Carleton UNIVERSITY

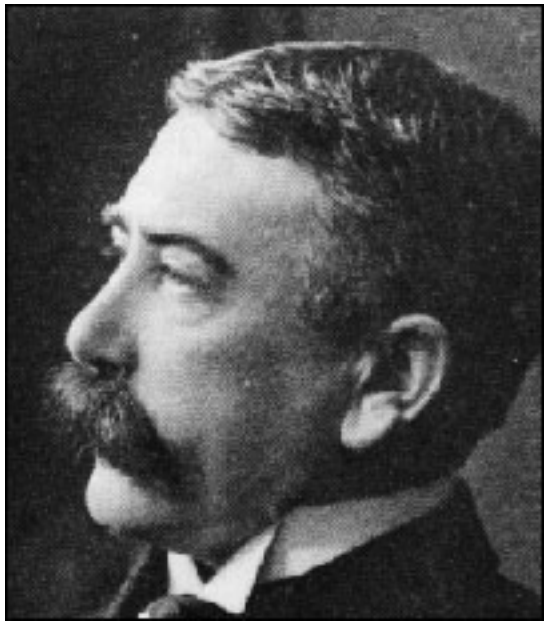
School of Linguistics and Language Studies

Speaker Series, March 30, 2012

On the Role and Evaluation of Contrast in Phonology

B. Elan Dresher
University of Toronto

”dans la langue il n’y a que des différences”



Ferdinand de Saussure, *Cours de linguistique générale* ([1916] 1972:166)

Introduction

In this talk I will present the main components of Modified Contrastive Specification (MCS, aka what some of us do in Toronto) as it touches on the role and evaluation of contrast in phonology (Avery & Rice 1989; Dresher, Piggott & Rice 1994; Dresher & Rice 2007; Hall 2007; Dresher 2009; Mackenzie 2009).

I will argue for the following positions:

Introduction

- Phonetic contrast is not the same as phonological contrast.
- Contrastive features are determined by feature ordering (a contrastive hierarchy), not by minimal contrasts.
- Contrastive hierarchies (i.e., the ordering of features), can vary cross-linguistically.
- The Contrastivist Hypothesis: only contrastive features can be active in the phonology.
- Corollary: to identify contrastive features, look for activity.
- The enhancement of contrastive features can account for surface effects like dispersion.

Introduction

I should add at the outset that I will be assuming that phonology operates on certain types of features, an assumption that is not universally shared.

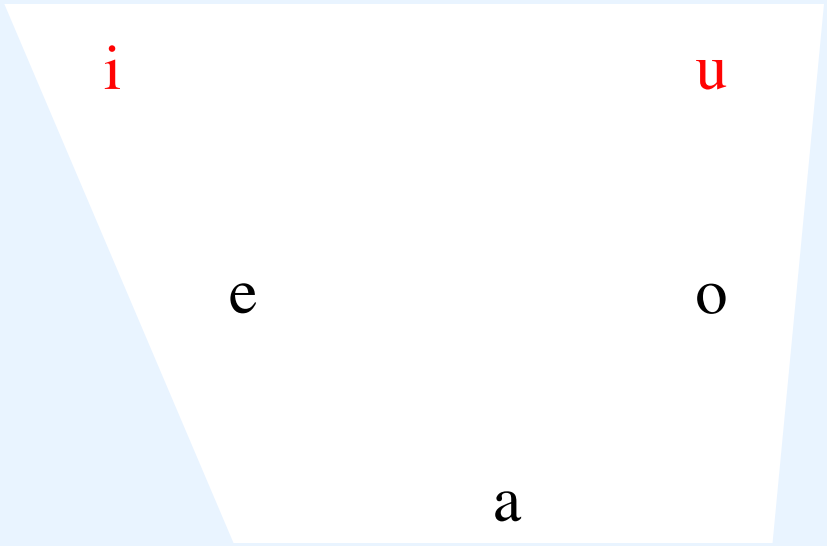
As Tobias Scheer (2010) observes, it is not clear how issues of contrast apply in frameworks like Dependency Phonology, Government Phonology, and CV-phonology.

I suspect that the basic concepts should apply there, too: the emphasis on representations as driving activity is something that MCS has in common with these theories.

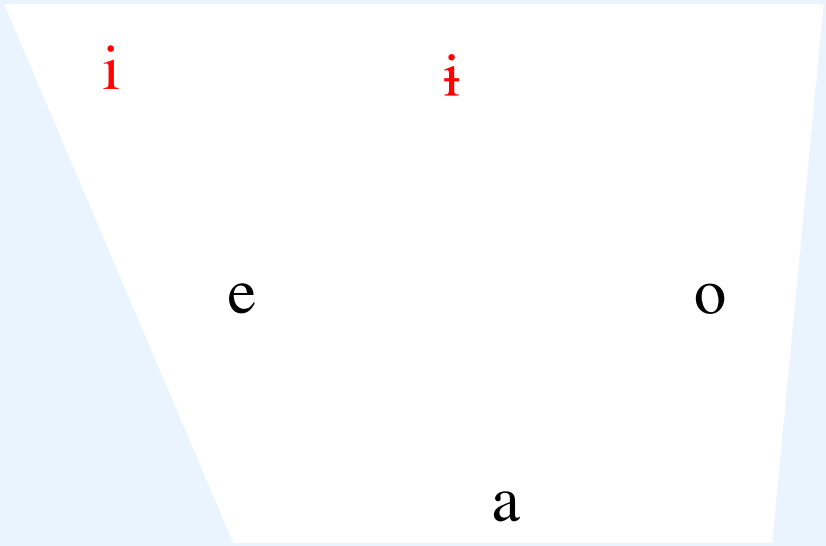
See, for example, Carvalho (2011), for an extension of the contrastive hierarchy to monovalent particle-like elements.

Phonetic Contrast

One can study the phonetics of contrast to see, for example, how perceptually salient the difference between sounds is.



The contrast between [i] and [u] is more perceptible...



...than the contrast between [i] and [ɨ]

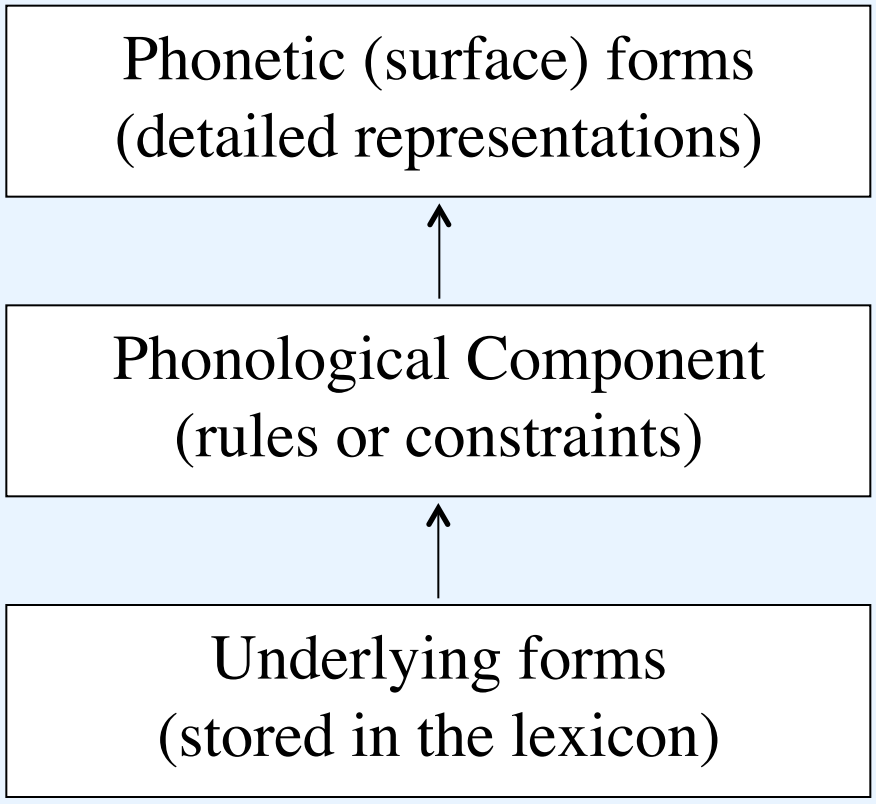
Phonetic Contrast

It is reasonable to suppose that good contrasts will be favoured in inventories over poor ones (Liljencrants & Lindblom 1972, Flemming 2004), or that perceptual effects of surface contrasts can influence phonological change.

This is an interesting topic, which I will refer to as phonetic contrast, because it is concerned with the surface phonetics of contrasts between sounds.

Phonetics and Phonological Patterns

However, the study of phonetic contrast has not been the sole —or even the central—preoccupation of phonologists or phonological theory since Saussure.

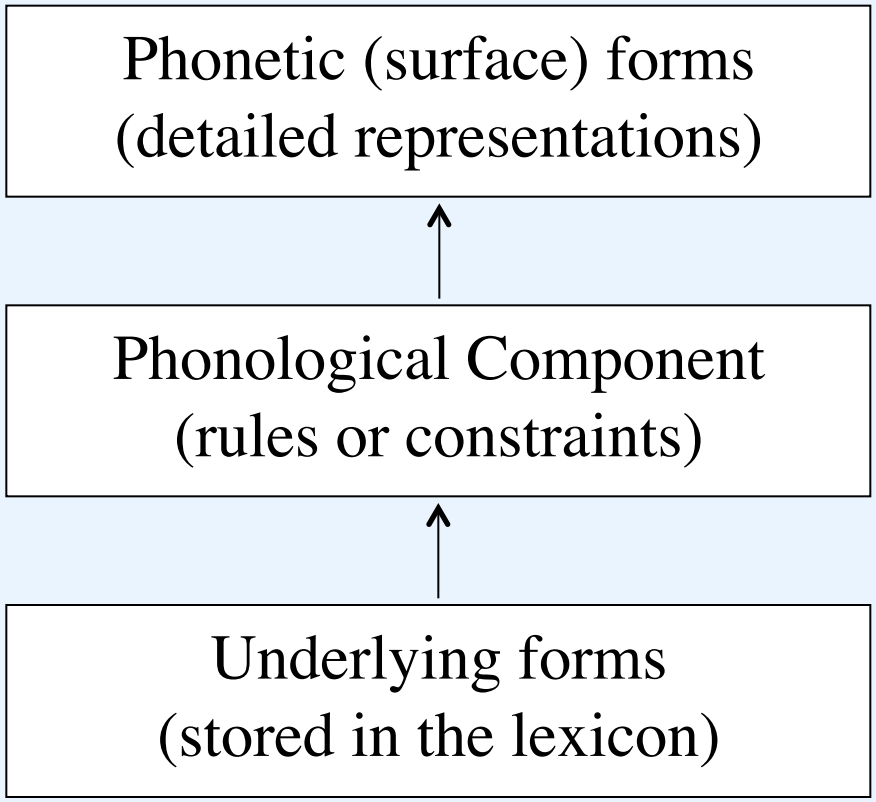


Underlying the phonetic surface forms phonologists have generally assumed that there exist lexical representations.

The levels are related by a phonological component

Phonetics and Phonological Patterns

Contrast is relevant to all these levels. Perceptual considerations that have been the subject of much recent interest are relevant to the phonetic level.



But the other levels are also affected by contrast, though in other ways.

First we need to make some hypotheses about the content of these levels.

Phonological Minimalism

MCS agrees with proposals by phonological 'minimalists' of various types (Anderson 2005; Anderson and Ewen 1987; Carr, Durand & Ewen 2005; Clements 2001; 2003; 2009; van der Hulst 1995; 1996; 2005; Hyman 2001; 2002; 2003; Morén 2003; 2006) that we should specify only those properties that the phonology requires.

Minimality and Activity

Clements (2001), for example, proposes (2001: 71–2) that 'phonological representations should be freed of superfluous representational elements, leaving only those that are essential to an understanding of lexical, phonological, and phonetic generalizations.'

He 'argues for a general principle of representational economy according to which features are specified in a given language only to the extent that they are needed in order to express generalizations about the phonological system.'

Active Feature Specification

He proposes a principle of *Active Feature Specification*:

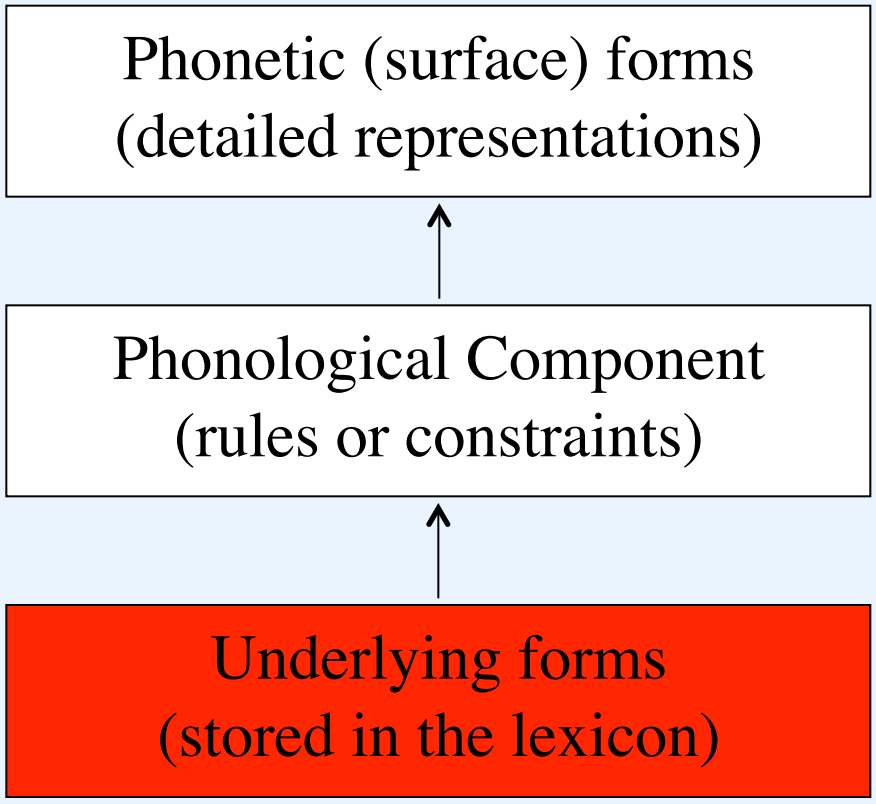
All and only those features that are active in a given language occur in its lexical and phonological representations.

'The term 'active feature' is used to designate a feature or feature value that is required for the expression of lexical contrasts or phonological regularities in a language, including both static phonotactic patterns and patterns of alternation.'

'In this view, whether or not a given feature or feature value is specified in a given language can only be determined from an examination of its system of contrasts and sound patterns.'

Conditions for feature specification

Clements proposes that each level is characterized by conditions of specification relevant to that level.



