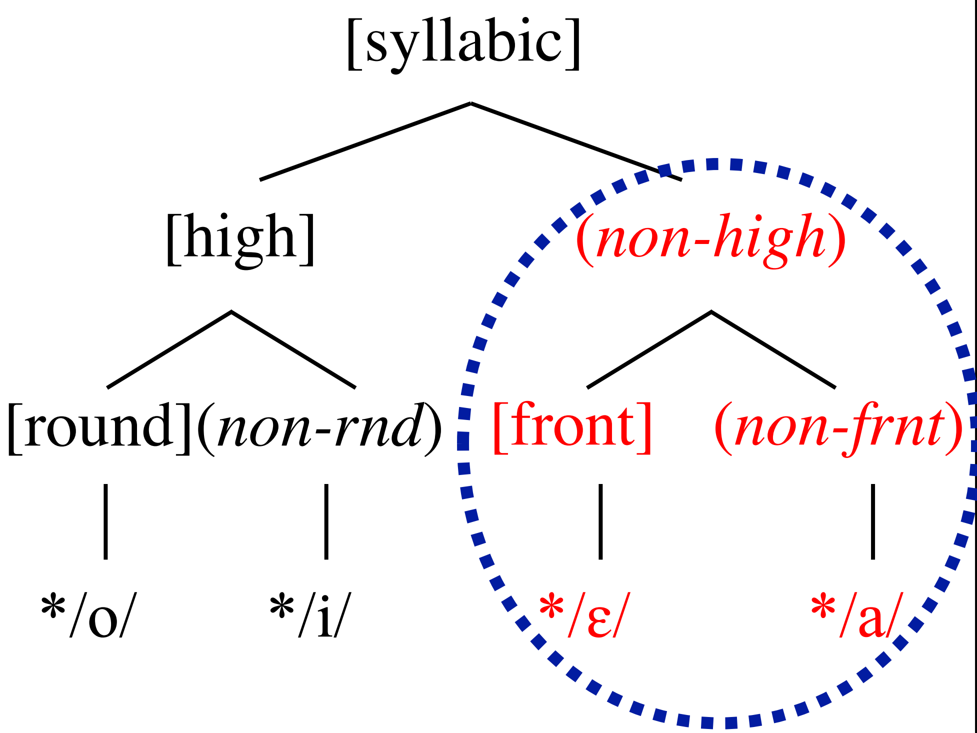
2. */ɛ/ merges with or shifts to */a/

Long and short */ɛ(ː)/ shift to /a(ː)/ in Cheyenne

Vowel harmony involves */ɛ(ː)/ and */a(ː)/ in Arapaho

Eastern and Western daughter languages

[high] > [round] > [front]

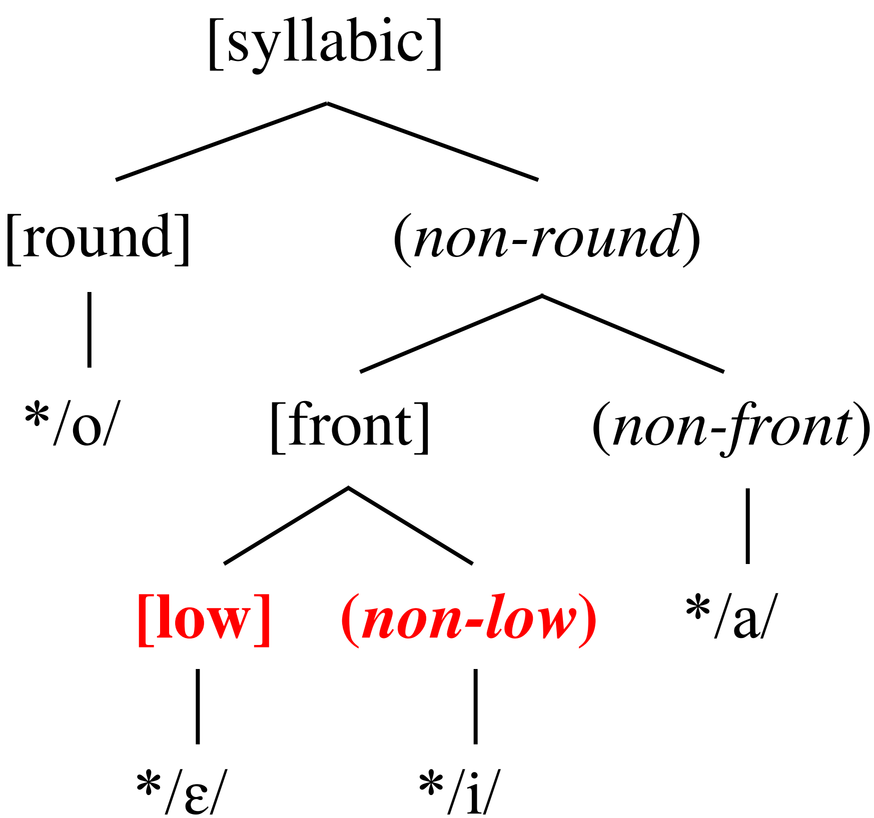


2. */ɛ/ merges with or shifts to */a/

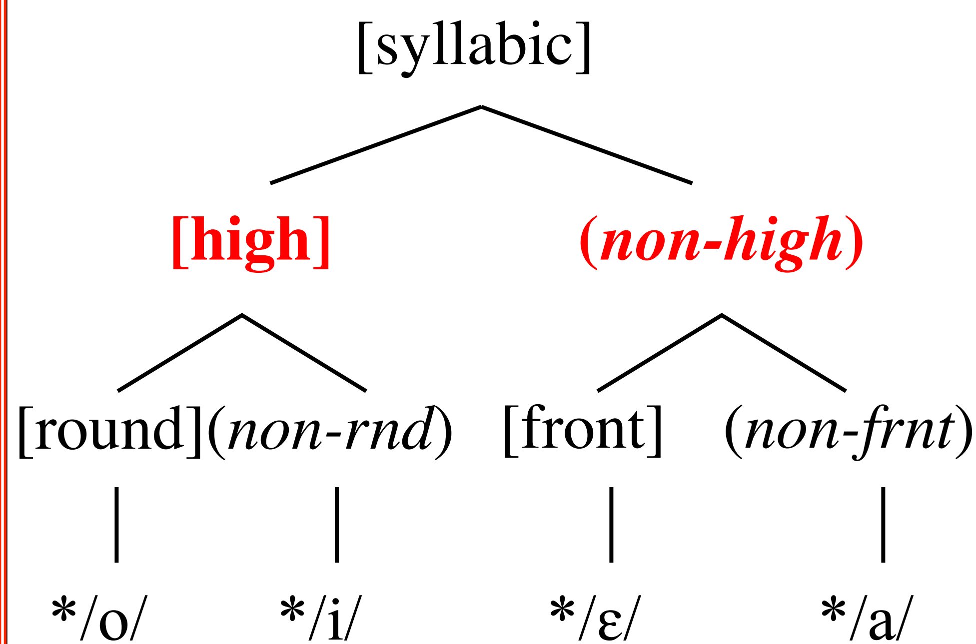
This follows from the sisterhood of */ɛ/ and */a/ under the new hierarchy.

A **single contrast shift** thus accounts for the patterning of a large number of phonological changes across the Algonquian family.

PA and Central languages



Eastern and Western languages



9.

Areal isoglosses: Borrowing Contrast shifts in the Ob-Ugric Mansi and Khanty languages

Harvey (2012) shows that contrastive shifts in the Ob-Ugric Mansi and Khanty languages show clear isoglosses and are borrowed between languages.

Ob-Ugric vowel systems

The Ob-Ugric languages are found in central Russia, to the east of the Ural mountains along the Ob river system. The two branches of Ob-Ugric are the Mansi languages, in the southwest, and the Khanty languages, to the east and north.

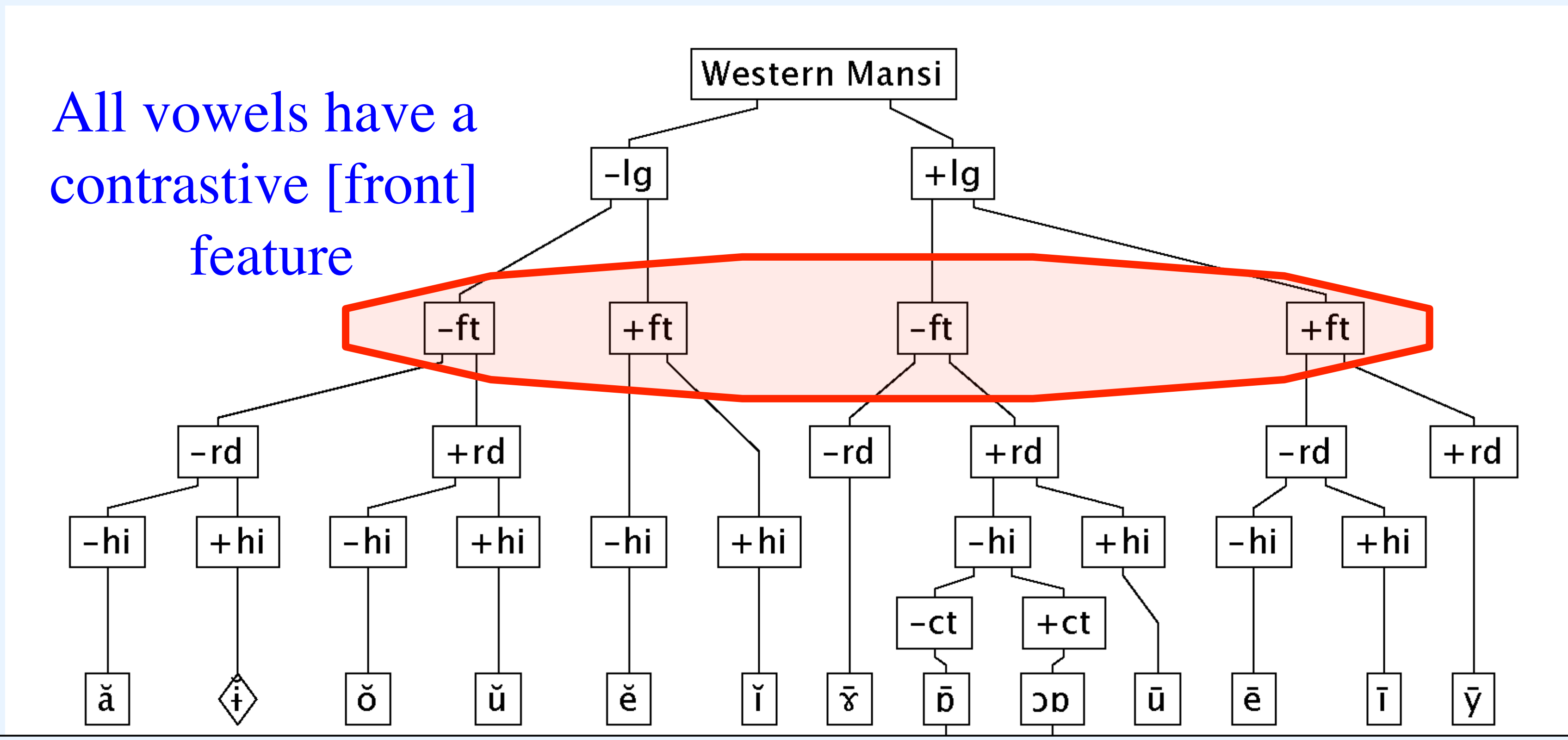
The Ob-Ugric languages inherited a complex vowel system: Proto-Ob-Ugric has been reconstructed to have 19 vowel phonemes (Harvey 2012, based on Sammallahti 1988).

Also characteristic of Ob-Ugric was a pervasive front-back vowel harmony that affected all vowels; we assume that the relevant feature is [front].

Early Western Mansi hierarchy

[lg] > [ft] > [rd] > [hi] > [ct]

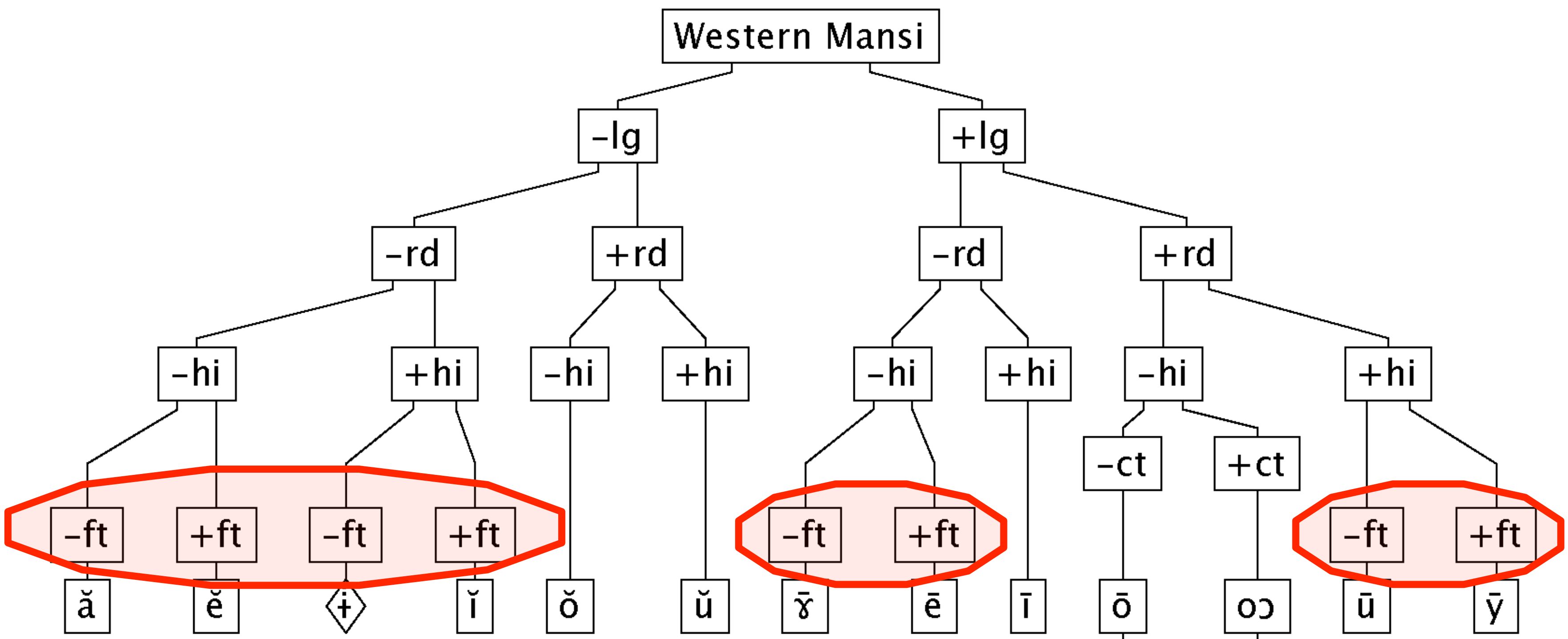
For example, Early Western Mansi has the feature hierarchy below; all vowels are contrastive for [front] and all participate in vowel harmony.