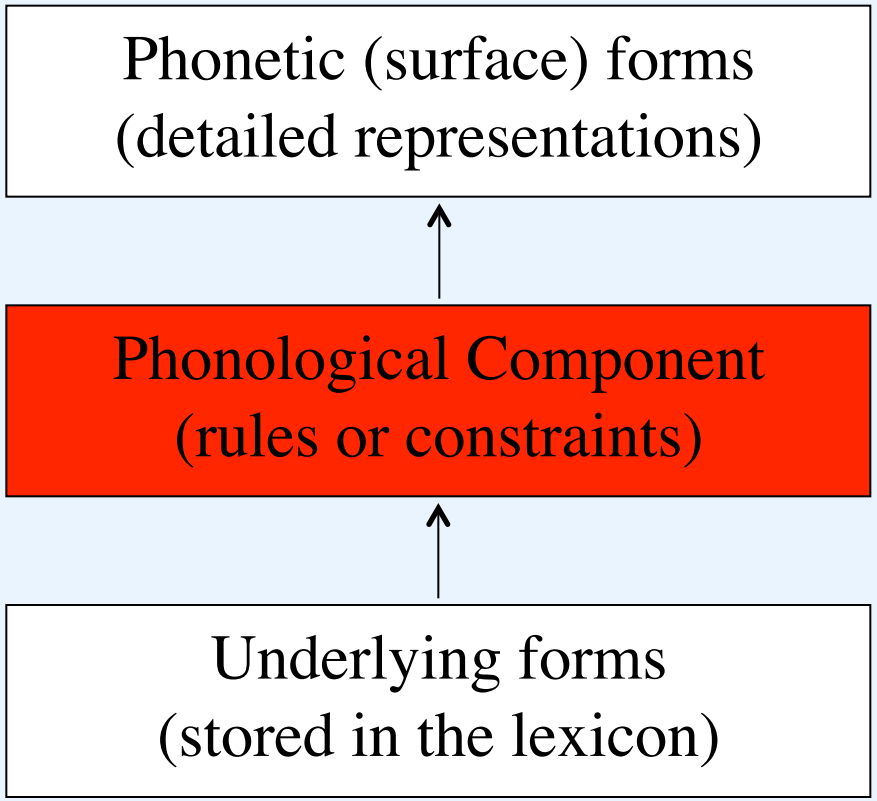
At the lexical level the condition is distinctiveness:

- a feature or feature value is present in the lexicon if and only if it is distinctive

A feature is *distinctive*, i.e. *contrastive*, in a given segment if it is required to distinguish that segment from another.

Conditions for feature specification

Clements proposes that each level is characterized by conditions of specification relevant to that level.

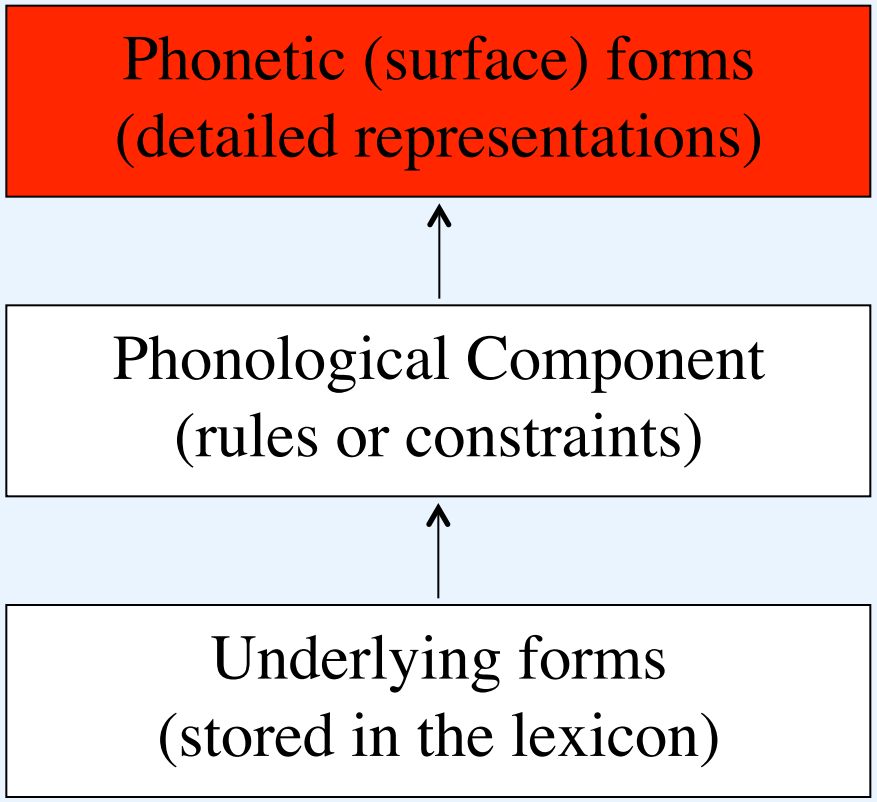


At the phonological levels the condition is feature activity:

- a feature or feature value is present at a given phonological level if it is required for the statement of phonological patterns (phonotactic patterns, alternations) at that level.

Conditions for feature specification

Clements proposes that each level is characterized by conditions of specification relevant to that level.

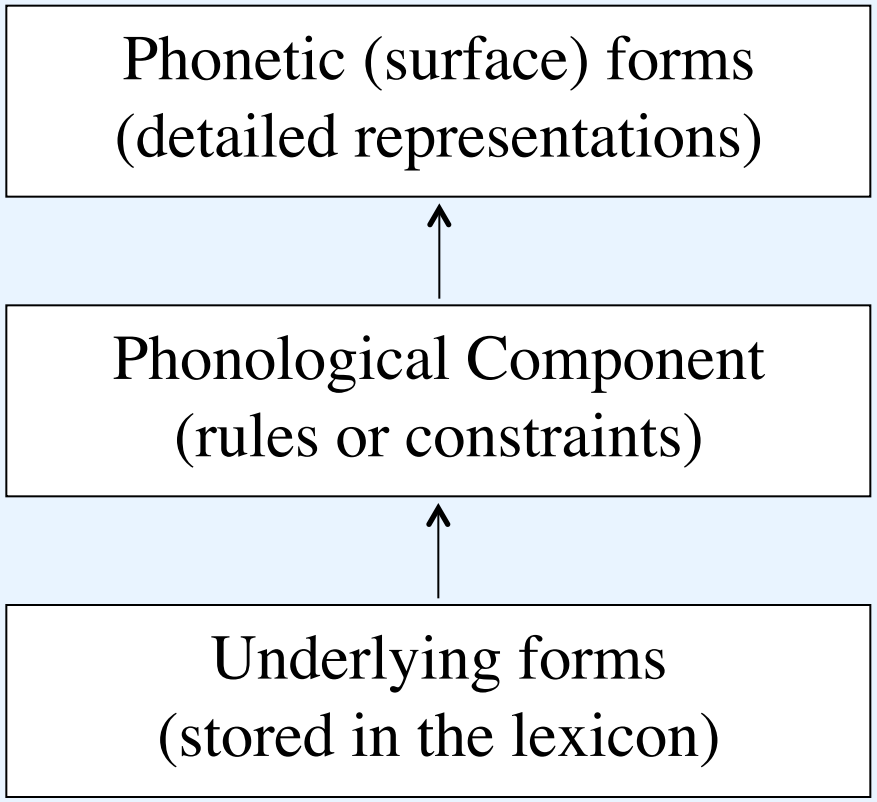


At the phonetic level the criterion is pronounceability:

- feature values are present in the phonetics if required to account for relevant aspects of phonetic realization

Phonetic and Phonological Contrast

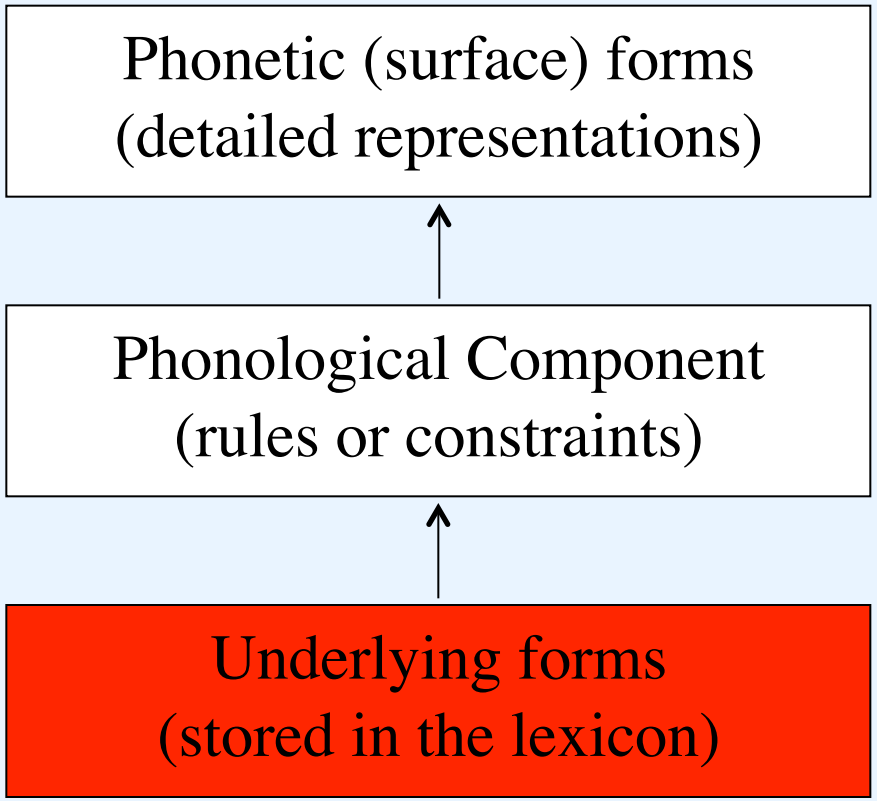
We can also surmise that the sort of contrasts we find at the phonetic level may be influenced by what goes on at the other levels.



In particular, by whatever contrastive considerations apply to those levels.

Contrast in underlying forms

Let's look at the lexical level, which Clements proposes consists only of contrastive features.

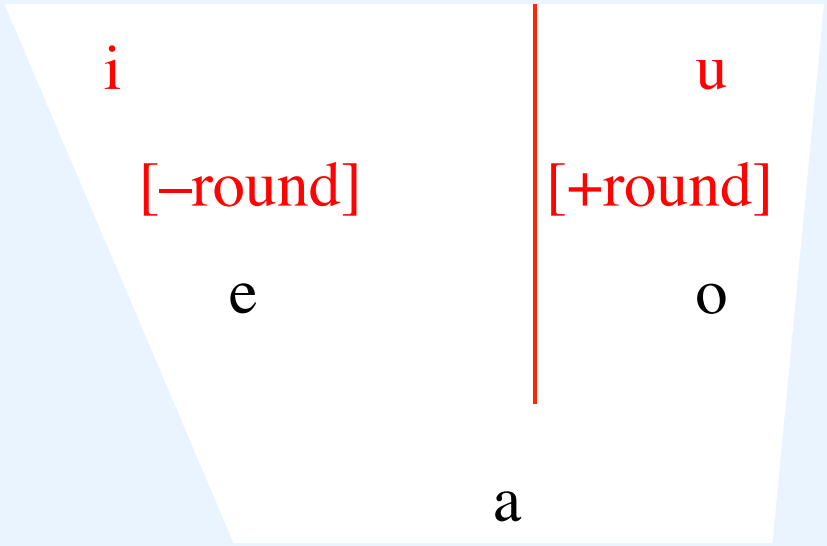


This view has a long history in phonological theory. Let's assume for the sake of discussion that it is correct.

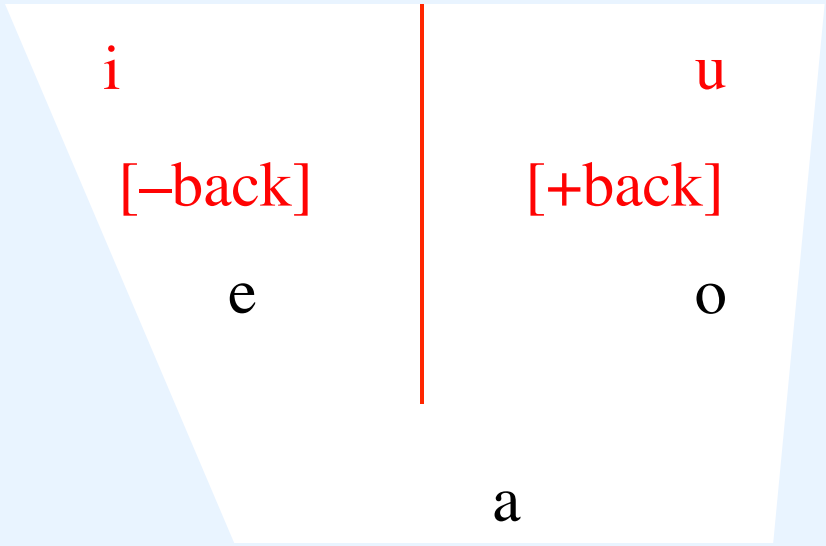
It remains to establish a way of identifying these contrastive features.

Phonological Contrast

This is not a trivial matter. For example, given that there is a contrast between /i/ and /u/, which features are required to distinguish them?



do /i/ and /u/ contrast with respect to [round]...

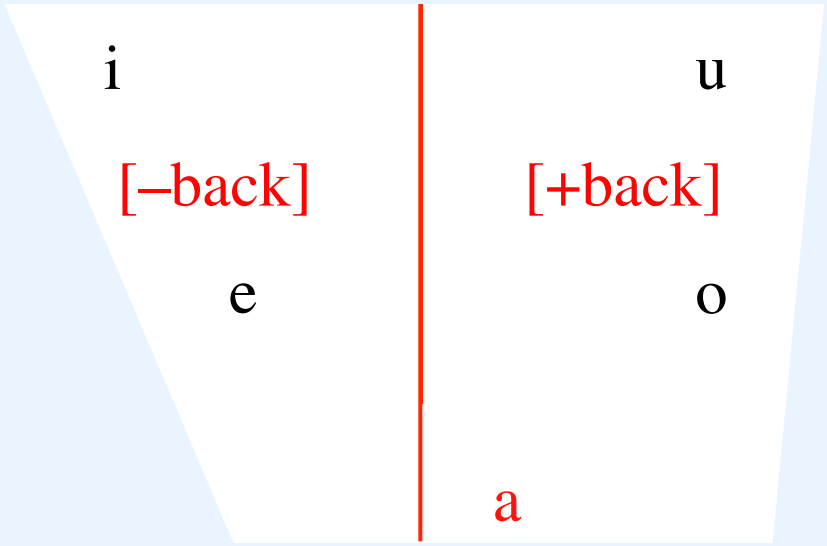


or do they contrast with respect to [back]?

Phonological Contrast

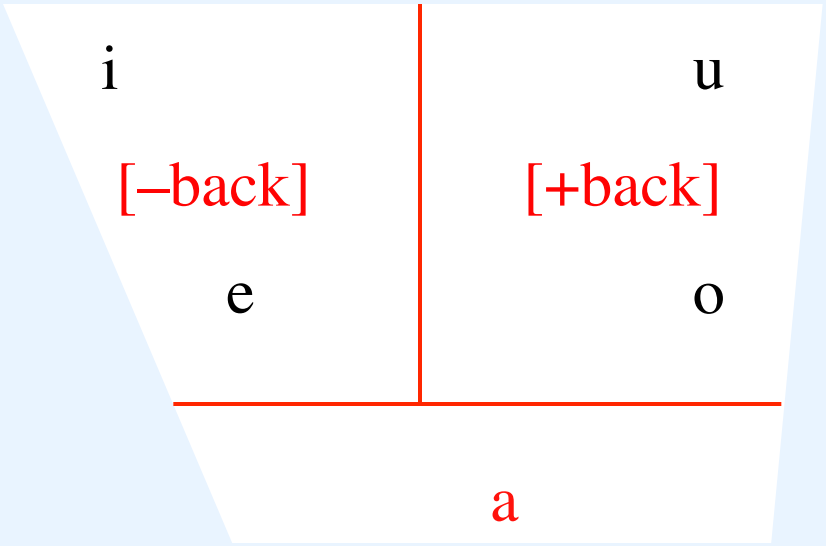
Suppose the answer is that they contrast with respect to [back]. Then another question arises about the status of /a/ with respect to this contrast:

/a/ participates in the contrast



is /a/ contrastively [+back]...

/a/ is outside the contrast



or is [back] redundant for /a/?

Phonological Contrast

To take another example, consider two analyses of the Catalan vowel system in the recent literature.

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 scope over the height features.

How do we establish contrasts?

How do we establish what the contrastive features are? Phonologists working in a variety of theoretical frameworks have independently proposed that 'minimal contrast' plays an important role in phonology (Padgett 2003, Calabrese 2005, Campos-Astorkiza 2009, Nevins 2010 explicitly, and many others implicitly).

Minimal Contrast

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]

Problems with Minimal Contrast

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

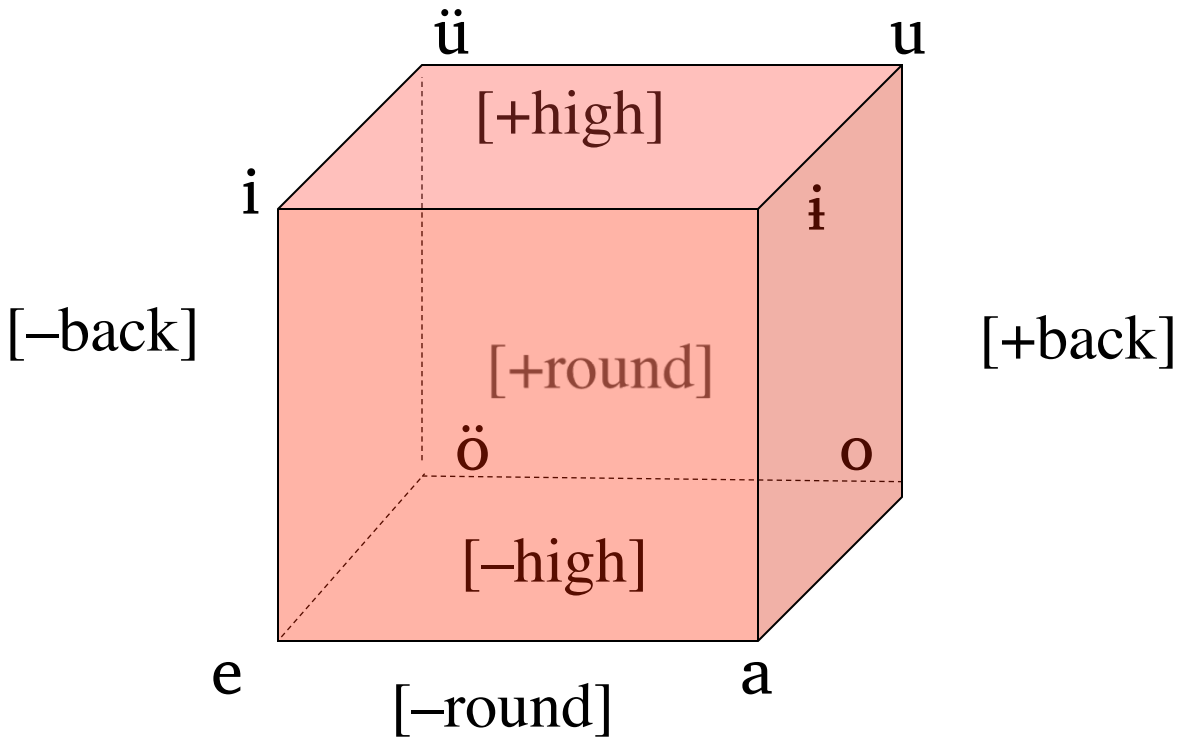
An example of the shortcomings of MC and how they are often tacitly set aside is Nevins's discussion of the Turkish vowel system (2010: 26).

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

Turkish Vowels

Here, every feature specification is contrastive, because the vowels completely fill the 2 x 2 x 2 = 8 cell vowel space.



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.

For example, /i/ 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 shown. There are no minimal contrasts at all. The 3 phonemes are too far apart in the $2^4 = 16$ slot feature space.

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 gives no results, because there are still no minimal pairs. The features [back] and [round] are getting in each other's way.

If we remove one of them, MC *seems* to work: [high] distinguishes /a/ from /u/, and [back] distinguishes /i/ from /u/. Circled features are designated noncontrastive.

	i	a	u
[high]	(+)	–	+
[back]	–	(+)	+

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

But I don't think that this is a proper contrastive specification. 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]	–	

An Alternative Approach

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.

There is in fact an alternative to Minimal Contrast that has an equally prestigious pedigree in phonological theory.

Reflecting on the cases we have seen, we observe that the Catalan analyses differ in the *relative scopes* of the features [ATR] in relation to [high] and [low].

Contrast: Relative Scopes of Features

Recall:

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 scope over the height features.

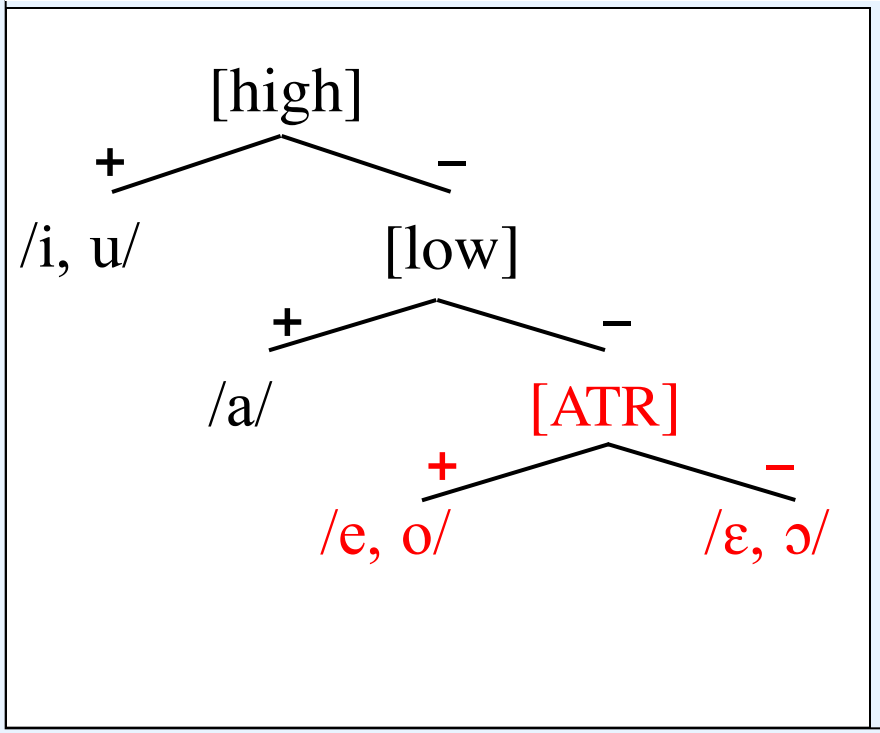
Relative Scope = Ordering

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]

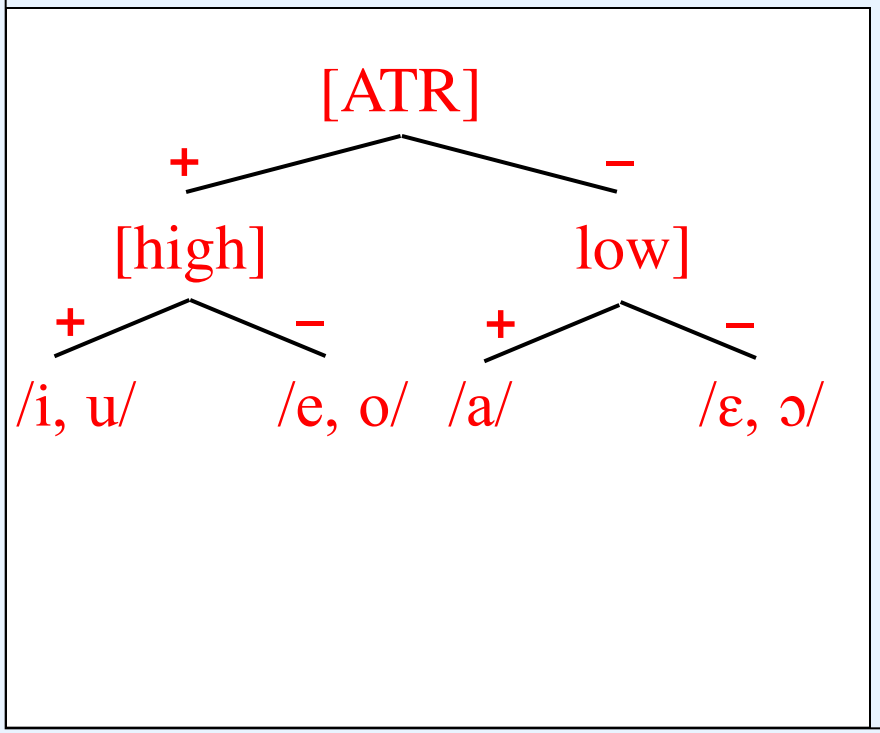
The tree diagram expresses the ordering

[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.

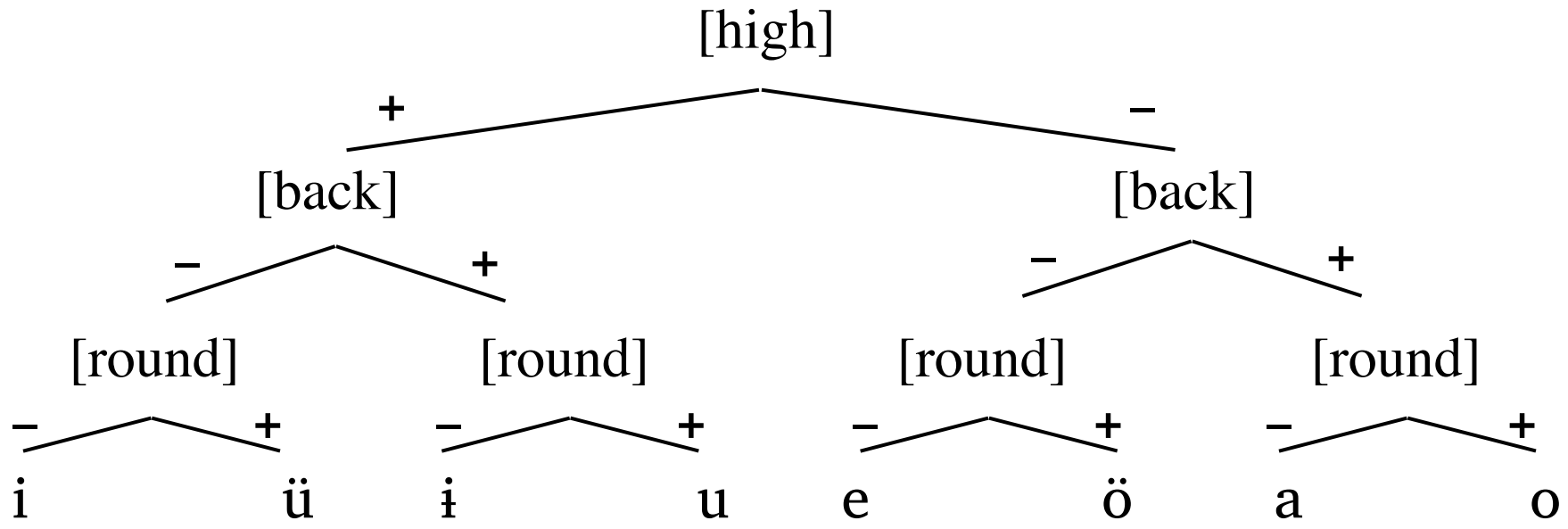
The features [high], [back], and [round] are ordered ahead of [low] and other possible features.

	[–back] [–round]	[–back] [+round]	[+back] [–round]	[+back] [+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.



Origins of the Branching Tree

Branching trees that express contrasts have antecedents in the work of Roman Jakobson and his collaborators. A tree of this kind underlies the feature specifications in Jakobson and Lotz (1949), and is explicit in Jakobson, Fant & Halle 1952, Jakobson & Halle 1956, etc.

Such a tree is prominent in Halle's (1959) *Sound Pattern of Russian*. Halle argues that such trees are the only way of ensuring that phonemes are properly distinctive.

Figure I–1, page 46 of *Sound pattern of Russian,* a magnificent tree diagram that shows the lexical feature specifications of every phoneme of Russian.