Later Western Mansi:

[lg] > [rd] > [hi] > [ct] > [ft]

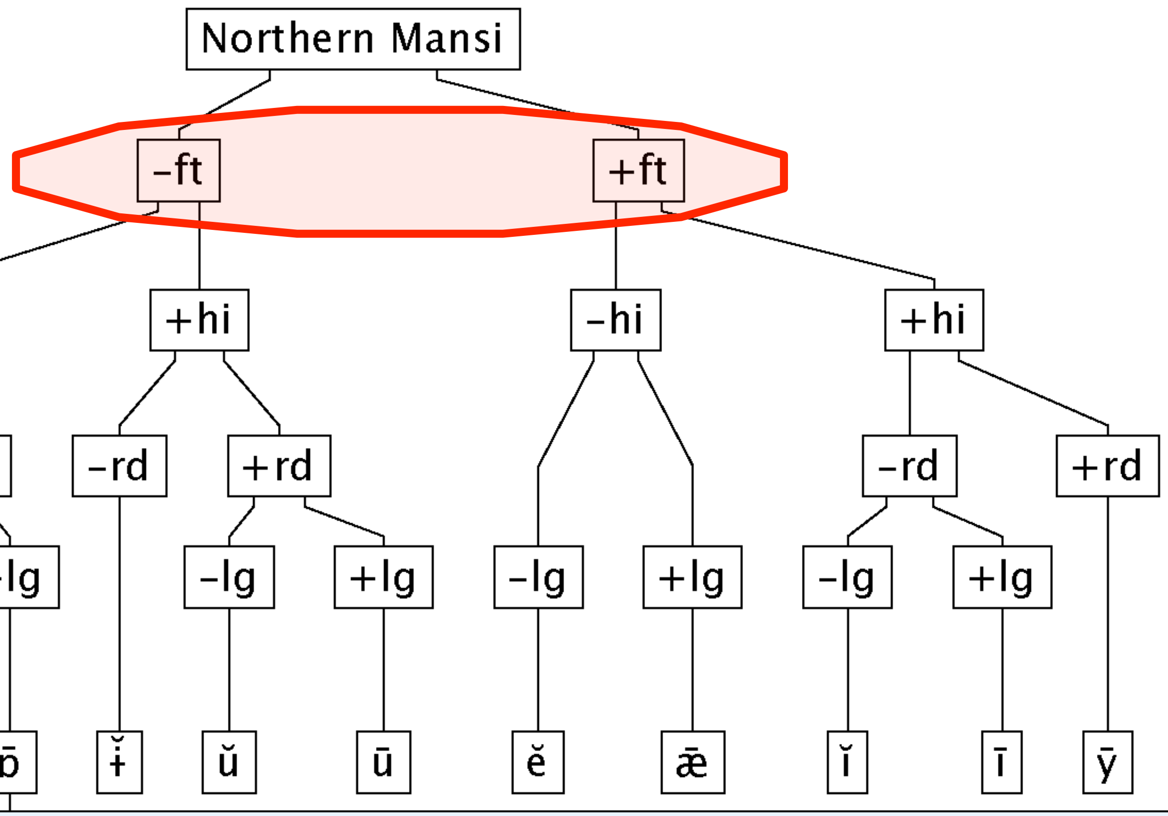
Subsequently, [front] drops to the bottom of the hierarchy. Front harmony is lost, and phonemes that were previously contrastively (*non-front*) develop front allophones.



Early Northern Mansi
[ft] > [hi] > [rd] > [lg]

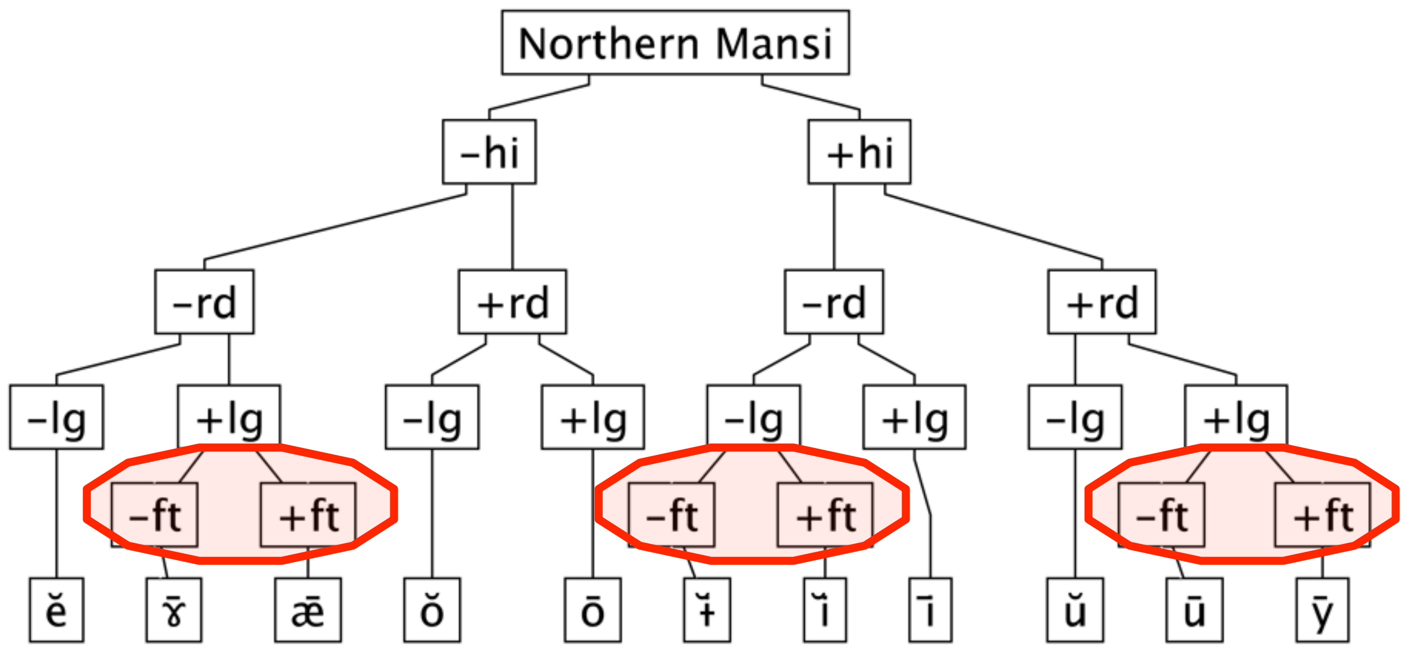
A similar development occurred in Northern Mansi.

All vowels have a contrastive [front] feature



Later Northern Mansi:
[hi] > [rd] > [lg] > [ft]

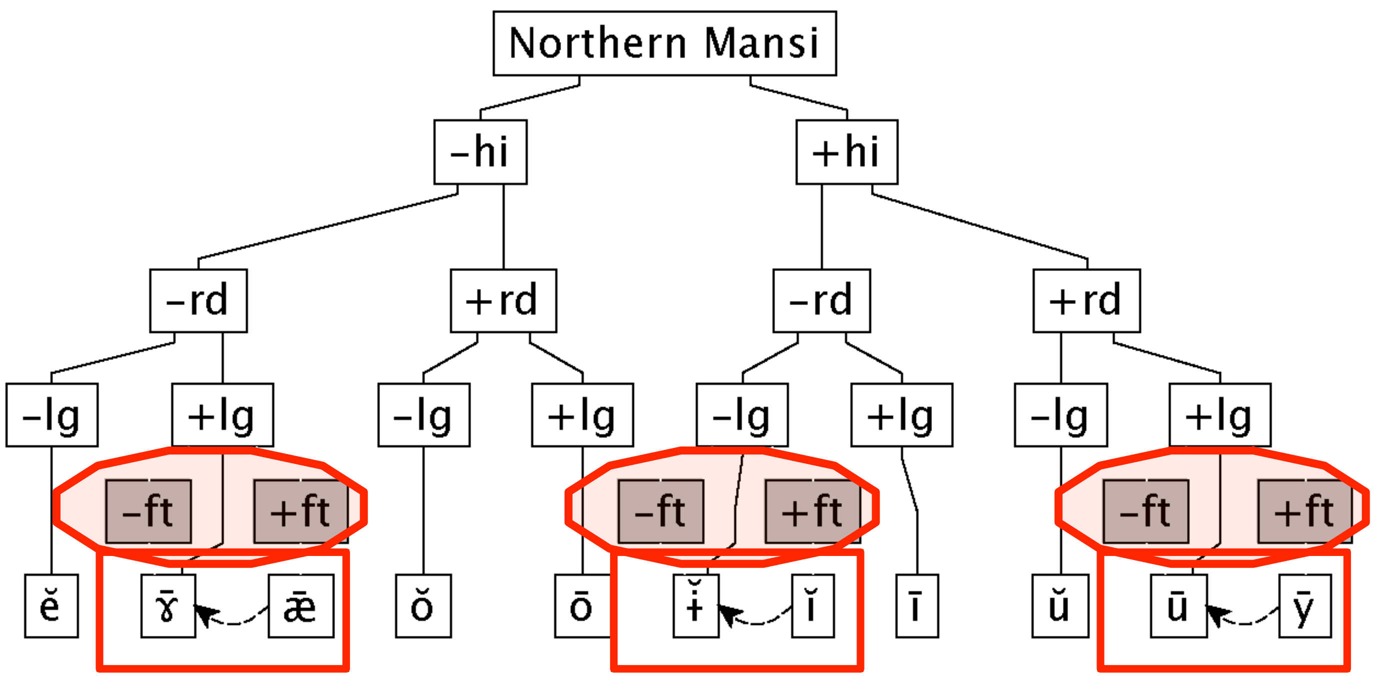
Here, too, [front] drops to the bottom, resulting in the loss of front harmony.



{*ĕ, *ŏ, *ō, *ī, *ŭ} are not contrastive for [front]

Later Northern Mansi:
[hi] > [rd] > [lg] > [ft]

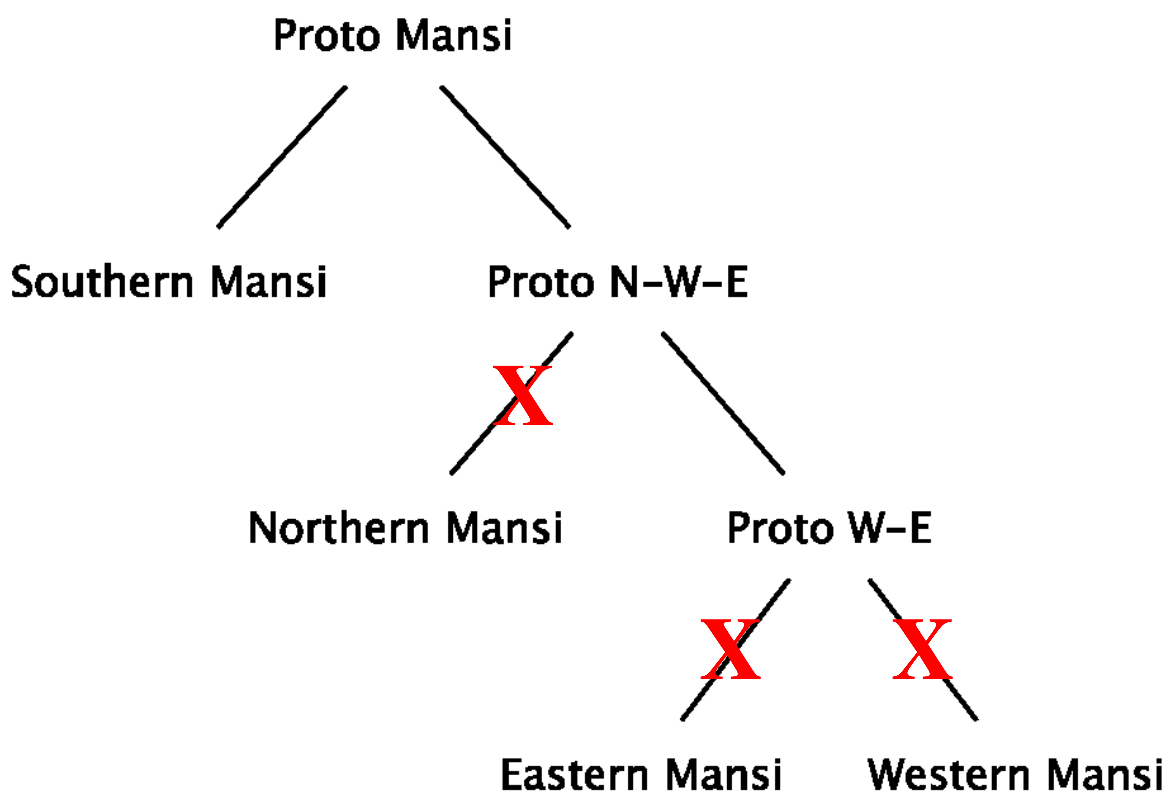
Some phonemes that were previously contrastively [front] merge with back vowels.