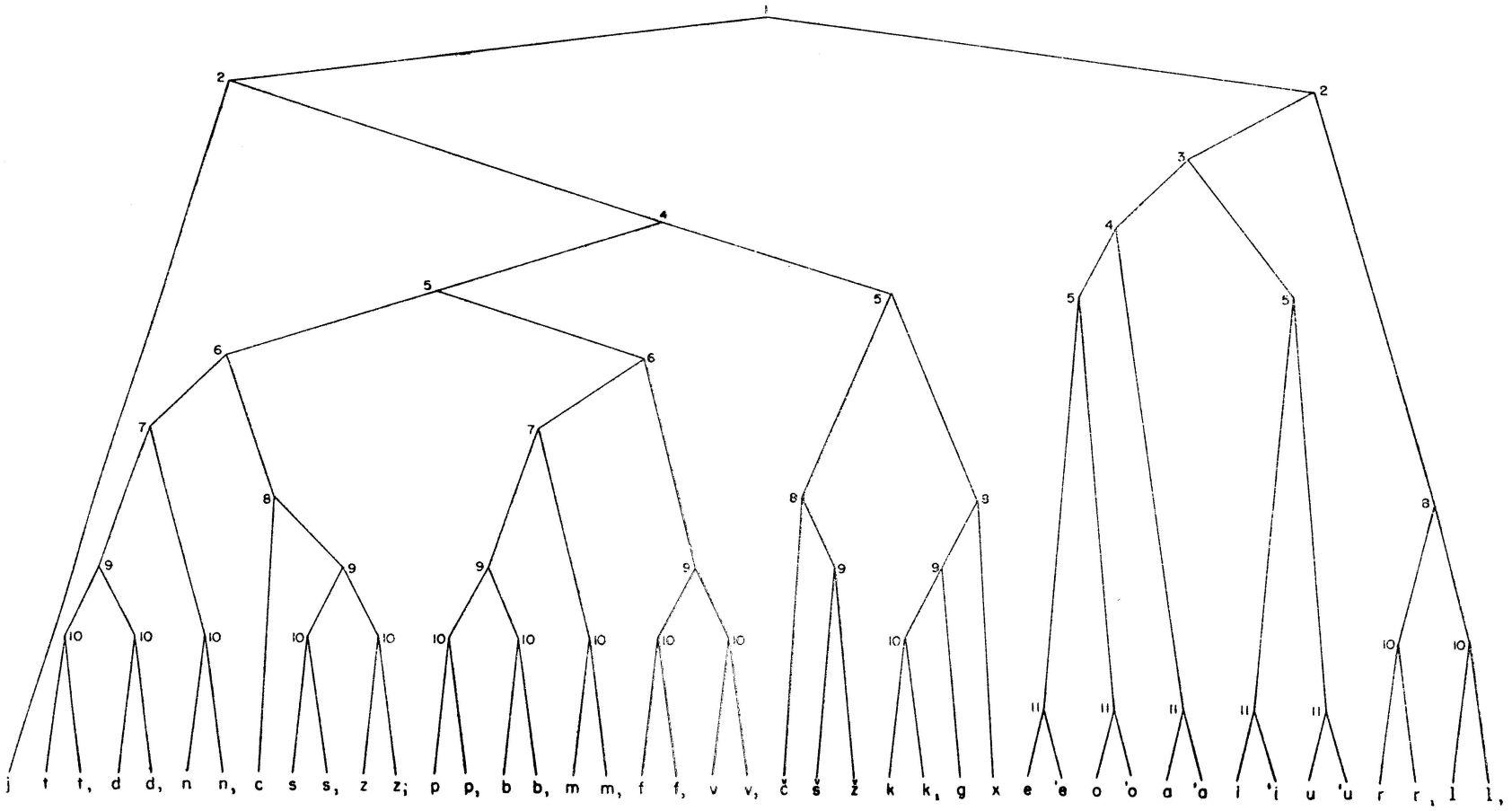


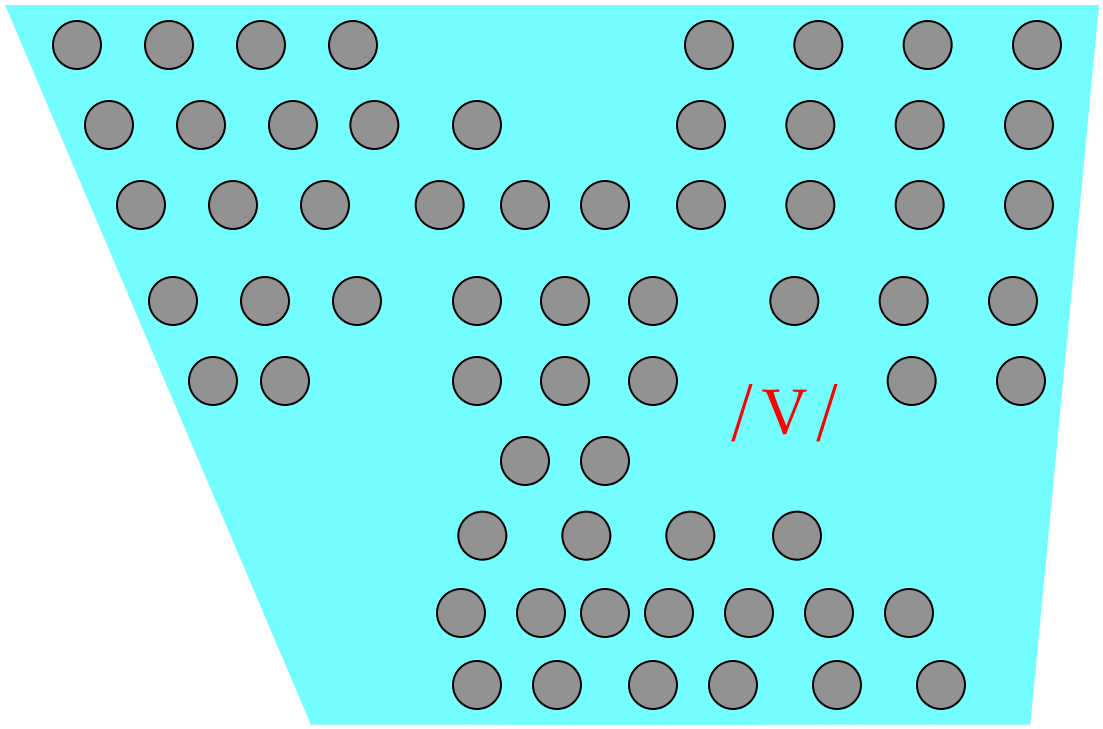
Fig. I-1. Branching diagram representing the morphonemes of Russian. The numbers with which each node is labelled refer to the different features, as follows: 1. vocalic vs. nonvocalic; 2. consonantal vs. nonconsonantal; 3. diffuse vs. nondiffuse; 4. compact vs. noncompact; 5. low tonality vs. high tonality; 6. strident vs. mellow; 7. nasal vs. nonnasal; 8. continuant vs. interrupted; 9. voiced vs. voiceless; 10. sharped vs. plain; 11. accented vs. unaccented. Left branches represent minus values, and right branches, plus values for the particular feature.

Contrastive specification by a hierarchy of features

Feature ordering is a way of determining contrastive specifications, via the Successive Division Algorithm (Dresher 1998, 2003, 2009, based on Jakobson, Fant & Halle 1952, Jakobson & Halle 1956)

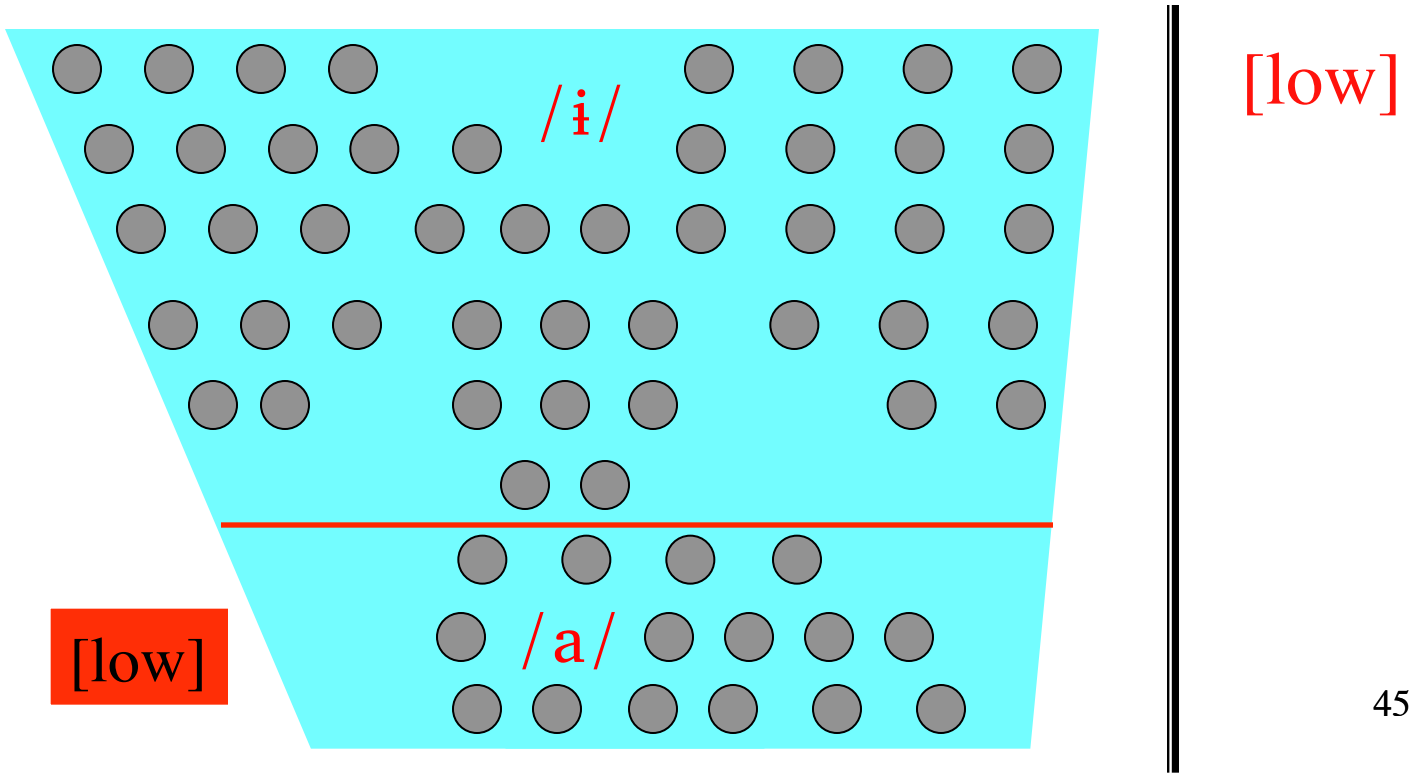
The Successive Division Algorithm

a. Begin with ***no*** feature specifications: assume all sounds are allophones of a single undifferentiated phoneme.



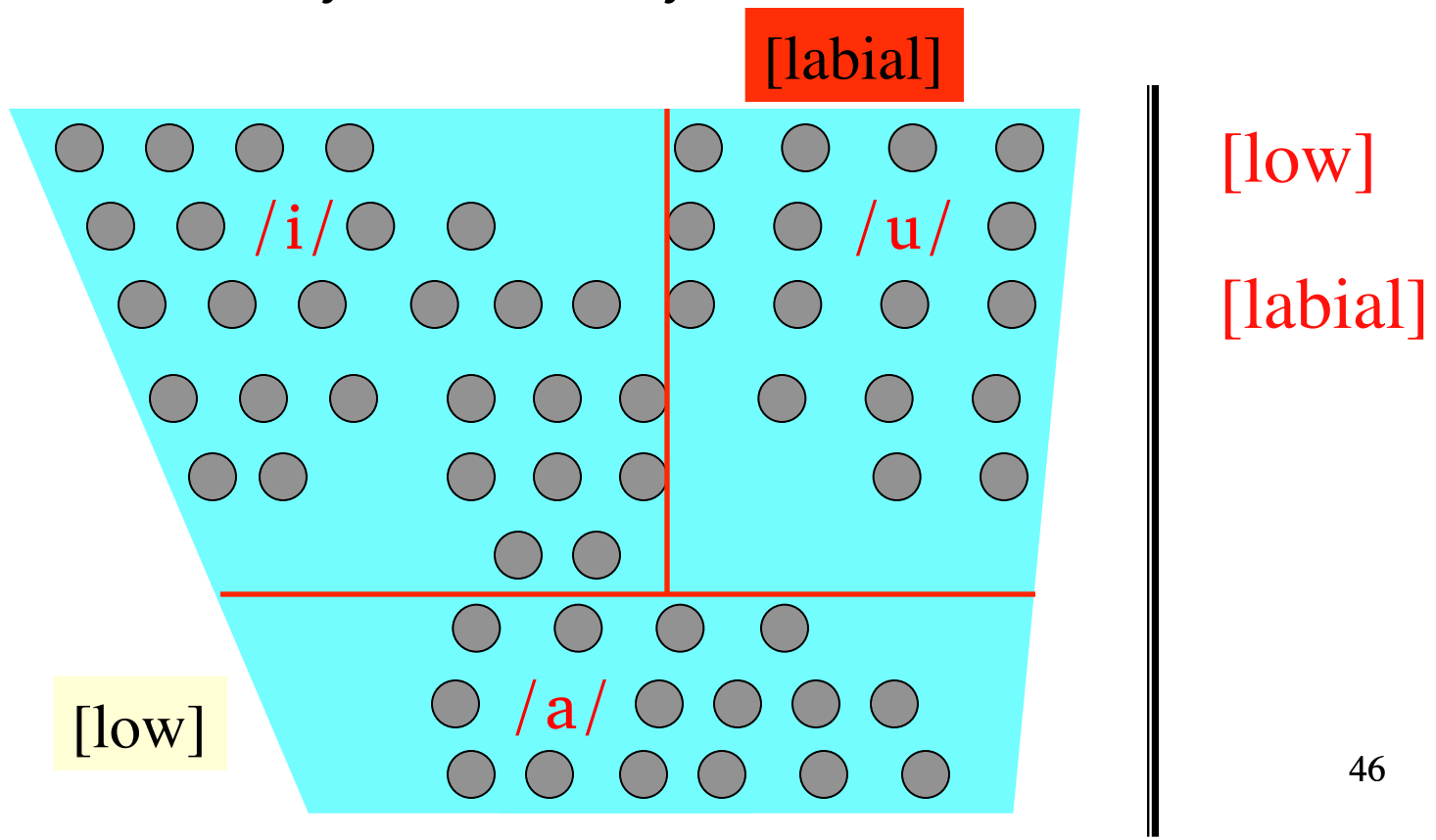
The Successive Division Algorithm

b. If the set is found to consist of more than one contrasting member, identify the contrastive feature and divide the set into as many subsets as the feature allows for.



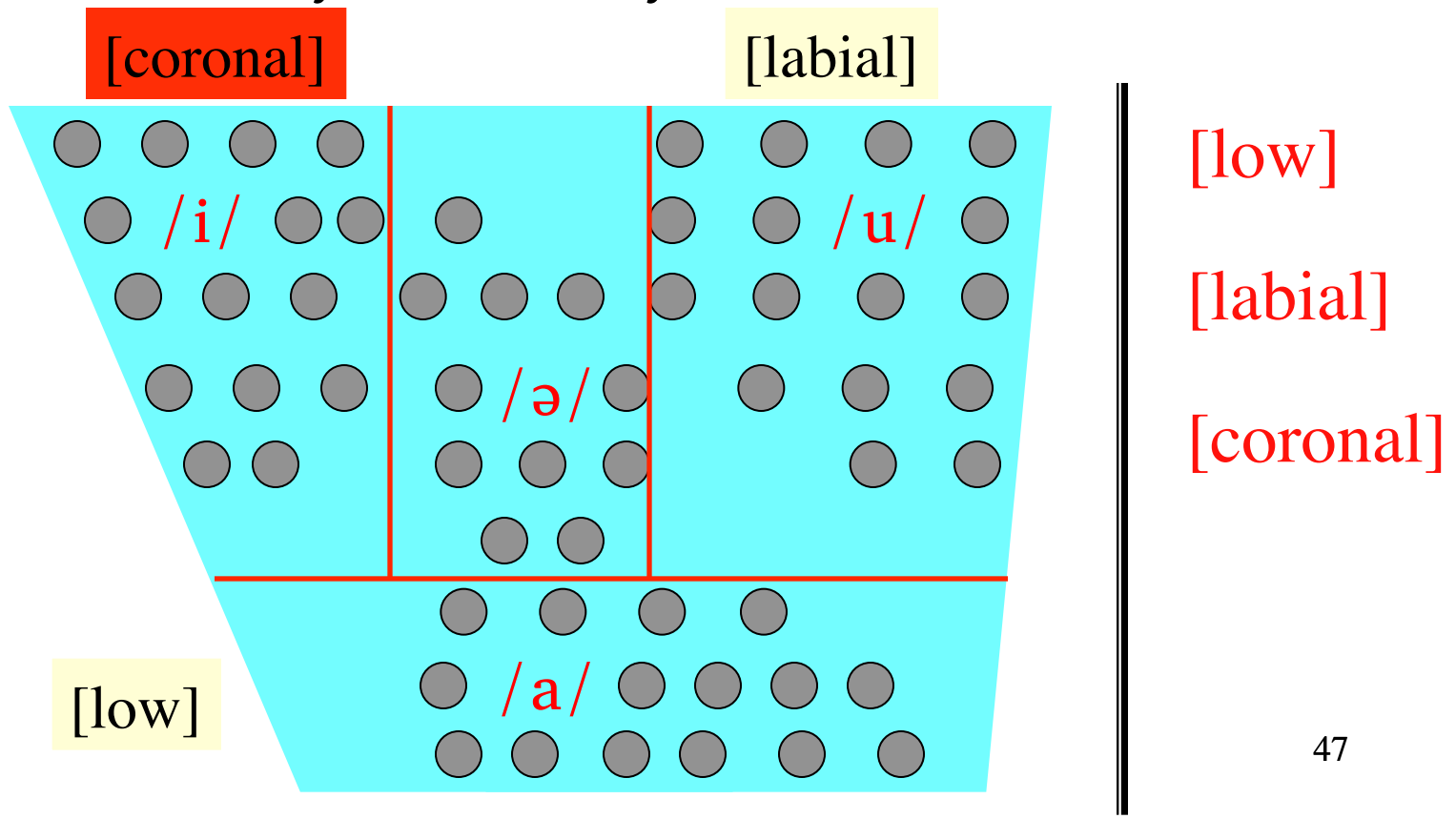
The Successive Division Algorithm

c. Repeat step (b) in each subset: keep dividing up the inventory into sets, applying successive features in turn, until every set has only one member.



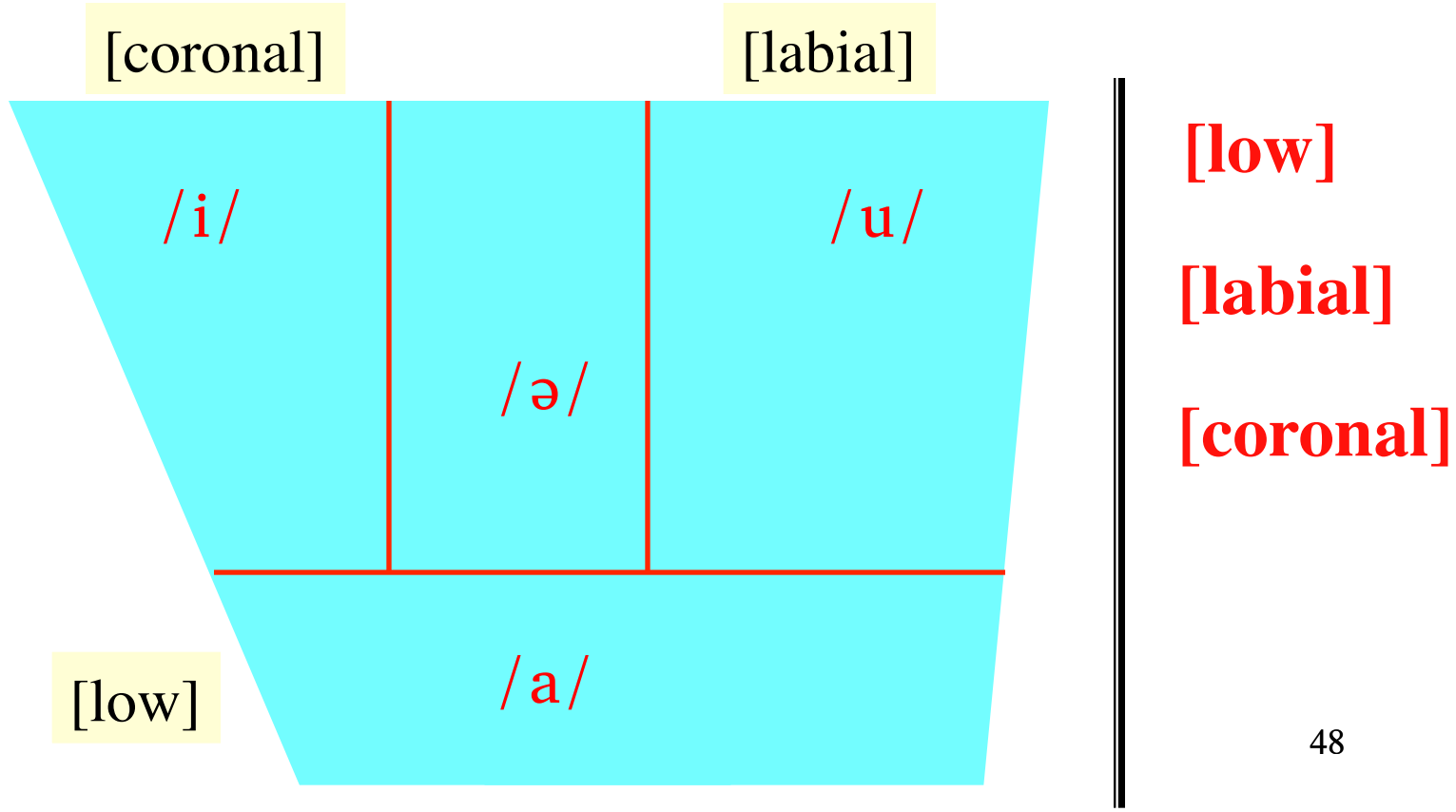
The Successive Division Algorithm

c. Repeat step (b) in each subset: keep dividing up the inventory into sets, applying successive features in turn, until every set has only one member.



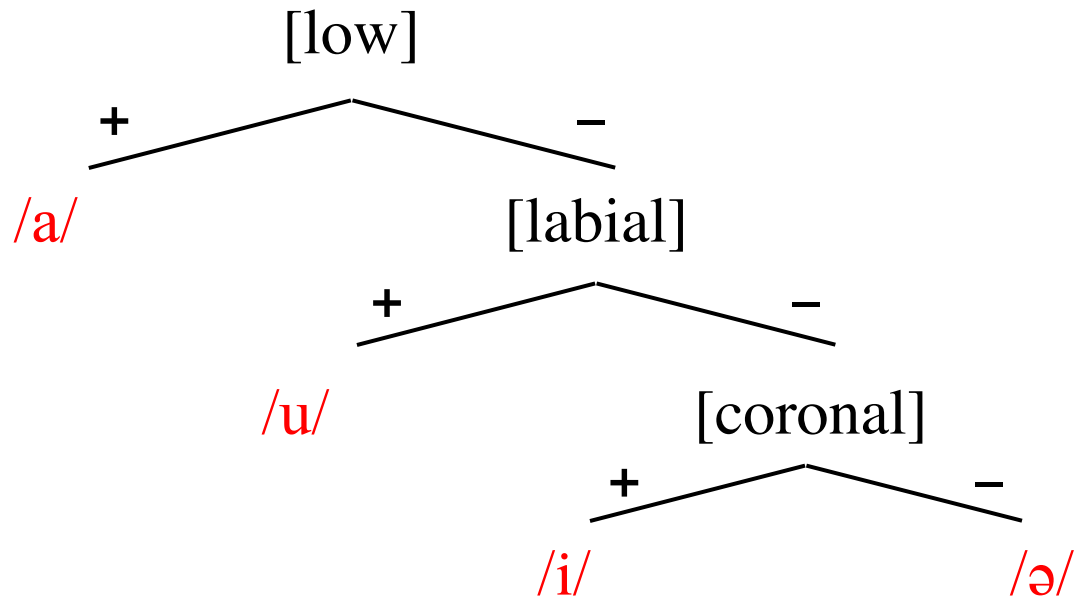
The Contrastive Hierarchy

The ordered list of features is called the *contrastive hierarchy* for the language in question.



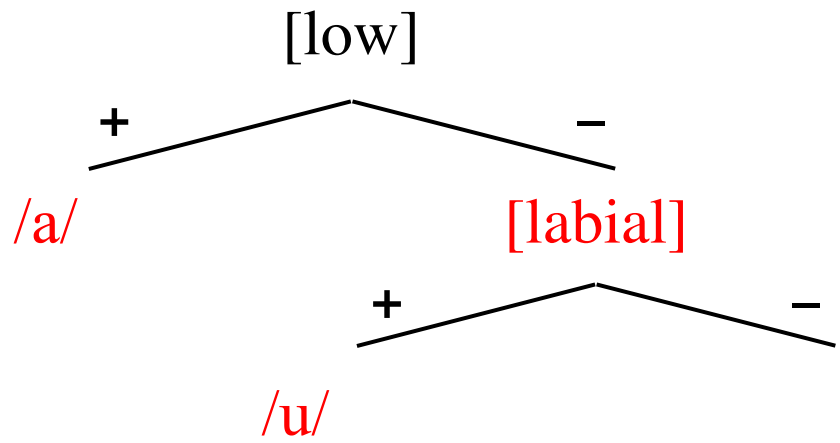
The Contrastive Hierarchy

The ordered list of features is called the *contrastive hierarchy* for the language in question.



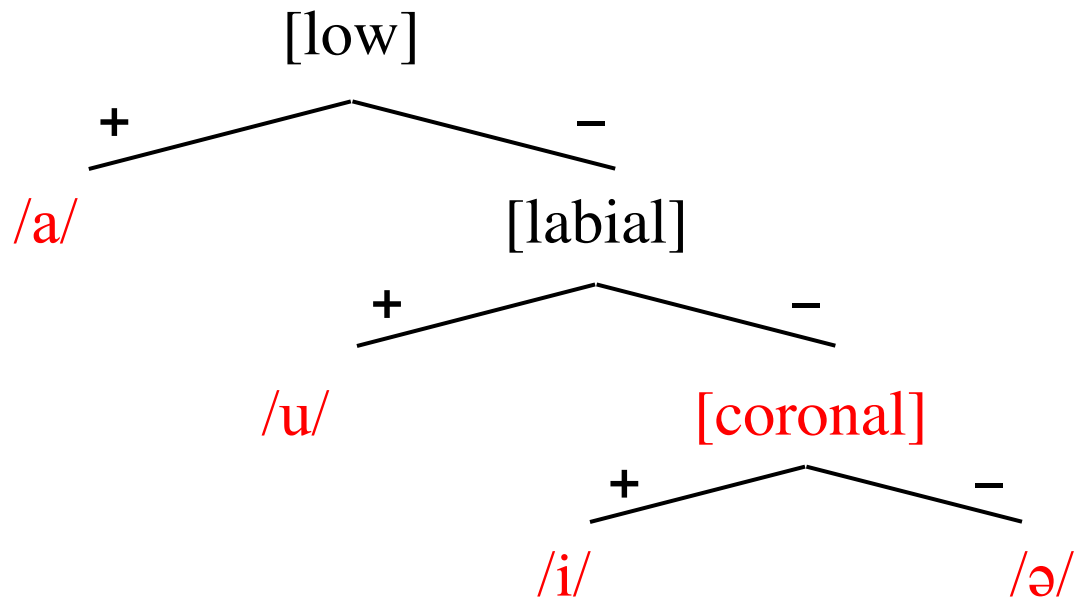
The Contrastive Hierarchy

On this approach, each contrast is minimal *at the point at which it applies*. At the point where [labial] applies, it makes a minimal contrast between /u/ and the [–labial] vowels.



The Contrastive Hierarchy

Later, the [–labial] vowels are further divided by [coronal]. After this happens, /u/ is no longer minimally different from /i/ and /ə/.



Contrast and Activity

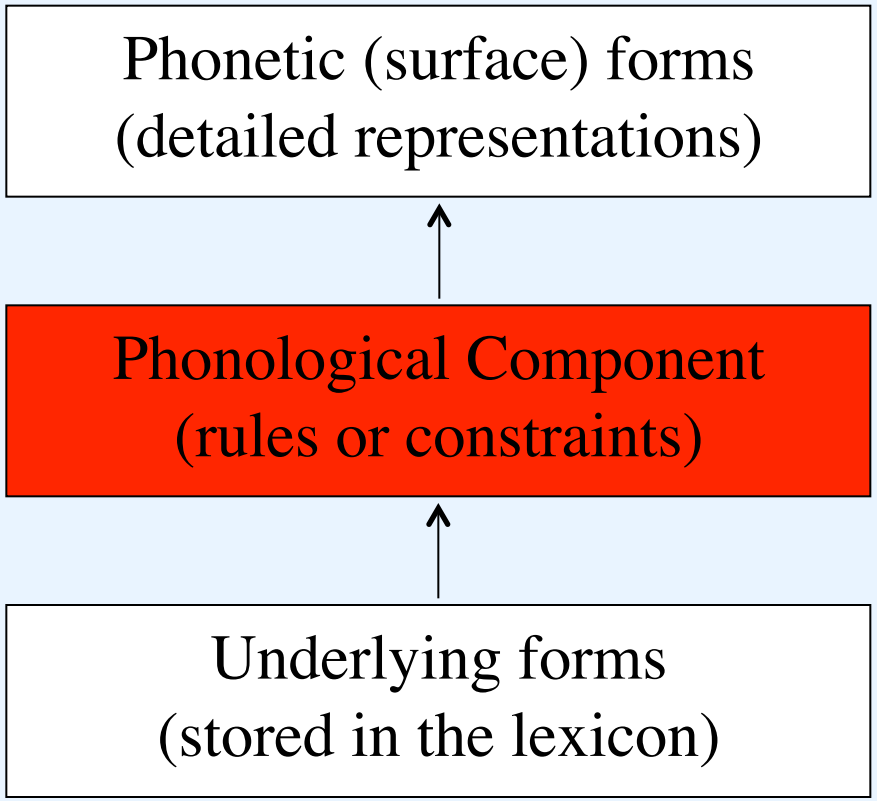
Why does it matter how we establish phonological contrasts between phonemes?

It matters because there is an empirical question that arises about the workings of the phonology:

Does phonology compute *all* features or only *contrastive* ones?

Conditions for feature specification

Recall that Clements proposed that only *active* features are specified in the phonological component.



At the phonological levels the condition is feature activity:

- a feature or feature value is present at a given phonological level if it is required for the statement of phonological patterns (phonotactic patterns, alternations) at that level.

Conditions for feature specification

Clements (2001: 79): 'An interesting question is whether one can maintain the following strong hypothesis:'

(7) Lexical feature representations are identical to phonological feature representations

'in other words, only lexically distinctive values are phonologically active.'

The Contrastivist Hypothesis

Hall (2007: 20) calls this the *Contrastivist Hypothesis*, which he formulates as follows:

> The phonological component of a language L operates only on those features which are necessary to distinguish the phonemes of L from one another.