Terminal merger from [+front] towards (*non-front*)

Genetic or areal?

[front] dropping did not occur early on in the genetic history of Proto Mansi. The shift occurred later in the daughter languages. The red X indicates when the [front]-dropping shift occurred.

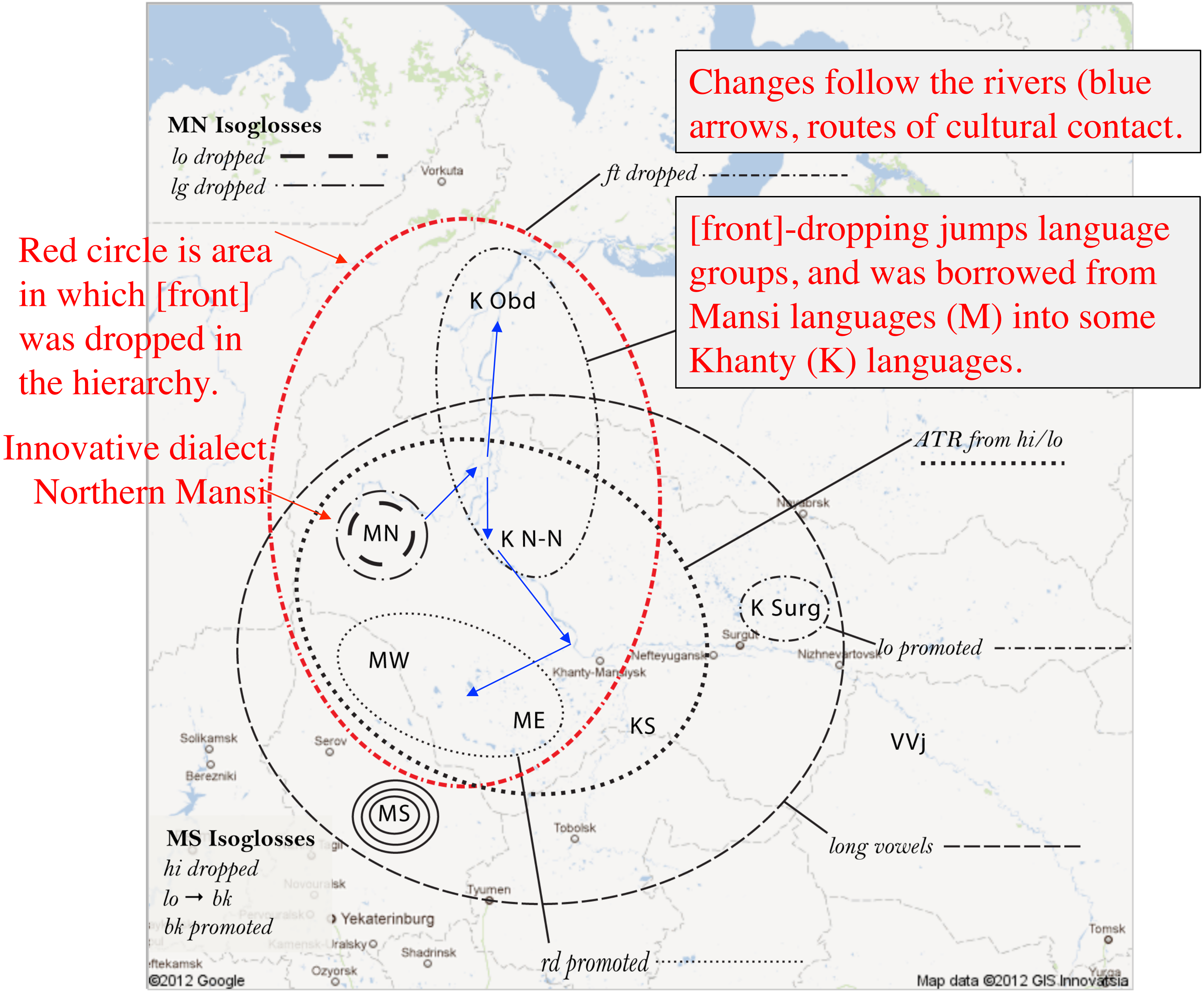


Can contrast shifts spread?

If [front] dropping is not a genetic inheritance common to the non-Southern Mansi languages, could it have been spread by areal diffusion?

That is, is can contrast shift show areal patterning, like other elements of linguistic systems?

To investigate this question, Harvey (2012) plotted a number of contrast shifts, and the results are shown on the following map. It is clear that the contrast shifts have occurred in a way that is not at all random.


Changes follow the rivers (blue arrows, routes of cultural contact.
[front]-dropping jumps language groups, and was borrowed from Mansi languages (M) into some Khanty (K) languages.
Red circle is area in which [front] was dropped in the hierarchy.
Innovative dialect Northern Mansi
MN Isoglosses
lo dropped
lg dropped
ft dropped
ATR from hi/lo
lo promoted
long vowels
rd promoted
MS Isoglosses
hi dropped
lo → bk
bk promoted
K Obd
K N-N
MN
MW
ME
KS
K Surg
VVj
MS
Vorkuta
Noyabrsk
Surgut
Nefteyugansk
Nizhnevartovsk
Khanty-Mansiysk
Solikamsk
Berezniki
Serov
Tobolsk
Tyumen
Yekaterinburg
Shadrinsk
Ozyorsk
Tomsk
©2012 Google
Map data ©2012 GIS Innovatsia

Can contrast shifts spread?

We conclude that there a pattern to these contrastive changes: they follow routes of cultural contact.

Contrast shifts show clear isoglosses and can be borrowed between languages.

It is also important to note that the contrastive analysis of the Ob-Ugric languages presented here is consistent with earlier dialect studies (Steinitz 1955; Honti 1998), and matches earlier observations about which dialects are conservative or innovative.

10.

The contrastive hierarchy and phonetic ‘substance’

Deriving features from activity

Krekoski (2013) constructs contrastive trees for the tone systems of a number of languages that descend from Middle Chinese.

He bases the trees not on the phonetics of the tones, but on the patterns of activity they display in the form of tone sandhi.

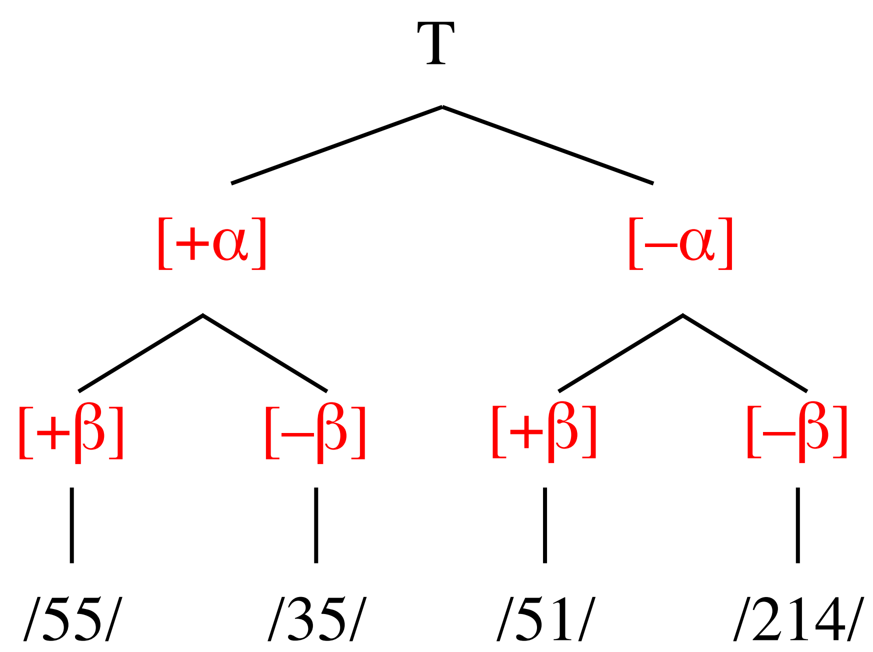
Thus, Beijing Mandarin has the 4 tones shown, which participate in 2 robust sandhi rules:

Beijing Mandarin tones		Beijing Mandarin tone sandhi
/55/	high level	/214/ ⟶ 35/_____/214/
/35/	rising	
/214/	low concave	/35/ ⟶ 55/{/35/, /55/}_____T
/51/	high falling	(T = any tone)

Beijing Mandarin contrastive hierarchy

Krekoski (2013) assumes that, where possible, tones related by a sandhi rule differ minimally, that is by only one feature.

Thus, tone /35/ differs by 1 feature from /214/ and from /55/. Below is a tree satisfying these constraints:



[α] and [β] are placeholders for features which will be given a phonetic interpretation.

Beijing Mandarin tone sandhi

/214/ ⟶ 35/______/214/

/35/ ⟶ 55/{/35/, /55/}______T

(T = any tone)

Pingyao (Jin) tone system

Pingyao is a Jin language with 4 underlying tones. Though two of them have merged at the surface, they can be distinguished by the way they participate in tonal alternations (Chen 2000).

Krekoski identifies 9 tone sandhi rules in Pingyao. Their inputs and outputs are summarized below. I omit alternations that are purely allotonic.

Pingyao tones

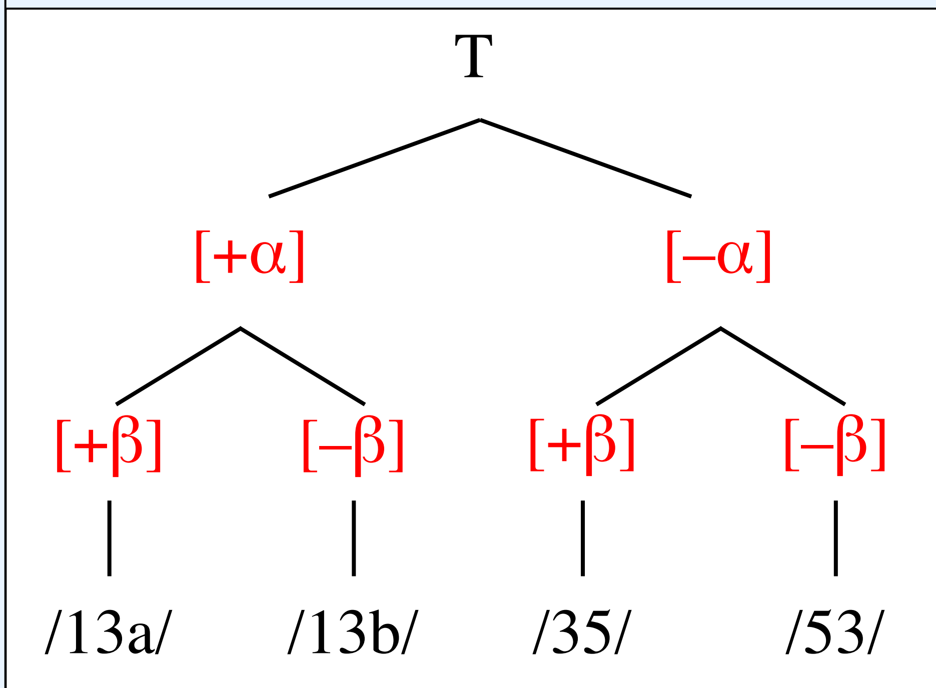
/13a/	low rising
/13b/	low rising
/53/	high falling
/35/	high rising

Pingyao tone sandhi

Input	Outputs
/13a/	35
/35/	13 [= 13a], 53
/53/	35, 13 [= 13b]

Pingyao (Jin) contrastive hierarchy

Following the same procedure as for Beijing, Krekoski arrives at a tree for Pingyao whereby each of the tonal alternations involves a change of only 1 feature.