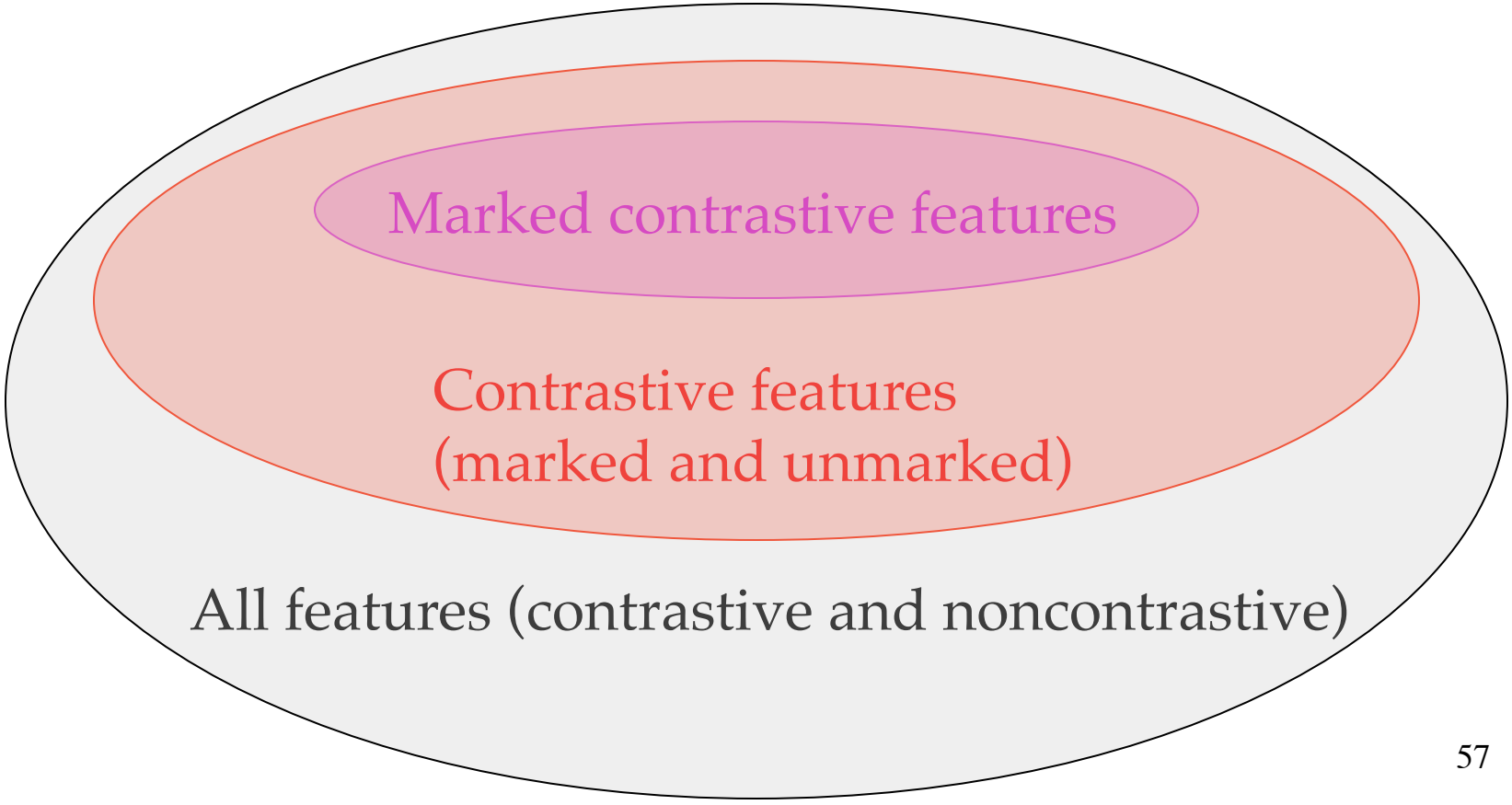
The Contrastivist Hypothesis

Clements (2001: 79): "This hypothesis is attractive in that, if true, it would place strong constraints on the nature of feature representation.'

'However, we shall see below that some features that are absent in lexical specification are active, and necessarily present, in the phonology, showing that (7) cannot be maintained in its strong form.'

The Contrastivist Hypothesis

Similarly, Calabrese (2005) and Nevins (2010) propose that phonological processes can target 3 circles of feature specifications:



Weak Contrastivist Hypothesis

The positions of Clements, Calabrese, and Nevins amount to a weak version of the Contrastivist Hypothesis:

> The phonological component of a language L *may* operate only on those features which are necessary to distinguish the phonemes of L from one another.

Weak Contrastivist Hypothesis?

Does the Contrastivist Hypothesis need to be weakened in this manner? It's not so clear: there is a major obstacle in evaluating the empirical status of this hypothesis.

The obstacle is that many analysts assume that contrast is determined by MC (Calabrese, Nevins), or by a fixed feature hierarchy (Clements).

Either way, the set of contrastive features that will be derived from a given inventory is *fixed*.

Variable Feature Hierarchies

Following work in the Modified Contrastive Specification (MCS) framework (Avery & Rice 1989; Dresher, Piggott & Rice 1994; Dresher & Rice 2007; Hall 2007; Dresher 2009, Mackenzie 2009), I assume rather that feature hierarchies may *vary* from language to language.

Even closely related dialects with identical-looking inventories may have different contrastive relations due to different feature orderings.

A nice example of this is given by Mackenzie (2005, 2009).

Nilotic Dialects (Mackenzie 2009)

Both Anywa (Reh 1996) and Dholuo (Tucker 1994), related Nilotic languages, have a dental~alveolar contrast in the coronal stops; in both languages, the alveolar nasal /n/ has no dental nasal partner.

Should /n/ be considered contrastively alveolar, or is it outside the dental~alveolar contrast, being only redundantly alveolar?

Anywa (Reh 1996)

Dental	Alveolar	
t̪	t	Voiceless stops
d̪	d	Voiced stops
	n	Nasals

Dholuo (Tucker 1994)

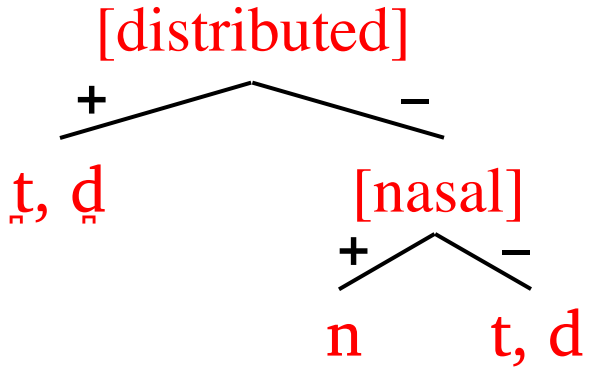
Dental	Alveolar
t̪	t
d̪	d
	n

Nilotic Dialects (Mackenzie 2009)

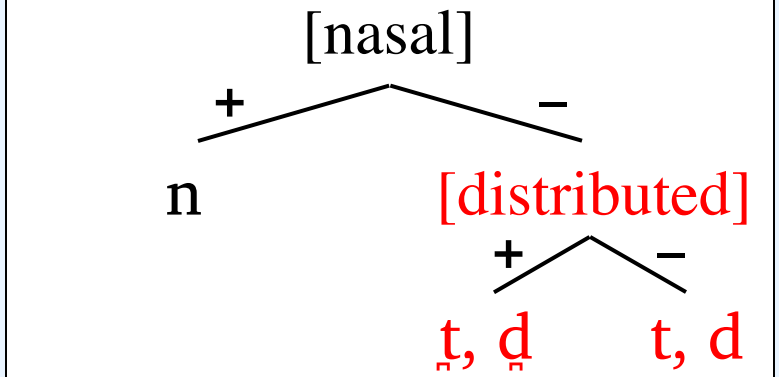
Mackenzie (2005, 2009) argues that the two languages adopt different solutions to this question: in Anywa /n/ acts as if it is contrastively alveolar with respect to co-occurrence restrictions; in Dholuo it acts neutrally with respect to the contrast.

In Anywa, the ordering is [distributed] > [nasal]; in Dholuo, the ordering is [nasal] > [distributed].

Anywa (Reh 1996)



Dholuo (Tucker 1994)



Contrast depends on point of view

As Trubetzkoy remarked in his 1936 article addressed to psychologists and philosophers, the correct classification of an opposition "depends on one's point of view"; but "it is neither subjective nor arbitrary, for the point of view is implied by the system." (Trubetzkoy 2001: 20)

Feature ordering is a way to incorporate "point of view" into the procedure of determining contrastive properties. Different orders result in different contrastive features.

How many features are contrastive?

Returning to the question of the empirical status of the Contrastivist Hypothesis,it is clear that the approach one adopts to identifying which features are contrastive will play a big role in how one evaluates the success of the hypothesis.

In this connection it is important to note that the MC approach labels *fewer* features as contrastive than does the SDA.

Which Features are Contrastive? MC

To take a simple example, consider an inventory with three vowels /a, i, u/ and the features [low] and [round] (if we pick any more features the MC approach won't work).

Minimal Contrast

	a	i	u
[low]	+	–	(–)
[round]	(–)	–	+

The feature [low] uniquely distinguishes /a/ from /i/.

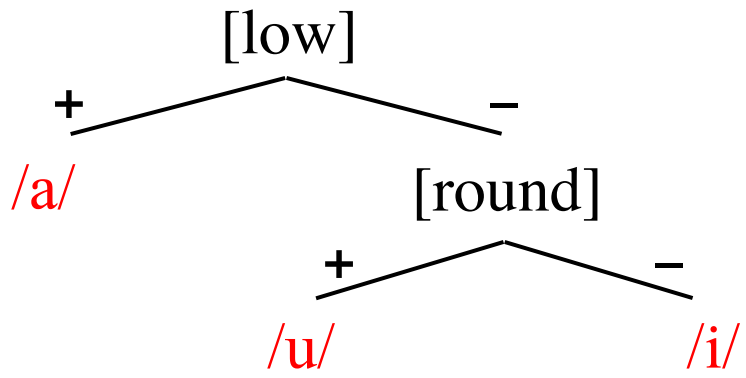
The feature [round] uniquely distinguishes /i/ from /u/.

There are 4 contrastive features and 2 non-contrastive features (circled).

Which Features are Contrastive? SDA

In a hierarchical approach we obtain different results. There are two outcomes, depending on the ordering of the features.

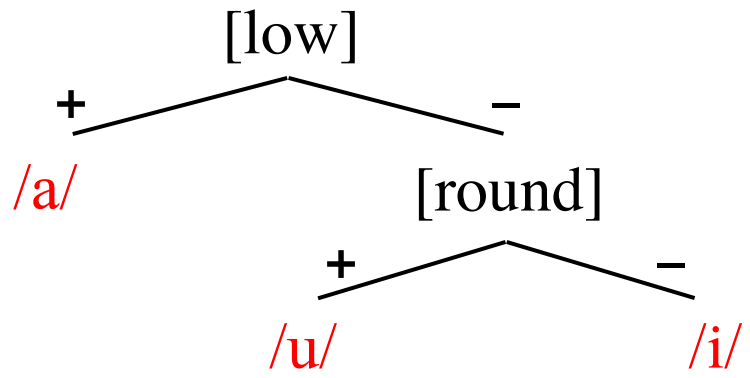
First, let's suppose that [low] is ordered above [round]:



Which Features are Contrastive? SDA

On this order, [low] is contrastive for all segments, and [round] is contrastive for /u/ and /i/.

5 features are contrastive and only 1 feature (circled) is non-contrastive.



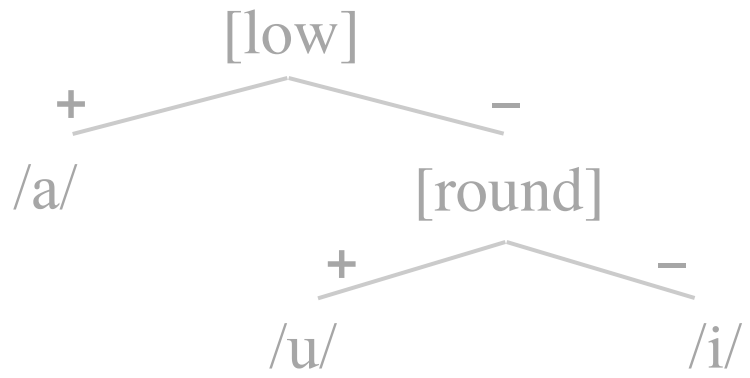
SDA 1: [low] > [round]

	a	i	u
[low]	+	–	–
[round]	(–)	–	+

Which Features are Contrastive? SDA

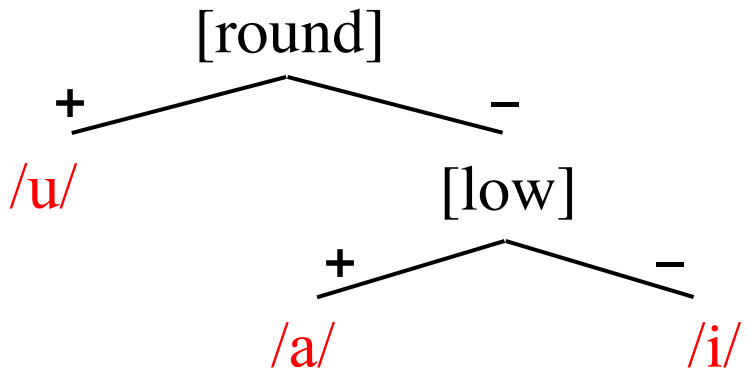
In the other possible order, [round] is contrastive for all segments, and [low] is contrastive for /a/ and /i/.

Again, 5 features are contrastive and only 1 is non-contrastive.



SDA 1: [low] > [round]

	a	i	u
[low]	+	–	–
[round]	–	–	+



SDA 2: [round] > [low]

	a	i	u
[low]	+	–	–
[round]	–	–	+

Which Features are Contrastive?

Comparing the two approaches, we observe that one or the other of the features that MC designates as non-contrastive is designated as contrastive by the SDA, in either ordering.

Minimal Contrast

	a	i	u
[low]	+	–	(–)
[round]	(–)	–	+

SDA 1: [low] > [round]

	a	i	u
[low]	+	–	–
[round]	(–)	–	+

SDA 2: [round] > [low]

	a	i	u
[low]	+	–	(–)
[round]	–	–	+

Against the MC Approach

Therefore, we might expect that there are cases where in an MC analysis it *looks like* non-contrastive features are active, contrary to the Contrastivist Hypothesis; but those same features could be designated contrastive by the SDA.

I argue that such cases in fact arise in Nevins's (2010) analyses of vowel harmony.

Yoruba Dialects

In Ifẹ Yoruba, lax (or RTR) mid vowels /ɛ, ɔ/ can occur non-finally only when another lax mid vowel follows (a, b).

Locality is computed only with respect to mid vowels (leaving aside /a/ for now); a high tense vowel can intervene (c, d).

Ifẹ Yoruba

a. olè ‘thief’ *ɔlè

b. ɔsɛ ‘soap’

c. ɔrúkɔ ‘name’

d. ɛ̀lùbɔ́ ‘yam flour’

Yoruba Dialects

Standard Yoruba has the same process (a, b), except that high vowels count in the computation (c, d).

Only tense mid vowels may precede a high vowel, even if a lax mid vowel occurs to the right.