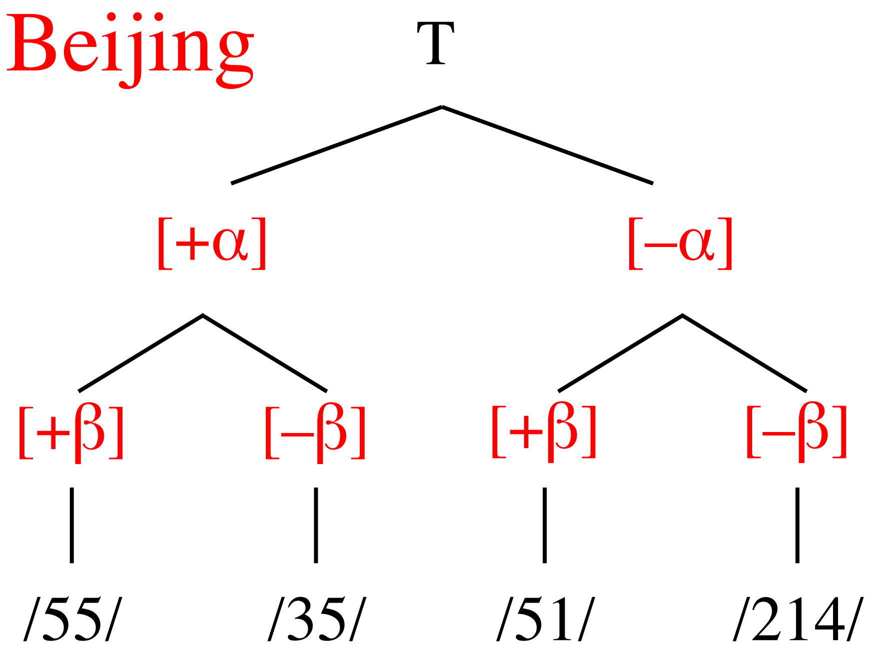
Pingyao tone sandhi

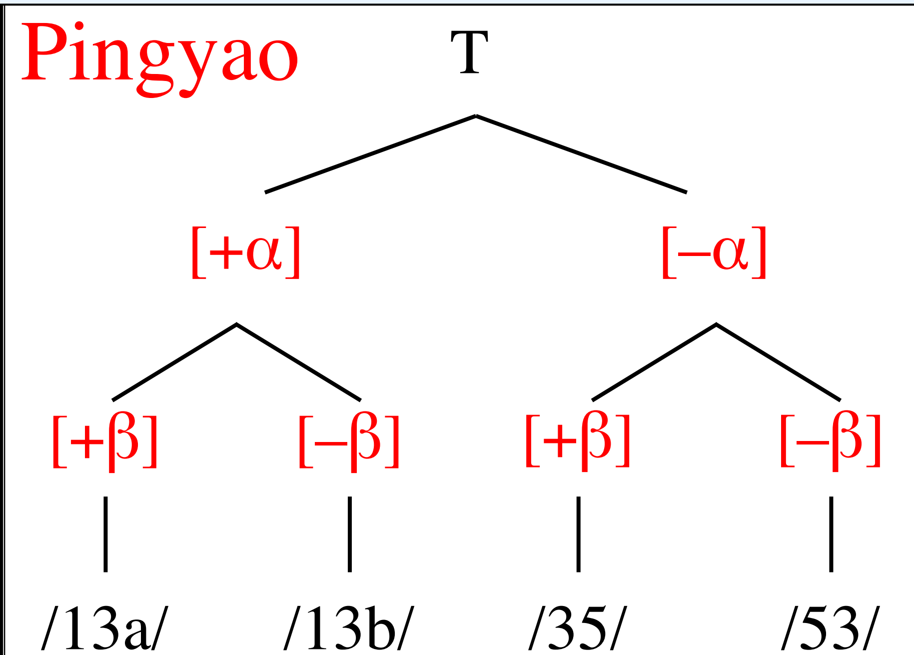
Input	Outputs
/13a/	35
/35/	13 [= 13a], 53
/53/	35, 13 [= 13b]

Beijing and Pingyao cognate tones

Krekoski observes that Beijing and Pingyao tones in corresponding positions in the trees are cognates, and descend from the same Middle Chinese tone.

That is, despite extensive changes in their phonetics, the tones retain the same positions in the contrastive hierarchy.

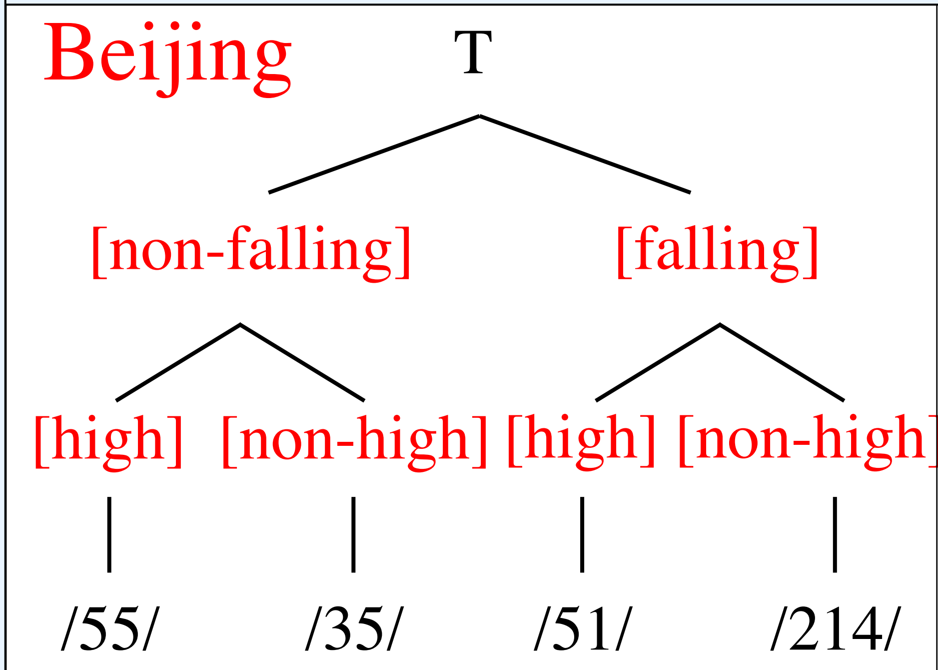


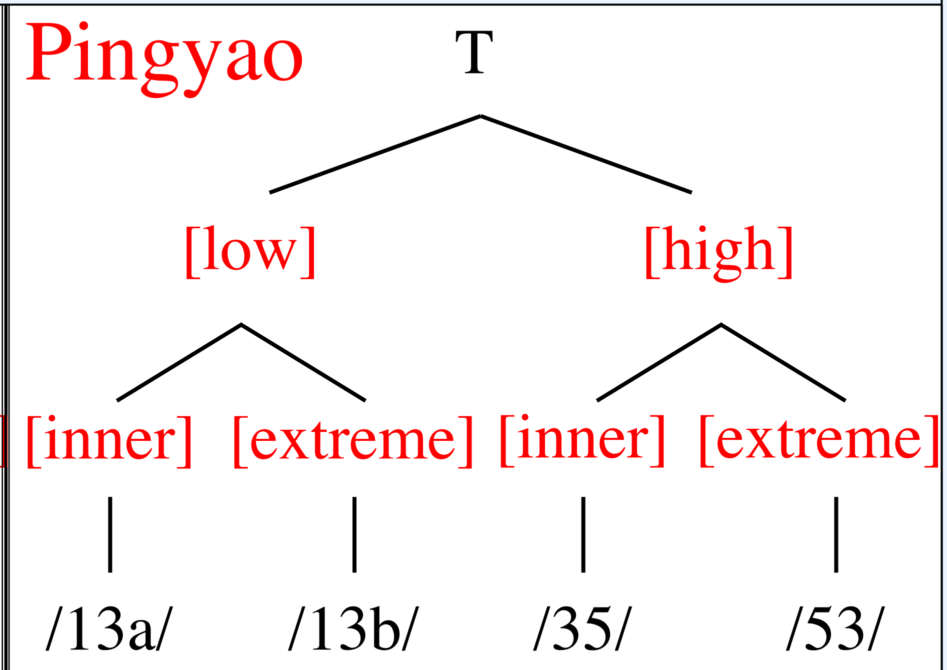


Beijing and Pingyao tone features

Up to here we have not tried to give the features phonetic interpretations; however, features are not purely abstract entities.

Krekoski (2013) suggests correlates for the features; I do not attempt to assign markedness. [extreme] refers to the periphery of a tonal space, [inner] to a more central region of the space.

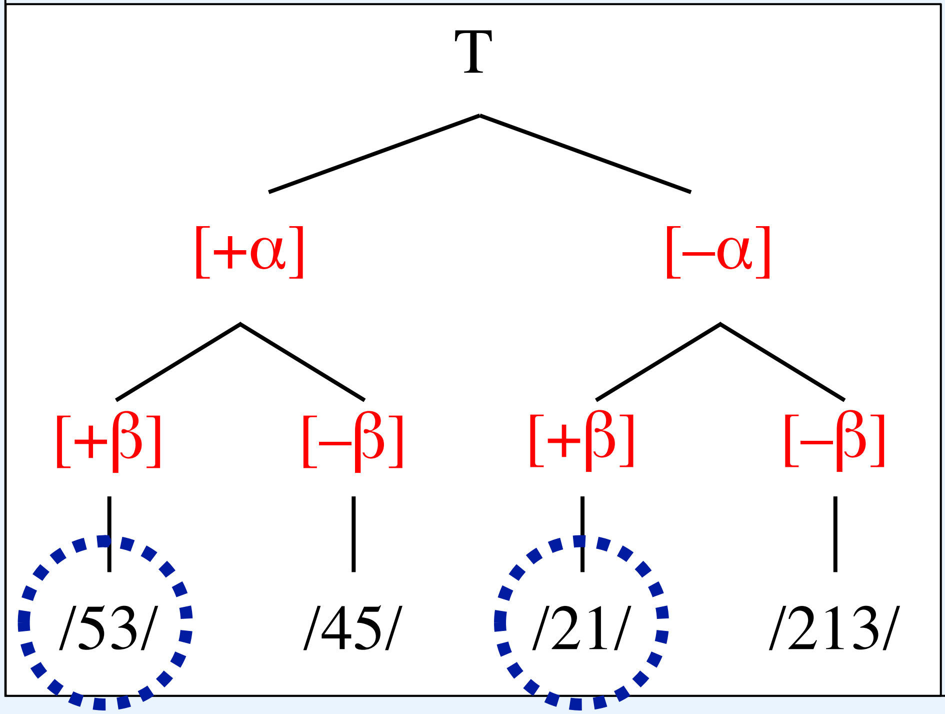




Substance strikes back: Tianjin Mandarin

Following the same methodology, Krekoski posits the tree below for Tianjin Mandarin.

Surprisingly, these tones do not correspond as expected with their cognates in Beijing and Pingyao.

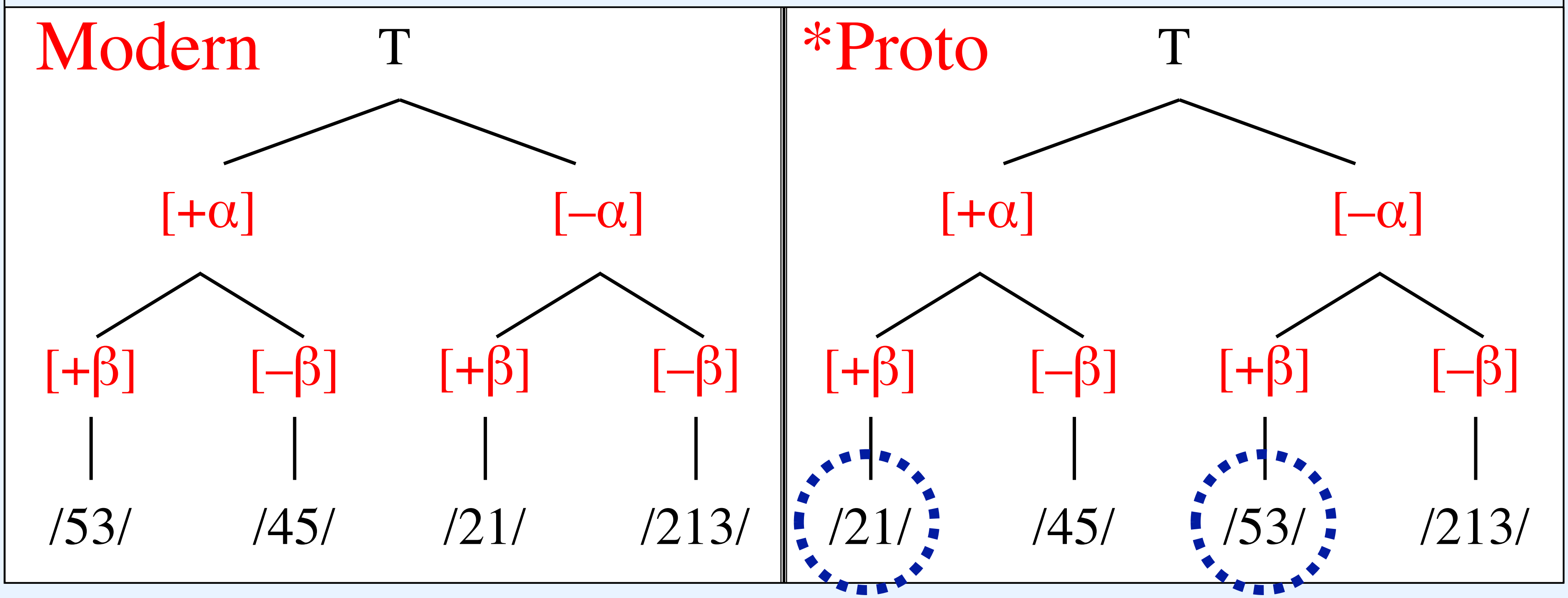


Tones /21/ and /53/ are in the 'wrong place' relative to the other dialects that descend from Middle Chinese.

Substance strikes back: Tianjin Mandarin

Tracing the tones from Middle Chinese, Krekoski proposes that an earlier stage of Tianjin (*Proto-Tianjin) must have had the hierarchy on the right.

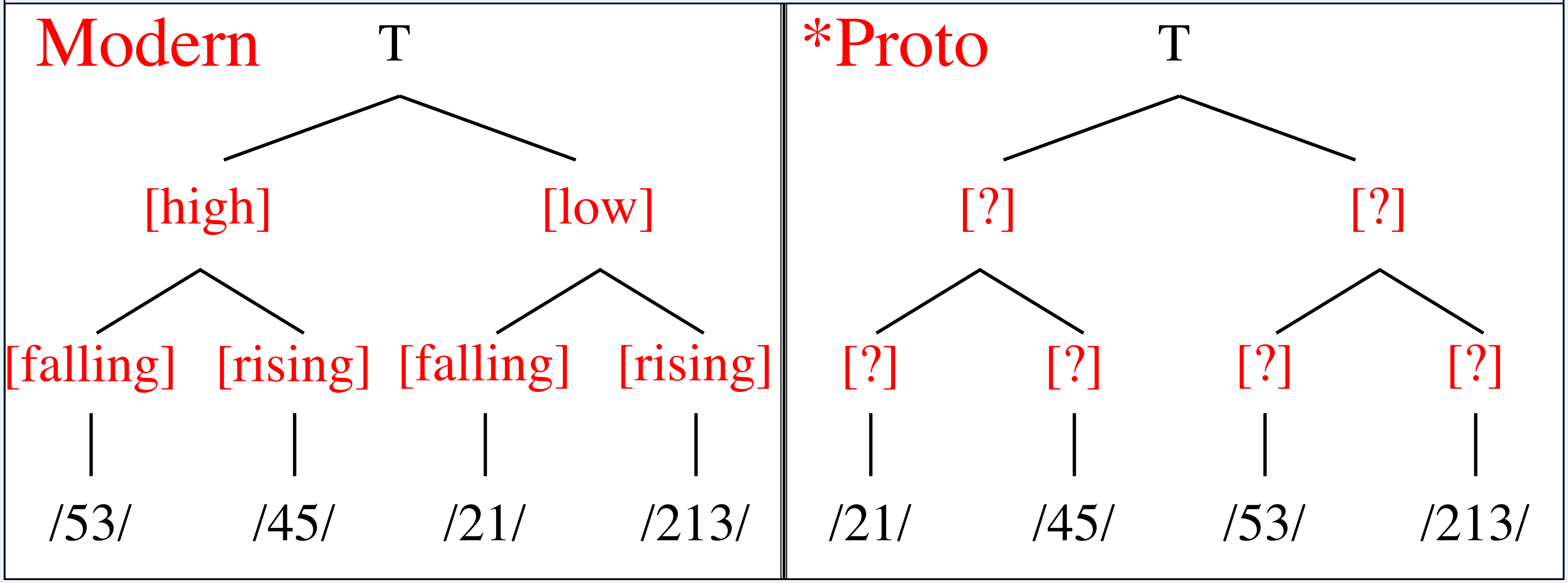
Why did a contrastive shift occur in the history of Tianjin? An answer can be found in the phonetics of the tones.



Substance strikes back: Tianjin Mandarin

Krekoski observes that it is difficult to find plausible phonetic correlates for the features in *Proto-Tianjin; whereas the Modern system clearly groups the tones by height. He proposes that

"Tonal drift likely accreted changes in height values until the system of contrasts reached some critical inflection point which precipitated the reanalysis of specifications."



Substance strikes back: Tianjin Mandarin

What this example illustrates is that features may be suggested by patterns of phonological activity, but that phonetic substance has a say also.

Contrastive trees for tonal features can remain stable even as the phonetic realizations of the tones change; but the feature tree is restructured when it gets too out of sync with the phonetics.

Without such a mechanism, we would expect a much greater proliferation of 'crazy rules' than we actually find.

The hierarchy influences substance

While phonetic substance influences the contrastive feature hierarchy, the influence is not all in this direction.

I argued above that the contrastive hierarchy serves as an organizing principle for synchronic phonology, and influences the direction of diachronic changes, such as mergers.

The conclusion is that influence runs in both directions.

11.

Contrast and OT

Contrast and OT

It has been claimed that contrasts 'emerge' from OT constraint rankings (Itô, Mester & Padgett 1995, Kirchner 1997).

Therefore, no special theory of contrast is necessary.

However, an arbitrary constraint ranking will not express a connection between contrast and phonological activity.

For OT to capture this relation it must incorporate the contrastive hierarchy.

In converting the contrastive hierarchy into an OT constraint set, we must make some assumptions about the output and the input.

The contrastive hierarchy in OT

Output

I will assume that the output of an OT implementation of the contrastive hierarchy is a set of contrastive specifications from which redundant feature specifications are excluded.

Input

I will assume for now that the input consists of fully-specified representations.

The analysis can easily be extended to include underspecified inputs, but we shall not do so here (see Dresher 2009).

The contrastive hierarchy in OT

Constraints

Two basic constraint types are needed to model a contrastive hierarchy:

- IO-IDENT F: 'Correspondent segments must have the same value of the feature F (either + or –)'.

- *[αF, Φ]: 'Exclude αF in the context Φ, where α ranges over + and –, and Φ is the set of features (with wider scope than F) forming the context of F.'

The contrastive hierarchy in OT

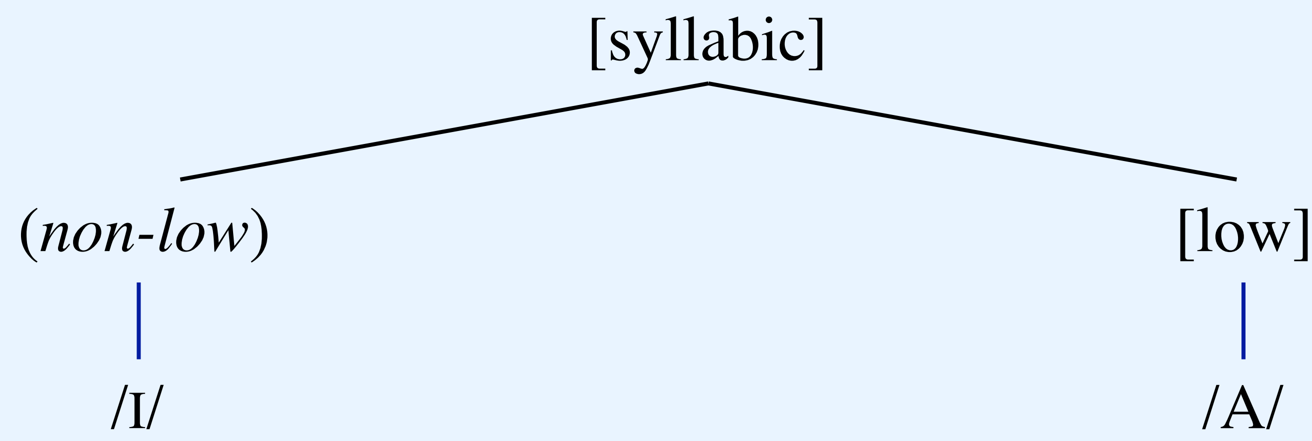
An Example

To illustrate, I will use the Classical Manchu vowel system that was mentioned earlier.

Recall that the feature hierarchy for this language proposed above is:

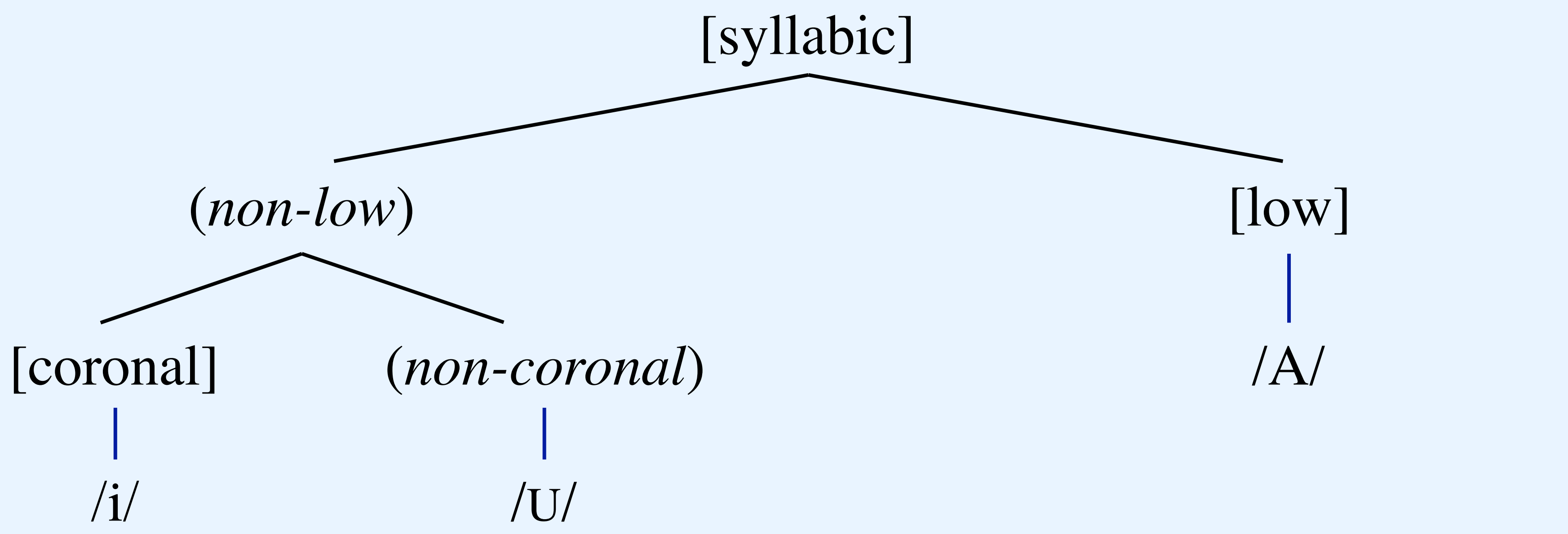
low > coronal > labial > ATR

For simplicity, I will assume features with both + and – values in this section. We can do the same thing with privative features.



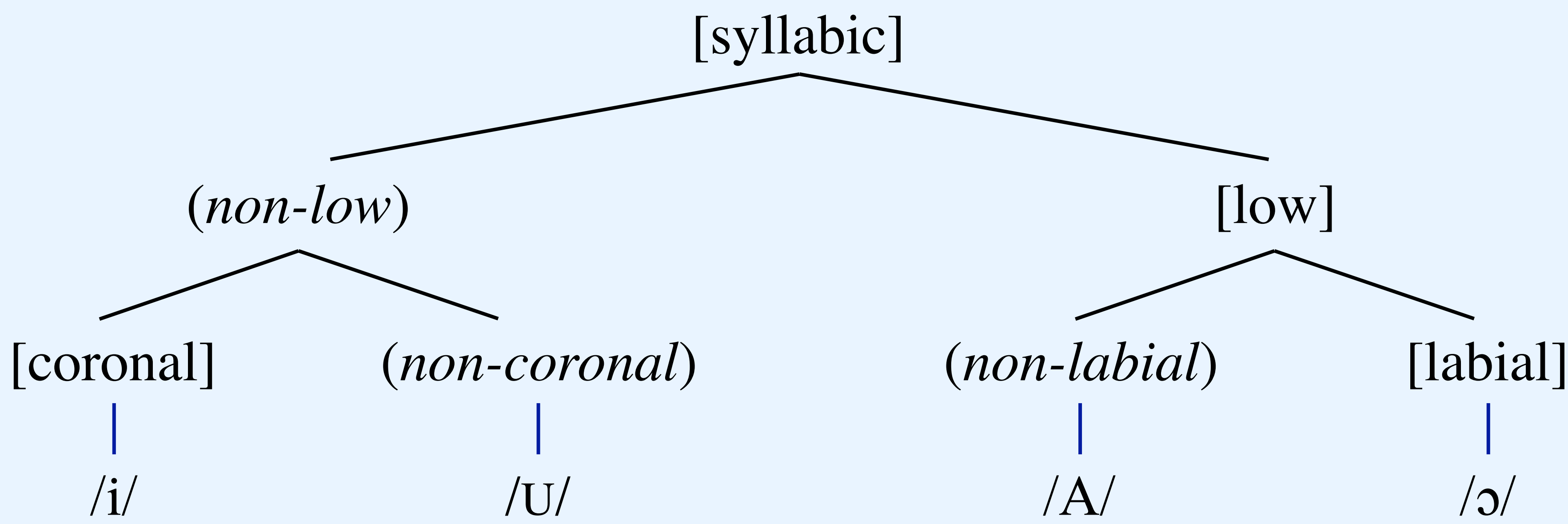
The first feature in the hierarchy is [low]. It has no exclusions.