Ifẹ Yoruba		Standard Yoruba	
a. olè	‘thief’	a. olè	‘thief’
b. ɔsɛ	‘soap’	b. ɔsɛ	‘soap’
c. ɔrúkɔ	‘name’	c. orúkɔ	‘name’
d. ɛ̀lùbɔ́	‘yam flour’	d. èlùbɔ́	‘yam flour’

Yoruba Dialects

Nevins (2010: 16) explains the difference as follows:

> The locality of vowel harmony in Ifẹ Yoruba is determined by the closest vowel contrastive for the tense/lax distinction, while the locality of vowel harmony in Standard Yoruba is determined by the closest vowel, period.

Nevins assumes that only mid vowels are contrastive for [RTR] in *both* dialects, in keeping with the MC approach to contrast.

MC Contrastive Features in Yoruba

Recall that on this approach contrastive features are those that uniquely distinguish two phonemes. (Following the usual practice I tacitly choose only one of [round] and [back] so that the MC method can appear to work.)

	i	e	ɛ	a	ɔ	o	u
[low]	–	–	–	+	–	–	–
[high]	+	–	–	–	–	–	+
[round]	–	–	–	–	+	+	+
[RTR]	–	–	+	+	+	–	–

MC Contrastive Features in Yoruba

Only the mid vowels can be contrastive for [RTR] in any dialect with the same vowel inventory.

Therefore, if high vowels block harmony in Standard Yoruba, it must be because [RTR] harmony computes *all* features, not just contrastive ones.

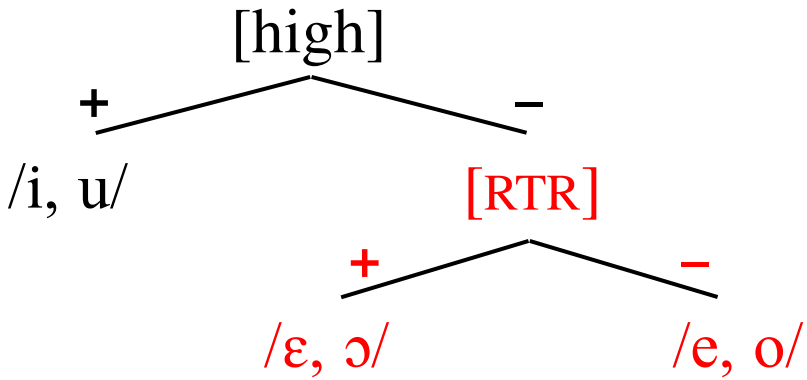
	i	e	ɛ	a	ɔ	o	u
[low]	–	–	–	+	–	–	–
[high]	+	–	–	–	–	–	+
[round]	–	–	–	–	+	+	+
[RTR]	–	–	+	+	+	–	–

SDA Contrastive Features in Yoruba

This conclusion does not follow in a hierarchical approach to contrast. The SDA *can* limit contrastive [RTR] to mid vowels, corresponding to ordering the features [high] > [RTR].

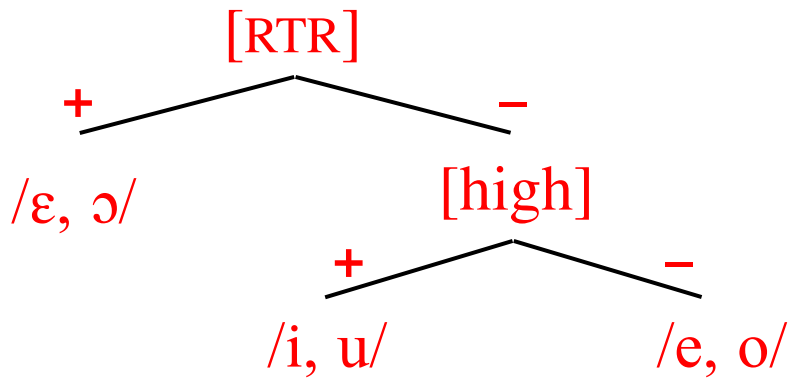
Ifẹ Yoruba: [hi] > [RTR]

	[–round]	[+round]
[+high]	i	u
[–RTR] [–high]	e	o
[+RTR] [–high]	ɛ	ɔ
	a	



SDA Contrastive Features in Yoruba

But the other ordering is also possible. On this ordering, *all* vowels are contrastive for [RTR], including the high vowels.



Standard Yoruba: [RTR] > [hi]

	[–round]	[+round]
[+high]	i	u
[–RTR]		
[–high]	e	o
[+RTR]	ɛ	ɔ
	a	

SDA Contrastive Features in Yoruba

It is thus not obvious that Standard Yoruba vowel harmony computes non-contrastive features. The difference between the dialects may be one of feature ordering, a difference in the relative scope of [RTR].

Ifẹ Yoruba: [hi] > [RTR]

	[–round]	[+round]
[+high]	i	u
[–RTR] [–high]	e	o
[+RTR] [–high]	ɛ	ɔ
	a	

Standard Yoruba: [RTR] > [hi]

	[–round]	[+round]
[+high] [–RTR]	i	u
[–high]	e	o
[+RTR]	ɛ	ɔ
	a	

SDA Contrastive Features in Yoruba

On this view, *both* Ifẹ and Standard Yoruba limit [RTR] harmony to contrastive values of [RTR].

The difference is in the contrastive scope of [RTR]: in Ifẹ Yoruba the high vowels are not included, in Standard Yoruba they are.

Ifẹ Yoruba: [hi] > [RTR]

	[–round]	[+round]
[+high]	i	u
[–RTR] [–high]	e	o
[+RTR] [–high]	ɛ	ɔ
	a	

Standard Yoruba: [RTR] > [hi]

	[–round]	[+round]
[+high] [–RTR]	i	u
[–high]	e	o
[+RTR] [–high]	ɛ	ɔ
	a	

Vowel Harmony and the Contrastivist Hypothesis

Therefore, we cannot conclude from this example that vowel harmony must sometimes compute all features rather than just contrastive ones.

So far, vowel harmony is consistent with the Contrastivist Hypothesis.

Yoruba Vowel Harmony

Below is how harmony applies to the word *ɔrúkɔ~orúkɔ* 'name' in each dialect, using Nevins's theory of harmony, but the hierarchical approach to contrast, adhering to the Contrastivist Hypothesis.

The initial mid vowel is unspecified for [RTR] and seeks a value from the nearest contrastive source to the right.

In Ifẹ Yoruba the nearest such source is the mid vowel /ɔ/; in Standard Yoruba it is the high vowel /ú/.

Ifẹ Yoruba: [hi] > [RTR]	Standard Yoruba: [RTR] > [hi]
O r ú k ɔ [ ] ⟶ [+RTR] [–RTR]	O r ú k ɔ [ ] ⟶ [–RTR] [+RTR]
= ɔ r ú k ɔ	= o r ú k ɔ

MC Contrastive Features of /a/

Interesting support for the hierarchical approach to contrast comes from the behaviour of the low vowel /a/.

In the MC approach, /a/ has a contrastive [+low] feature, but no other feature, including [RTR], is contrastive, because no other feature uniquely distinguishes /a/ from another phoneme.

	i	e	ɛ	a	ɔ	o	u
[low]	–	–	–	+	–	–	–
[high]	+	–	–	–	–	–	+
[round]	–	–	–	–	+	+	+
[RTR]	–	–	+	+	+	–	–

/a/ in [RTR] Harmony

On this approach we might expect, then, that /a/ would pattern parallel to the high vowels: that it would be neutral to [RTR] harmony in Ifẹ Yoruba (which computes *contrastive values only*), but that it would participate in harmony in Standard Yoruba (where *all values* are computed).

EXPECT

Ifẹ Yoruba	Standard Yoruba
a. oba ‘king’	a. ɔba ‘king’
b. èpà ‘peanut’	b. ɛ̀pà ‘peanut’

/a/ in [RTR] Harmony

We might expect, then, that /a/ would pattern parallel to the high vowels: that it would be neutral to [RTR] harmony in Ifẹ Yoruba (compute contrastive values only), but that it would participate in Standard Yoruba (all values computed).

But this is not what happens: /a/ triggers [RTR] harmony in *both* dialects (Ọla Orie 2001).

ACTUAL

Ifẹ Yoruba			Standard Yoruba	
a.	*oba ‘king’	ɔba	a. ɔba	‘king’
b.	*èpà ‘peanut’	ɛ̀pà	b. ɛ̀pà	‘peanut’

Nevins (2010): Sonority Hurdles

Nevins (2010: 194) has an explanation for why /a/ participates in [RTR] harmony in Ifẹ Yoruba, even though harmony in this dialect is limited to contrastive features, and /a/ is not contrastive for [RTR]. He writes:

> 'certain elements can terminate the search as a result of their inherent high-sonority. These sonority-peaks should be excluded from the domain of search by their noncontrastive value, but impose a hurdle past which search cannot proceed.'

That is, Nevins needs to appeal to a special explanation for the patterning of /a/ in Ifẹ Yoruba, based on its sonority.

SDA Contrastive Features in Yoruba

But a feature-ordering approach yields a simpler account.

We haven't considered where the feature [low] fits into the contrastive hierarchies of these dialects.

Ifẹ Yoruba: [hi] > [RTR]

	[–round]	[+round]
[+high]	i	u
[–high] [–RTR]	e	o
[–high] [+RTR]	ɛ	ɔ
	a	

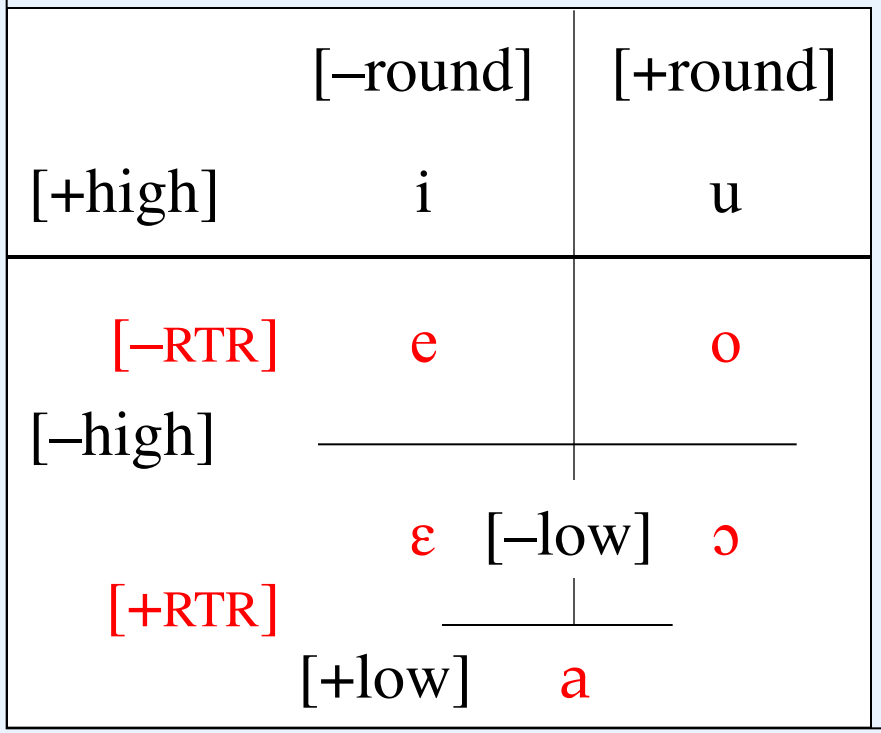
Standard Yoruba: [RTR] > [hi]

	[–round]	[+round]
[+high] [–RTR]	i	u
[–high]	e	o
[+RTR]	ɛ	ɔ
	a	

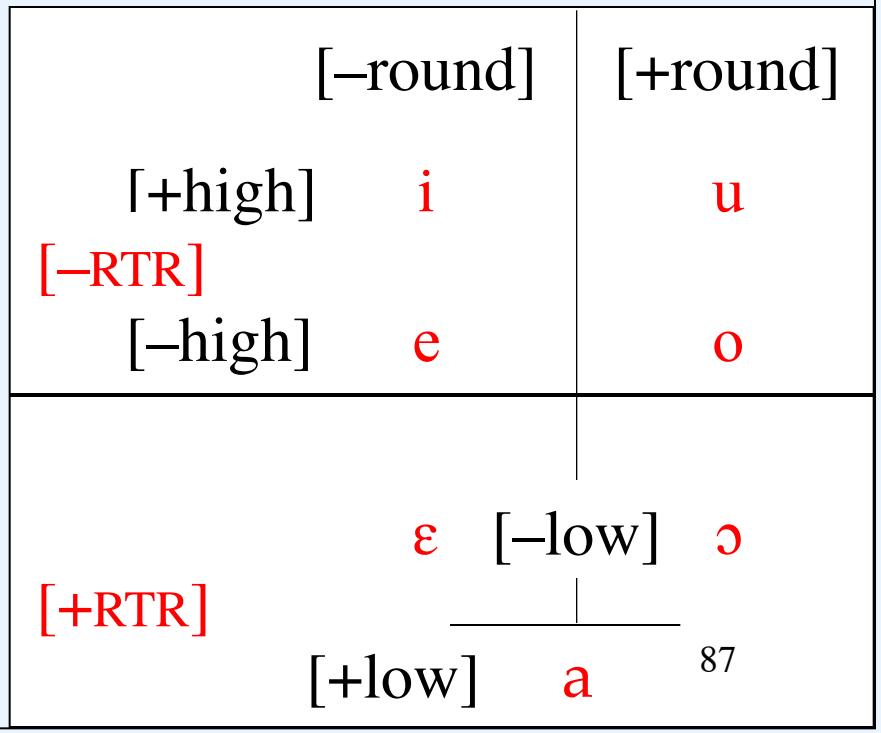
SDA Contrastive Features in Yoruba

Evidently, /a/ is contrastive for [RTR] in *both* dialects, the result of ordering [low] after [RTR] in both.