/–low, +cor, –lab, +ATR/	**Id [low]**								
–low, +cor, –lab, +ATR									
+low, +cor	***! –low**								



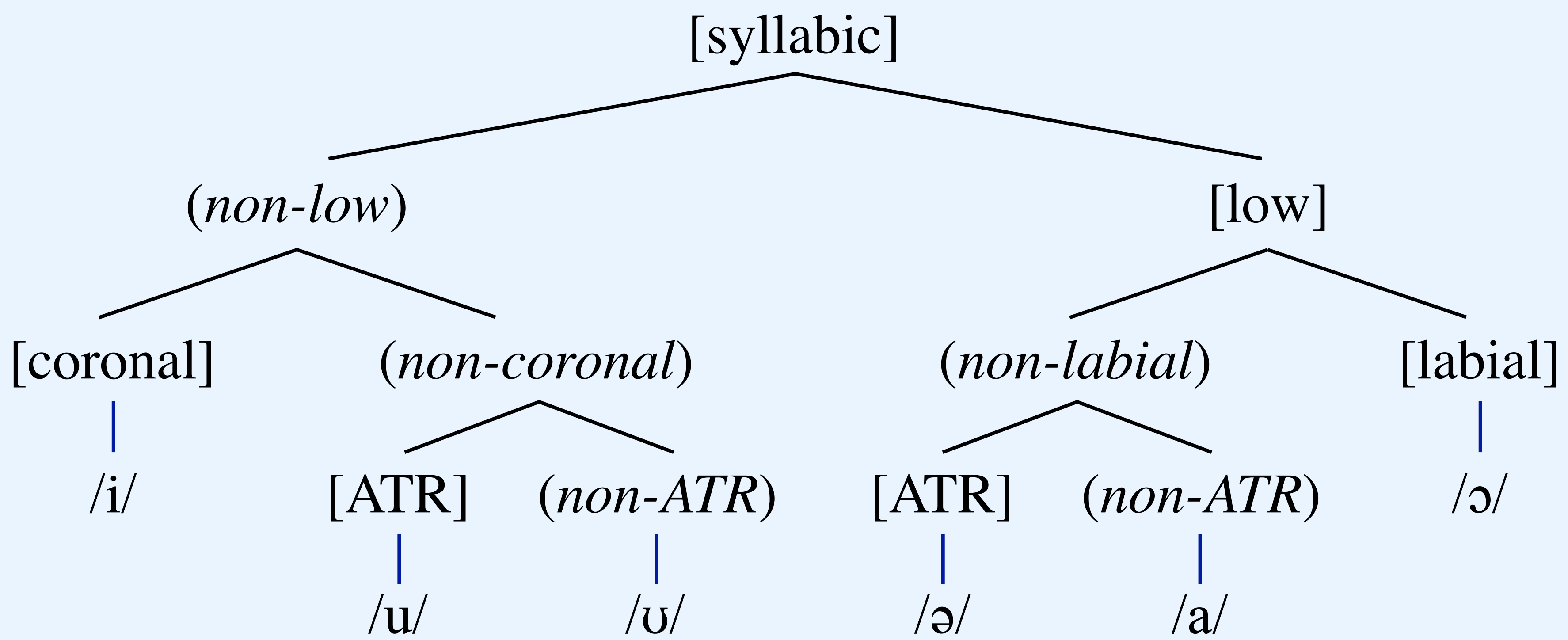
The second feature is [coronal]. It is excluded with [+low]

/–low, +cor, –lab, +ATR/	ID [low]	*[+low cor]	ID [cor]						
–low, +cor, –lab, +ATR									
–low, –cor, +ATR			*! –cor						



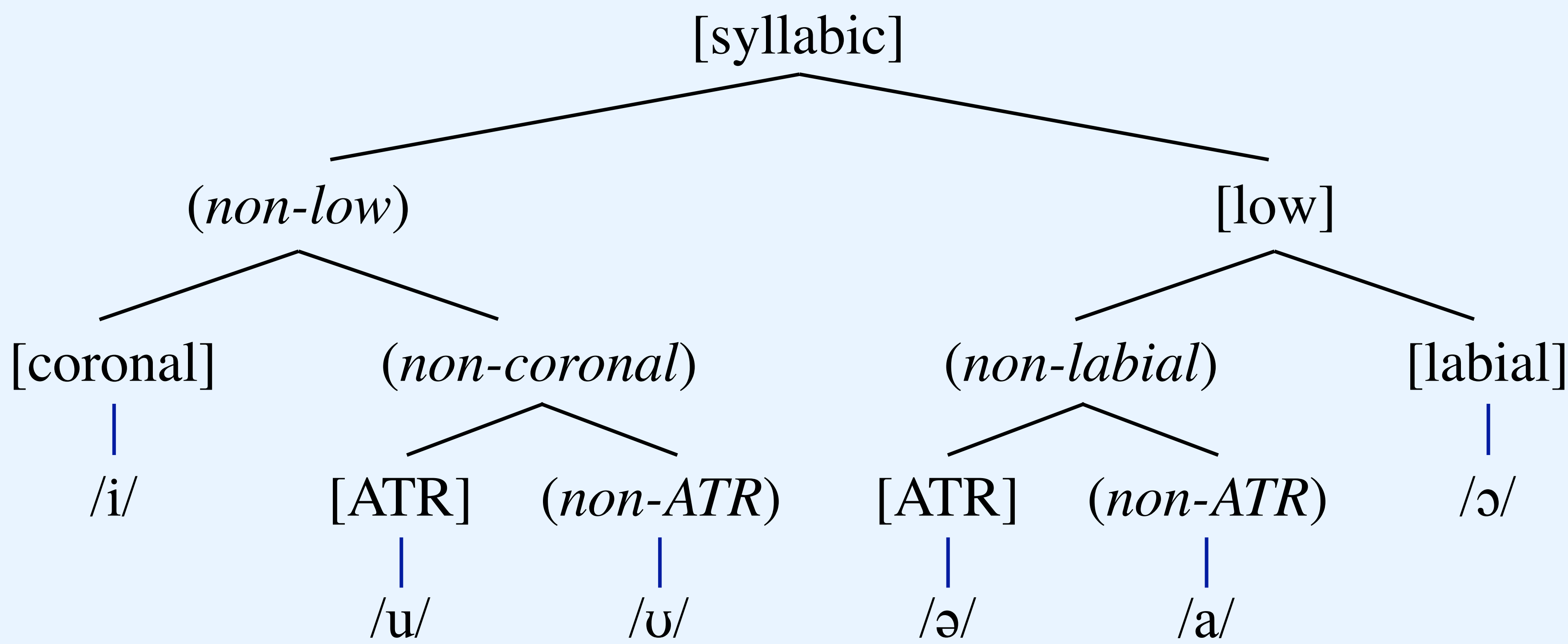
The third feature is [labial]. It is excluded with [–low].

/–low, +cor, –lab, +ATR/	Id [low]	*[+low cor]	Id [cor]	*[–low lab]	Id [lab]				
–low, +cor, –lab, +ATR				*! lab					
–low, +cor, –ATR					*				



The fourth feature is [ATR]. It is excluded with [+cor] and [+lab]

/–low, +cor, –lab, +ATR/	**Id [low]**	***[+low cor]**	**Id [cor]**	***[–low lab]**	**Id [lab]**	***[+cor ATR]**	***[+lab ATR]**	**Id [ATR]**	
–low, +cor, +high					*			*	
–low, +cor, –ATR					*	***! ATR**			



All other features are redundant and are excluded.

/–low, +cor, –lab, +ATR/	**ID [low]**	***[+low cor]**	**ID [cor]**	***[–low lab]**	**ID [lab]**	***[+cor ATR]**	***[+lab ATR]**	**ID ATR]**	***[F]**
–low, +cor, +high					*			*	***! hi**
☞ **–low, +cor**					*			*	

The contrastive hierarchy in OT

General Procedure for Converting a Contrastive Hierarchy to an OT Constraint Hierarchy Given an Ordering of Features

a. Go to the next contrastive feature in the list, Fi. If there are no more contrastive features, go to (e).

b. In the next stratum of constraints, place any co-occurrence constraints of the form *[αFi, Φ], where Φ consists of features ordered higher than Fi.

c. In the next stratum, place the constraint IO-IDENT [Fi].

d. Go to (a).

e. In the next constraint stratum, place the constraint *[F], and end.

The contrastive hierarchy in OT

Every contrastive hierarchy can be converted into a constraint hierarchy by the above procedure.

But the converse does not hold: not every constraint hierarchy can be converted into a contrastive hierarchy.

Limiting constraint hierarchies to those that conform to a well-formed contrastive hierarchy captures the relation between contrast and phonological activity and constrains the class of possible grammars.

For more on the contrastive hierarchy in OT, see papers by Sara Mackenzie in *Lingua (*2011) and especially *Phonology* (2013).

12.

Conclusions

Conclusions

The approach to phonology I have sketched here is based on a fundamental distinction between a phonetic and phonological analysis of the sound systems of languages.

This view builds on approaches to phonology pioneered by Sapir and the Prague School (Jakobson and Trubetzkoy), instantiated within a generative grammar.

More specifically, it views phonemes as being composed of contrastive features that are themselves organized into language-particular hierarchies.

Because of the hypothesized connection between contrast and activity, we expect languages with similar hierarchies and inventories to exhibit similar patterns.

Conclusions

In some of the language families I have surveyed here, feature hierarchies appear to be relatively stable, as exemplified by the vowel systems of Manchu-Tungusic, Eastern Mongolian, Yupik-Inuit, and branches of Algonquin, and the tonal systems of the Chinese dialects reviewed here.

Contrast shifts can occur, however, for various reasons, and these can result in dramatic differences in patterning, as shown by the modern Manchu languages, Central Algonquin as compared with Eastern and Western, and extensive changes in Ob-Ugric vowel systems (over a long period of time).

Conclusions

Ob-Ugric shows that elements of feature hierarchies can spread and be borrowed, like other aspects of linguistic structure.

The Tianjin Mandarin tone system shows that there is a limit to how far the phonetics can get out of sync with the feature hierarchy before something has to give.

I have also briefly discussed Spahr's (2014) proposal that the intermediate nodes of a contrastive feature tree can also receive phonetic interpretations, as in the case of neutralizing vowel reduction.

Phonology and phonetic substance

The approach presented here shares with 'substance-free' theories the idea that features are emergent (Hale & Reiss 2000a, b, 2008; Morén 2003, 2006, 2007; Odden 2006; Blaho 2008; Samuels 2011, 2012; Iosad 2012; see Hall 2014 for discussion).

Some of these theories go too far, in my view, in shifting the explanation for phonological patterning to external factors.

In this way they resemble phonetics-driven approaches to phonology that they otherwise oppose (e.g., Boersma 1998; Pierrehumbert, Beckman & Ladd 2000; Hayes, Kirchner & Steriade 2004; Steriade 2009).

Phonology and phonetic substance

In his review of Samuels (2011), Hall (2012: 738) comments:

> "the substance-free and the substance-based views are alike in that they both posit functional phonetic explanations for substantive phonological patterns… the two lines of thought, in their different ways, both turn away from the practice of constructing formal explanations for substantive patterns."

The contrastive feature hierarchy restores the balance between functional and formal explanations, to the extent that it serves as a formal organizing principle of the phonology.

Phonology and the Faculty of Language

Finally, it has been suggested that only syntactic recursion is part of the narrow faculty of language (FLN; Hauser, Chomsky & Fitch 2002), and that phonology is outside FLN.

However, the contrastive hierarchy has a recursive digital character, like other aspects of FLN.

Like syntax, phonology takes substance from outside FLN and converts it to objects that can be manipulated by the linguistic computational system.

The parallels between phonology and syntax may go even further, if it turns out that syntax, too, is in the business of creating contrastive hierarchies of morphosyntactic features (Cowper & Hall 2013).

Readings

For a detailed review of early work in the MCS framework, see Dresher (2009) and the references therein. The readings below and on the next slide are a sampling of more recent publications; see the References for full citations. Please see http://homes.chass.utoronto.ca/~dresher/publications.html for my recent papers and talks.

Dresher, B. Elan. 2009. *The contrastive hierarchy in phonology*.

Dresher, B. Elan. 2014. The arch not the stones: Universal feature theory without universal features. *Nordlyd*.

Dresher, B. Elan. 2015. The motivation for contrastive feature hierarchies in phonology. *Linguistic Variation*.

Dresher, B. Elan. 2016. Contrast in phonology 1867–1967: History and development. *Annual Review of Linguistics* 2.

Dresher, B. Elan, Christopher Harvey & Will Oxford. 2014. Contrast shift as a type of diachronic change. *NELS 43 Proceedings*.

Readings (continued)

Hall, Daniel Currie. 2011a. Contrast. In *The Blackwell Companion to Phonology*.

Hall, Daniel Currie. 2011b. Phonological contrast and its phonetic enhancement: Dispersedness without dispersion. *Phonology*.

Hall, Daniel Currie. 2013. Redundant features in a contrast-based approach to phonology. In *Proceedings of the 2012 Annual Conference of the CLA*.

Ko, Seongyeon. 2012. Tongue root harmony and vowel contrast in Northeast Asian languages. Doctoral dissertation, Cornell University.

Mackenzie, Sara. 2011. Contrast and the evaluation of similarity: Evidence from consonant harmony. *Lingua*.

Mackenzie, Sara. 2013. Laryngeal co-occurrence restrictions in Aymara: Contrastive representations and constraint interaction. *Phonology*.

Oxford, Will. 2015. Patterns of contrast in phonological change: Evidence from Algonquian vowel systems. *Language*.

Spahr, Christopher. 2014. A contrastive hierarchical account of positional neutralization. *The Linguistic Review*.

THANK YOU!

For discussions, ideas, and analyses I would like to thank Elizabeth Cowper, Daniel Currie Hall, Paula Fikkert, Ross Godfrey, Christopher Harvey, Ross Krekoski, Will Oxford, Keren Rice, Christopher Spahr, and Zhang Xi, and other members of the project on *Markedness and the Contrastive Hierarchy in Phonology* at the University of Toronto (Dresher and Rice 2007):

http://homes.chass.utoronto.ca/~contrast/

References

Angoujard, Jean-Pierre. 1997. *Théorie de la syllabe. Rythme et qualité*. Paris: CNRS Éditions.

Archangeli, Diana. 1988. Aspects of underspecification theory. *Phonology* 5: 183–207.

Backley, Phillip. 2011. *An introduction to Element Theory*. Edinburgh: EUP.

Barnes, Jonathan. 2006. *Strength and weakness at the interface: Positional neutralization in phonetics and phonology*. Berlin & New York: Mouton de Gruyter.

Barrie, Mike. 2003. Contrast in Cantonese vowels. *Toronto Working Papers in Linguistics* 20: 1–19.

Blaho, Sylvia. 2008. The syntax of phonology: A radically substance-free approach. Doctoral dissertation, University of Tromsø.

Boersma, Paul. 1998. *Functional phonology: Formalizing the interactions between articulatory and perceptual drives*. The Hague: Holland Academic Graphics.

Calabrese, Andrea. 2005. *Markedness and economy in a derivational model of phonology*. Berlin: Mouton de Gruyter.

Campos Astorkiza, Judit Rebeka. 2007. Minimal contrast and the phonology – phonetics interaction. Doctoral dissertation, University of Southern California.

Carvalho, Joaquim Brandão de. 2011. Contrastive hierarchies, privative features, and Portuguese vowels. *Linguística : Revista de Estudos Linguísticos da Universidade do Porto* 6: 51–66.

Chen, Matthew. 2000. *Tone sandhi*. Cambridge: CUP.

Chomsky, Noam. 1964. *Current issues in linguistic theory*. The Hague: Mouton.

Chomsky, Noam & Morris Halle. 1968. *The sound pattern of English.* New York: Harper & Row. Chomsky, Noam & Morris Halle. 1968. *The sound pattern of English.* New York: Harper & Row.

Clements, G. N. 2001. Representational economy in constraint-based phonology. In T. Alan Hall (ed.), *Distinctive feature theory*, 71–146. Berlin: Mouton de Gruyter.

Clements, G. N. & Rachid Ridouane (eds.). 2011. *Where do features come from? Cognitive, physical and developmental bases of distinctive speech categories*. Amsterdam: John Benjamins.

Compton, Richard & B. Elan Dresher. 2011. Palatalization and 'strong' *i* across Inuit dialects. *Canadian Journal of Linguistics/Revue canadienne de linguistique* 56: 203–228.

Cowper, Elizabeth & Daniel Currie Hall. 2013. Reductiō ad discrīmen: Where features come from. Presented at the Conference on Features in Phonology, Morphology, Syntax, and Semantics, University of Tromsø, October 2013.

Crosswhite, Katherine M. 2001. *Vowel reduction in Optimality Theory*. New York: Routledge.

Davidsen-Nielsen, Niels. 1978. *Neutralization and the archiphoneme: Two phonological concepts and their history*. Copenhagen: Akademisk Forlag.
Dorais, Louis-Jacques. 2003. *Inuit uqausiqatigiit: Inuit languages and dialects (second, revised edition)*. Iqaluit: Nunavut Arctic College.
Dresher, B. Elan. 1998. On contrast and redundancy. Paper presented at the annual meeting of the Canadian Linguistic Association, Ottawa, May 1998.
Dresher, B. Elan. 2003. Contrast and asymmetries in inventories. In Anna-Maria di Sciullo (ed.), *Asymmetry in grammar, volume 2: Morphology, phonology, acquisition*, 239–57. Amsterdam: John Benjamins.
Dresher, B. Elan. 2009. *The contrastive hierarchy in phonology*. Cambridge: CUP.
Dresher, B. Elan. 2014. The arch not the stones: Universal feature theory without universal features. *Nordlyd* 41.2: 165–181, special issue on Features ed. by Martin Krämer, Sandra Ronai and Peter Svenonius. University of Tromsø — The Arctic University of Norway.
Dresher, B. Elan. 2015. The motivation for contrastive feature hierarchies in phonology. *Linguistic Variation* 15: 1–40.
Dresher, B. Elan. 2016. Contrast in phonology 1867–1967: History and development. *Annual Review of Linguistics* 2. Review in Advance first posted online on September 25, 2015. (Changes may still occur before final publication online and in print.) http://www.annualreviews.org/doi/abs/ 10.1146/annurev-linguistics-011415-040800.

Dresher, B. Elan, Christopher Harvey & Will Oxford. 2014. Contrast shift as a type of diachronic change. In Hsin-Lun Huang, Ethan Poole & Amanda Rysling (eds.), *NELS 43: Proceedings of the Forty-Third Annual Meeting of the North East Linguistic Society, The City University of New York, Volume One*, 103–116. Amherst, MA: GLSA.

Dresher, B. Elan & Keren Rice. 2007. Markedness and the contrastive hierarchy in phonology. http://homes.chass. utoronto.ca/~contrast/.

Dresher, B. Elan & Xi Zhang. 2005. Contrast and phonological activity in Manchu vowel systems. *Canadian Journal of Linguistics/Revue canadienne de linguistique* 50: 45–82.

Flemming, Edward S. 2002. *Auditory representations in phonology*. London: Routledge.

Gardner, Matt Hunt. 2012. Beyond the phonological void: Contrast and the Canadian Shift. Ms., Department of Linguistics, University of Toronto.

Godfrey, Ross. 2012. Opaque intervention in Khalkha Mongolian vowel harmony: A contrastive account. *McGill Working Papers in Linguistics* 23. 14 pages. Published online at http://www.mcgill.ca/mcgwpl/files/mcgwpl/godfrey2012_0.pdf.

Hale, Mark & Charles Reiss. 2000a. "Substance abuse" and "dysfunctionalism": Current trends in phonology. *Linguistic Inquiry* 31: 157–169.

Hale, Mark & Charles Reiss. 2000b. Phonological theory without substance. In Noel Burton-Roberts, Philip Carr & Gerard Docherty (eds.), *Phonological knowledge: Conceptual and empirical foundations*, 161–184. Oxford: OUP.

Hale, Mark & Charles Reiss. 2008. *The phonological enterprise*. Oxford: OUP.

Hall, Daniel Currie. 2007. The role and representation of contrast in phonological theory. Doctoral dissertation, University of Toronto.

Hall, Daniel Currie. 2011a. Contrast. In *The Blackwell Companion to Phonology*, edited by Marc van Oostendorp, Colin J. Ewen, Elizabeth Hume & Keren Rice, volume 1, chapter 2, 27–53. Oxford: Wiley Blackwell.

Hall, Daniel Currie. 2011b. Phonological contrast and its phonetic enhancement: Dispersedness without dispersion. *Phonology* 28: 1–54.

Hall, Daniel Currie. 2012. Review of Bridget D. Samuels, *Phonological architecture : A biolinguistic perspective*. *Journal of Linguistics* 48. 736–741.

Hall, Daniel Currie. 2013. Redundant features in a contrast-based approach to phonology. In *Proceedings of the 2012 Annual Conference of the Canadian Linguistic Association*, edited by Paula Caxaj, 11 pp. Toronto: Canadian Linguistic Association. Published online at http://cla-acl.ca/?p=909.

Hall, Daniel Currie. 2014. On substance in phonology. *Proceedings of the 2014 annual conference of the Canadian Linguistic Association*. 14 pages. http://cla-acl.ca/wp-content/uploads/Hall-2014.pdf.

Halle, Morris. 1959. *The sound pattern of Russian: A linguistic and acoustical investigation*. The Hague: Mouton. Second printing, 1971.

Harvey, Christopher. 2012. Contrastive shift in Ob-Ugric Vowel systems. Ms., Department of Linguistics, University of Toronto.

Hauser, Marc D., Noam Chomsky & W. Tecumseh Fitch. 2002. The faculty of language: What is it, who has it, and how did it evolve? *Science* 298. 1569–1579.

Hayes, Bruce, Robert Kirchner & Donca Steriade (eds.). 2004. *Phonetically based phonology*. Cambridge: CUP.

Honti, László. 1998. Ob Ugrian. In *The Uralic languages*, ed. by Daniel Abondolo, 327–357. London: Routledge.

Hulst, Harry van der. 1993. Units in the analysis of signs. *Phonology* 10: 209–241.

Hulst, Harry van der. 1995. Radical CV phonology: the categorial gesture. In Jacques Durand & Francis Katamba (eds.), *Frontiers of phonology*, 80–116. Essex: Longman.

Hulst, Harry van der. 1996. Radical CV phonology: the segment–syllable connection. In Jacques Durand & Bernard Laks (eds.), *Current trends in phonology: Models and methods*, 333–61. Salford: European Studies Research Institute (ESRI).

Hulst, Harry van der. 2005. The molecular structure of phonological segments. In Philip Carr, Jacques Durand & Colin J. Ewen (eds.), *Headhood, elements, specification and contrastivity: Phonological papers in honour of John Anderson*, 193–234. Amsterdam: John Benjamins.

Hulst, Harry van der. 2014. Minimal vowel representations in Radical cv Phonology. Chapter of a book on vowel harmony in progress. Ms., Department of Linguistics, University of Connecticut.

Hulst, Harry van der & Beata Moskal. 2013. Patterns of defective labial vowel harmony in Turkic languages. *Dilbilim Araştırmaları Dergisi* 2013/1: 17–52.

Hyman, Larry M. 2010. Do tones have features? In John A. Goldsmith, Elizabeth Hume & W. Leo Wetzels (eds.), *Tones and features*, 50–80. Berlin: Mouton De Gruyter.

Iosad, Pavel. 2012. Representation and variation in substance-free phonology: A case study in Celtic. Doctoral dissertation, University of Tromsø.

Itô, Junko, Armin Mester & Jaye Padgett. 1995. Licensing and underspecification in Optimality Theory. *Linguistic Inquiry* 26: 571–613.

Jakobson, Roman. 1931. Prinzipien der historischen Phonologie. *TCLP* 4: 247–267 (Copenhagen). English translation in *A reader in historical and comparative linguistics*, ed. by Allan R. Keiler, 121–138. New York: Holt, Rinehart and Winston, 1972.

Jakobson, Roman, C. Gunnar M. Fant & Morris Halle. 1952. *Preliminaries to Speech Analysis.* MIT Acoustics Laboratory, Technical Report, No. 13. Reissued by MIT Press, Cambridge, Mass., Eleventh Printing, 1976.

Jakobson, Roman & Morris Halle. 1956. *Fundamentals of Language.* The Hague: Mouton.

Kaye, Jonathan, Jean Lowenstamm & Jean-Roger Vergnaud (KLV). 1985. The internal structure of phonological elements: A theory of charm and government. *Phonology Yearbook* 2: 305–28.

Kaun, Abigail Rhoades. 1995. The typology of rounding harmony: An Optimality Theoretic approach. Doctoral dissertation, University of California, Los Angeles.

Kiparsky, Paul. 1965. Phonological change. Doctoral dissertation, MIT.

Kirchner, Robert. 1997. Contrastiveness and faithfulness. *Phonology* 14: 83–111.

Ko, Seongyeon. 2010. *A contrastivist view on the evolution of the Korean vowel system. Proceedings of the Sixth Workshop on Altaic Formal Linguistics (WAFL 6)*. *MIT Working Papers in Linguistics* 61: 181-196.

Ko, Seongyeon. 2011. Vowel contrast and vowel harmony shift in the Mongolic languages. *Proceedings of the Seventh Workshop on Altaic Formal Linguistics (WAFL 7)*. *MIT Working Papers in Linguistics* 62: 187–202.

Ko, Seongyeon. 2012. Tongue root harmony and vowel contrast in Northeast Asian languages. Doctoral dissertation, Cornell University.

Korn, David (1969). Types of labial vowel harmony in the Turkic languages. *Anthropological Linguistics* 11: 98–106.

Krekoski, Ross. 2013. On tone and the nature of features. Ms., Department of Linguistics, University of Toronto.

Li, Bing. 1996. *Tungusic vowel harmony*. The Hague: Holland Academic Graphics.

Liljencrants, Johan & Björn Lindblom. 1972. Numerical simulation of vowel quality systems: The role of perceptual contrast. *Language* 48. 839–862.
Lindblom, Björn. 1986. Phonetic universals in vowel systems. In John J. Ohala & Jeri J. Jaeger (eds.), *Experimental phonology*, 13–44. New York: Academic Press.
Lloret, Maria-Rosa. 2008. On the nature of vowel harmony: Spreading with a purpose. In Antonietta Bisetto and Francesco E. Barbieri (eds.), *Proceedings of the XXXIII Incontro di Grammatica Generativa*, 15–35. Bologna: University of Bologna.
Mackenzie, Sara. 2011. Contrast and the evaluation of similarity: Evidence from consonant harmony. *Lingua* 121: 1401–1423.
Mackenzie, Sara. 2013. Laryngeal co-occurrence restrictions in Aymara: Contrastive representations and constraint interaction. *Phonology* 30: 297–235.
McCawley, James D. 1967. Sapir's phonologic representation. *International Journal of American Linguistics* 33: 106–111.
Mesgarani, Nima, Stephen V. David, Jonathan B. Fritz & Shihab A. Shamma. 2008. Phoneme representation and classification in primary auditory cortex. *Journal of the Acoustical Society of America* 123. 899–909.
Mielke, Jeff. 2008. *The emergence of distinctive features*. Oxford: OUP.
Morén, Bruce. 2003. The Parallel Structures Model of feature geometry. *Working Papers of the Cornell Phonetics Laboratory* 15: 194–270. Ithaca, NY.

Morén, Bruce. 2006. Consonant-vowel interactions in Serbian: Features, representations and constraint interactions. *Lingua* 116: 1198–1244.
Morén, Bruce. 2007. Minimalist/substance-free feature theory: Why and how. Ms., Center for Advanced Study in Theoretical Linguistics, University of Tromsø.
Moskal, Beata. 2012. An elementary approach to labial harmony in Turkic languages. *Proceedings of the 2012 Northwest Linguistics Conference*. *University of Washington Working Papers* 29. 17 pages. Published online at http://depts.washington.edu/uwwpl/editions/vol29.html.
Moskal, Beata. 2013. It is elementary my dear Watson!—Labial harmony in Turkic and Tungusic languages. *Proceedings of the 8th Workshop on Altaic Linguistics (WAFL8)*. *MIT Working Papers in Linguistics* 67: 245–256.
Moulton, William G. 1960. The short vowel systems of Northern Switzerland: A study in structural dialectology. *Word* 16: 155–182.
Nevins, Andrew. 2010. *Locality in vowel harmony*. Cambridge, MA: MIT Press.
Newman, Stanley (1944). *Yokuts language of California* (VFPA 2). New York: The Viking Fund Publications in Anthropology.
Odden, David. 2006. Phonology ex nihilo. Presented at the Phonology Get-Together, Universitetet i Tromsø, December 2006. Handout available online at http://www.ling.ohio-state.edu/~odden/Phonology_ex_Nihilo.pdf.

Oxford, Will. 2012. ‘Contrast shift’ in the Algonquian languages. *Proceedings from the Montreal-Ottawa-Toronto (MOT) Phonology Workshop 2011: Phonology in the 21st Century: In Honour of Glyne Piggott. McGill Working Papers in Linguistics* 22.1. 9 pages. Published online at http://www.mcgill.ca/mcgwpl/files/mcgwpl/oxford2012_0.pdf.

Oxford, Will. 2015. Patterns of contrast in phonological change: Evidence from Algonquian vowel systems. *Language* 91: 308–357.

Padgett, Jaye. 2003. Contrast and post-velar fronting in Russian. *Natural Language and Linguistic Theory* 21: 39–87.

Pierrehumbert, Janet, Mary E. Beckman & D. R. Ladd. 2000. Conceptual foundations of phonology as a laboratory science. In Noel Burton-Roberts, Philip Carr & Gerard Docherty (eds.), *Phonological knowledge: Conceptual and empirical issues*, 273–303. Oxford: OUP.

Purnell, Thomas & Eric Raimy. 2013. Contrastive features in phonetic implementation: The English vowel system. Presented at the CUNY Phonology Forum Conference On The Feature, January 2013.

Qinggertai (Chingeltei). 1982. Guanyu Yuanyin Hexielü [On the Vowel Harmony Rule]. *Zhongguo Yuyanxue Bao* 1: 200–220.

Rice, Keren. 2003. Featural markedness in phonology: Variation. In *The second Glot International state-of-the-article book: The latest in linguistics*, ed. by Lisa Cheng & Rint Sybesma, 387–427. Berlin: Mouton de Gruyter.

Rice, Keren. 2007. Markedness in phonology. In *The Cambridge handbook of phonology*, ed. by Paul de Lacy, 79–97. Cambridge: CUP.

Roeder, Rebecca V. & Matt Hunt Gardner. 2013. The phonology of the Canadian Shift revisited: Thunder Bay and Cape Breton. *University of Pennsylvania Working Papers in Linguistics (Selected Papers from NWAV 41)* 19.2: 161–170.

Rohany Rahbar, Elham. 2008. A historical study of the Persian vowel system. *Kansas Working Papers in Linguistics* 30: 233–245. Samuels, Bridget D. 2011. *Phonological architecture : A biolinguistic perspective*. Oxford: OUP.

Sammallahti, Pekka. 1988. Historical phonology of the Uralic languages. In *Handbuch der Orientalistik: Handbook of Uralic studies, vol 1. The Uralic languages*, ed. by Denis Sinor, 478–554. Leiden: E. J. Brill.

Samuels, Bridget D. 2011. *Phonological architecture : A biolinguistic perspective*. Oxford: OUP.

Samuels, Bridget. D. 2012. The emergence of phonological forms. In Anna Maria Di Sciullo (ed.), *Towards a biolinguistic understanding of grammar: Essays on interfaces*, 193–213. Amsterdam: John Benjamins.

Sandler, Wendy. 1993. Sign language and modularity. *Lingua* 89: 315–351.

Sapir, Edward. 1925. Sound patterns in language. *Language* 1: 37-51.

Saussure, Ferdinand de. 1972 [1916]. *Cours de linguistique générale. Publié par Charles Bally et Albert Sechehaye; avec la collaboration de Albert Riedlinger. Éd. critique préparée par Tullio de Mauro*. Paris: Payot.

Scatton, Ernest A. 1984. *A reference grammar of modern Bulgarian*. Columbus, OH: Slavica Publishers, Inc.

Schane, Sanford A. 1984. The fundamentals of particle phonology. *Phonology Yearbook* 1: 129–55.

Scheer, Tobias. 1999. A theory of consonantal interaction. *Folia Linguistica* 32: 201–37.

Spahr, Christopher. 2014. A contrastive hierarchical account of positional neutralization. *The Linguistic Review* 31: 551–585.

Steinitz, Wolfgang. 1955. *Geschichte des wogulischen Vokalismus*. Berlin: Akademie-Verlag.

Steriade, Donca. 2009. The phonology of perceptibility effects: The P-map and its consequences for constraint organization. In Kristin Hanson & Sharon Inkelas (eds.), *The nature of the word: Studies in honor of Paul Kiparsky*, 151–179. Cambridge, MA: MIT Press.

Stevens, Kenneth N., Samuel Jay Keyser & Haruko Kawasaki. 1986. Toward a phonetic and phonological theory of redundant features. In Joseph S. Perkell & Dennis H. Klatt (eds.), *Symposium on invariance and variability of speech processes*, 432–469. Hillsdale, NJ: Lawrence Erlbaum.

Svantesson, Jan-Olaf. 1985. Vowel harmony shift in Mongolian. *Lingua* 67: 283–327.

Trubetzkoy, N. S. 1939. *Grundzüge der Phonologie*. Göttingen:Vandenhoek & Ruprecht.

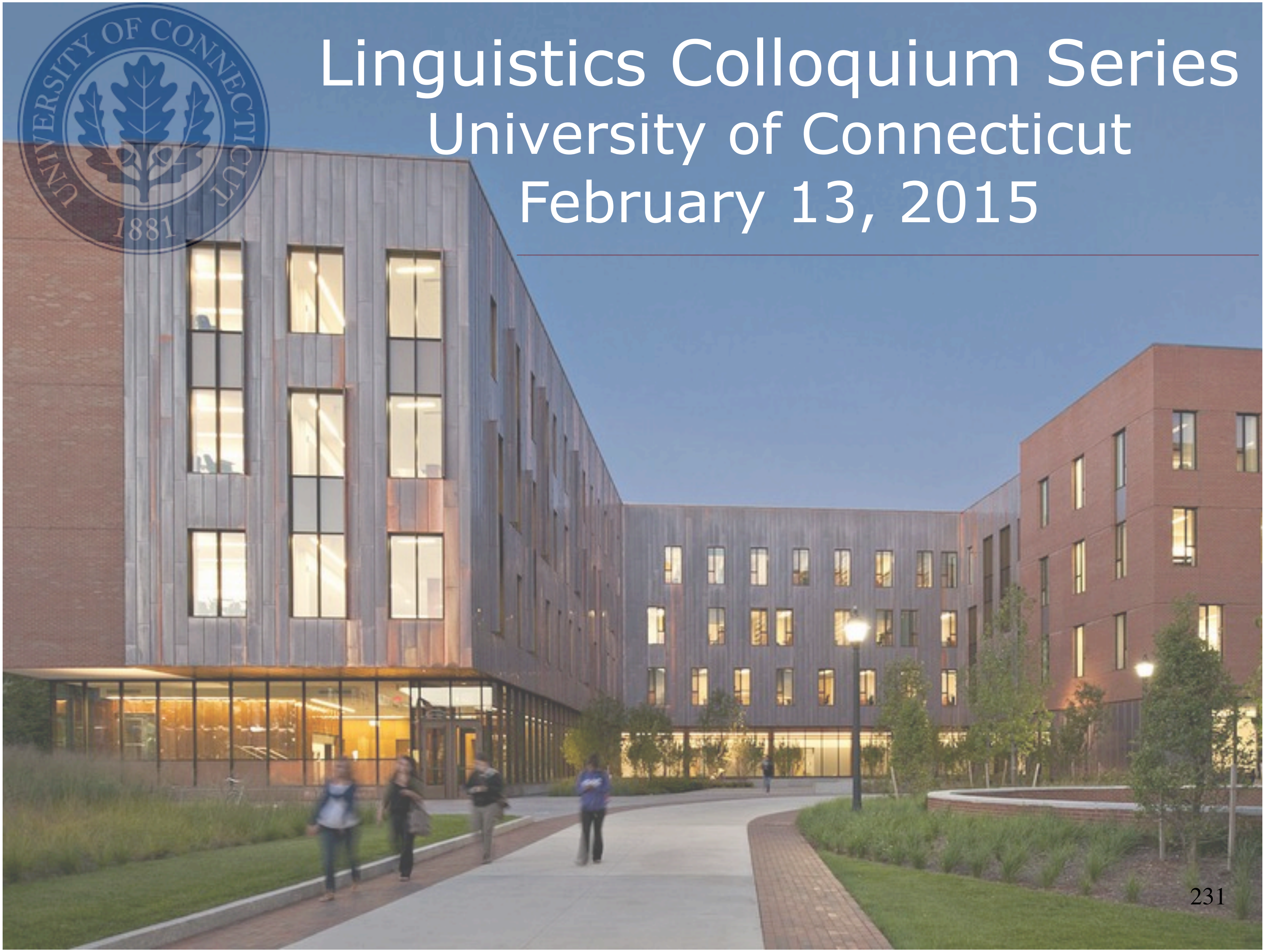
Voeltzel, Laurence & Ali Tifrit. 2013. From binary features to elements: The case of Scandinavian. Paper presented at Features in Phonology, Morphology, Syntax and Semantics: What are they? CASTL, University of Tromsø, October-November 2013.

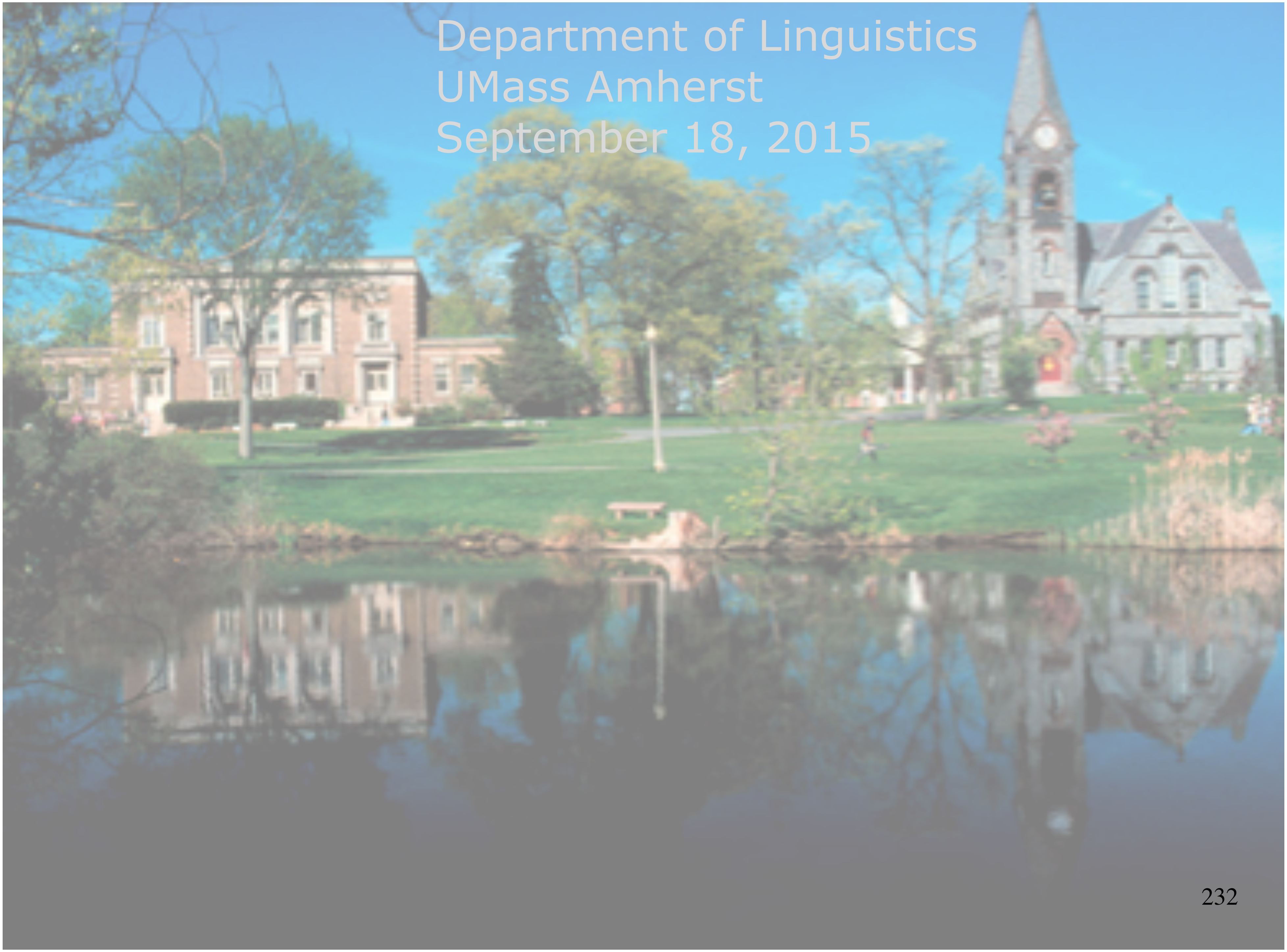
Walker, Rachel. 2005. Weak triggers in vowel harmony. *Natural Language and Linguistic Theory* 23: 917–89.

Zhang, Xi. 1995. Vowel harmony in Oroqen (Tungus). In Päivi Koskinen (ed.), *Toronto Working Papers in Linguistics* 14: 161–174.

Zhang, Xi. 1996. Vowel systems of the Manchu-Tungus languages of China. Doctoral dissertation, University of Toronto.

Linguistics Colloquium Series
University of Connecticut
February 13, 2015




Department of Linguistics
UMass Amherst
September 18, 2015