Ifẹ Yoruba: [hi] > [RTR] > [low]



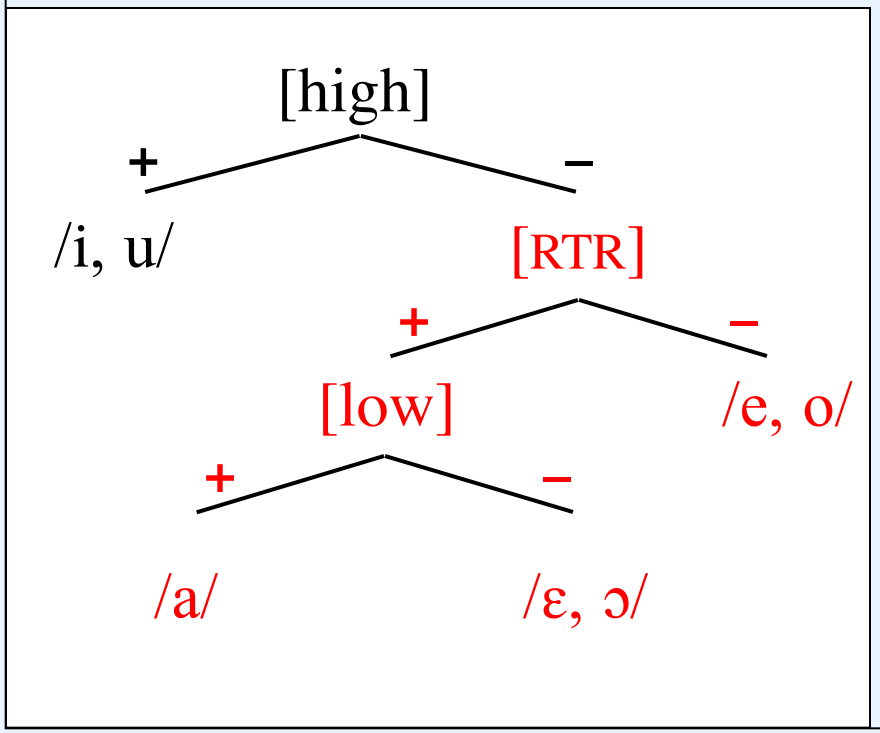
Std Yoruba: [RTR] > [hi] > [low]



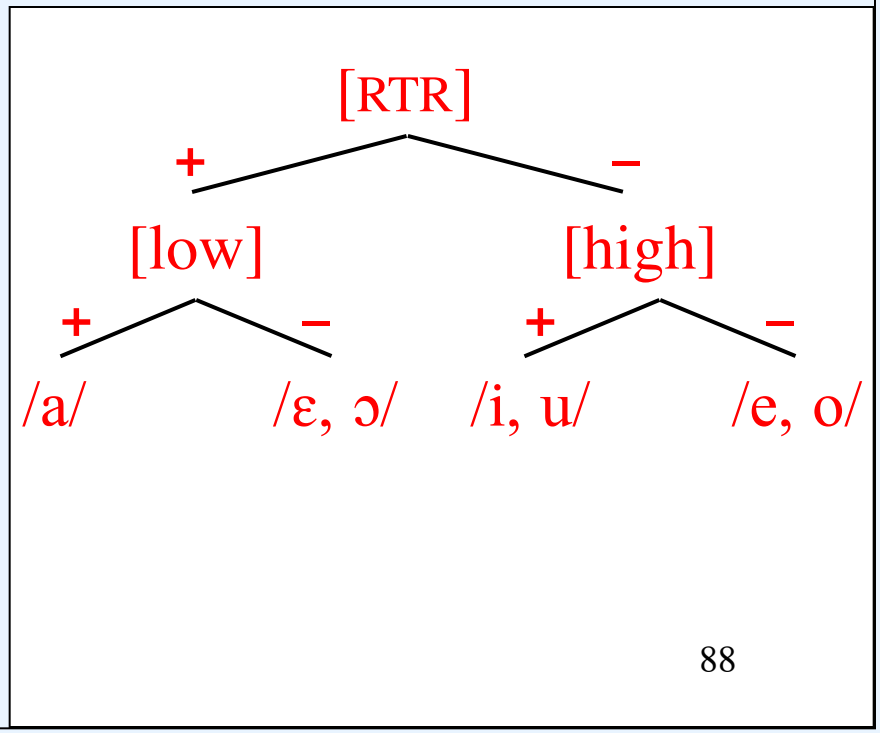
SDA Contrastive Features in Yoruba

Evidently, /a/ is contrastive for [RTR] in *both* dialects, the result of ordering [low] after [RTR] in both.

Ifẹ Yoruba: [hi] > [RTR] > [low]



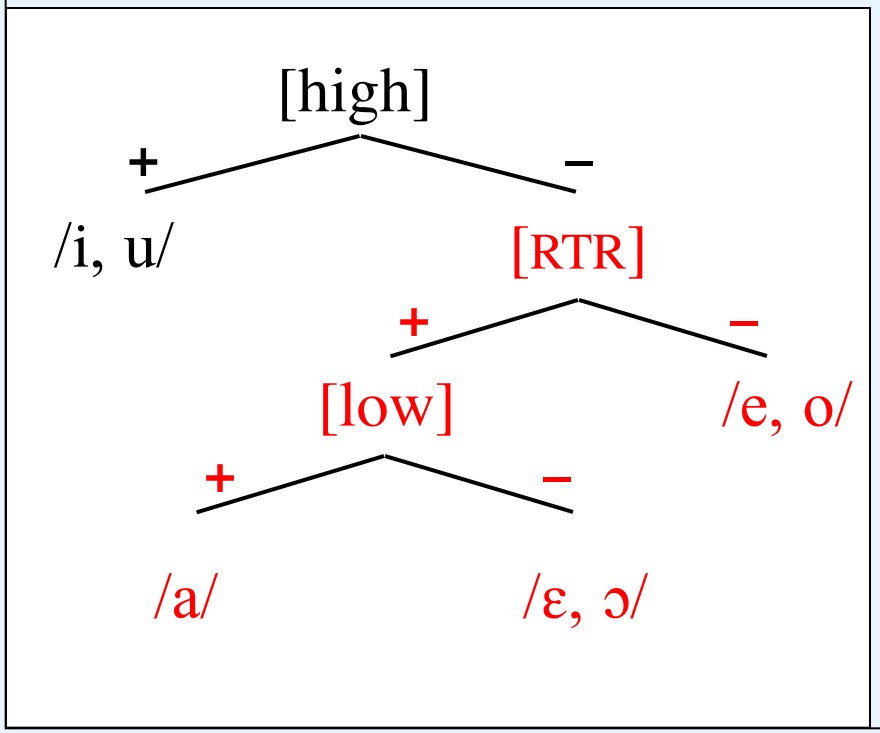
Std Yoruba: [RTR] > [hi] > [low]



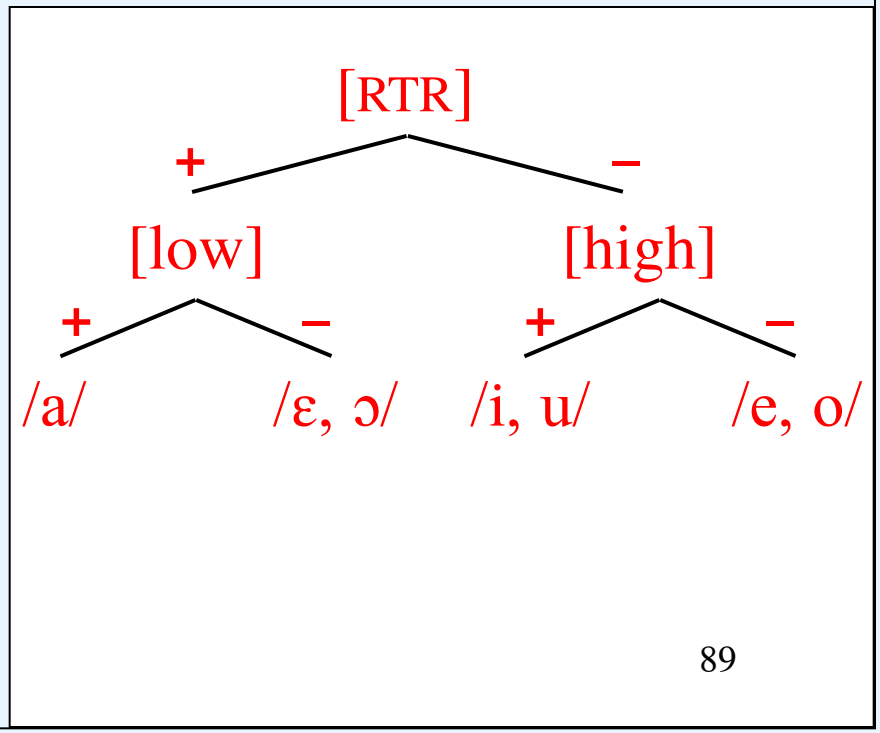
SDA Contrastive Features in Yoruba

One might argue that this result is not *required* by the SDA: we can order the features this way if this gives the correct result.

Ifẹ Yoruba: [hi] > [RTR] > [low]



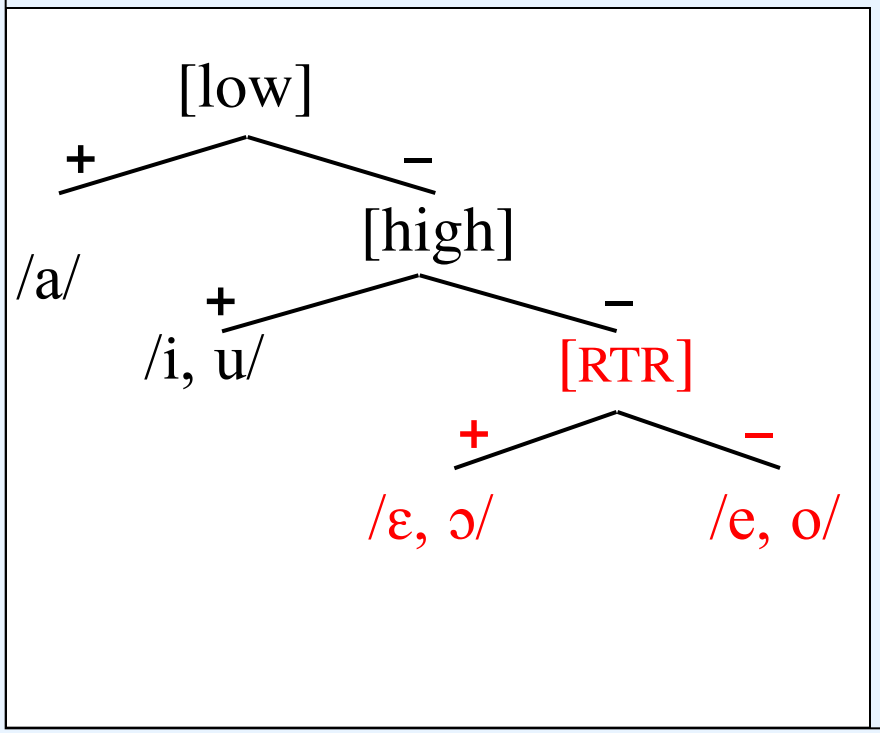
Std Yoruba: [RTR] > [hi] > [low]



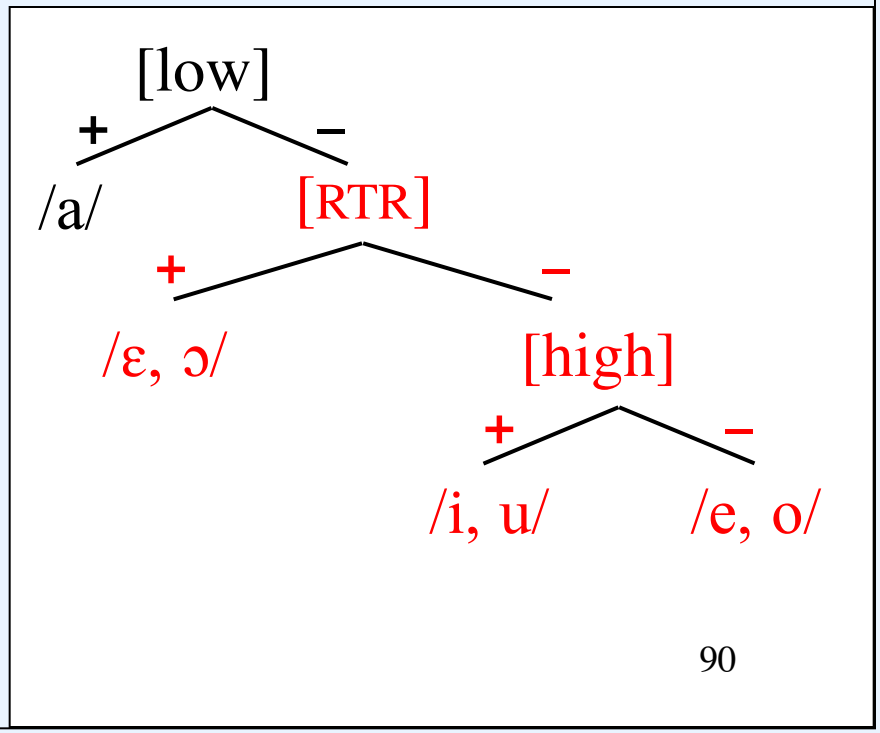
SDA Contrastive Features in Yoruba

But the theory also allows for other orderings; for example, we can put [low] at the top of the order, which puts /a/ outside the domain of [RTR] harmony.

Or: [low] > [hi] > [RTR]



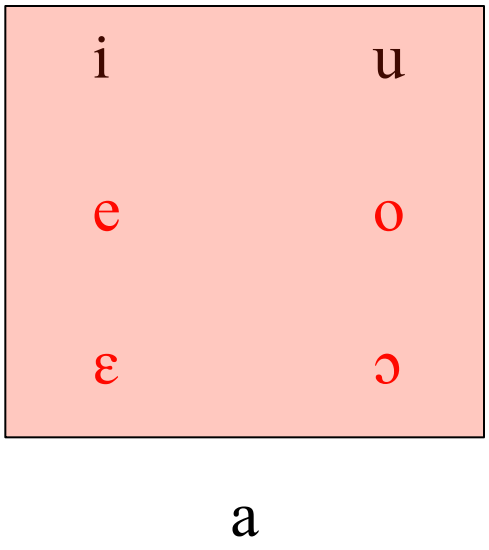
Or: [low] > [RTR] > [high]



A Sonority-based Prediction

Nevins (2010: 195) predicts that certain patterns allowed by free ordering do not occur. I paraphrase his formulation as follows:

Given a language where some vowels are contrastive for a feature (e.g. [RTR]), and where other vowels are noncontrastive for that feature (by MC: here the high and low vowels); and given that harmony normally computes only contrastive features; then if the noncontrastive vowels differ in sonority:

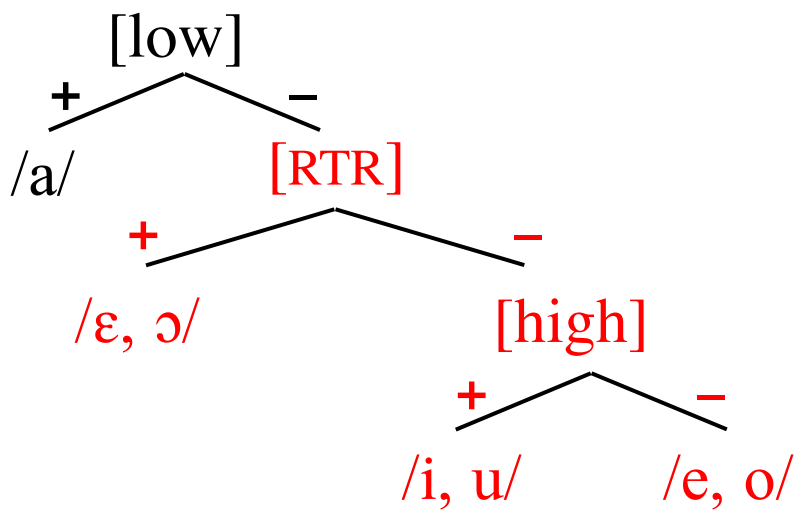


it will never be the case that a higher sonority noncontrastive vowel (/a/) is transparent while a lower sonority noncontrastive vowel (/i, u/) is not.

A Sonority-based Prediction

Looking at this from the point of view of feature ordering, the prediction is that the order [low] > [RTR] > [high] is not permitted.

[low] > [RTR] > [high]

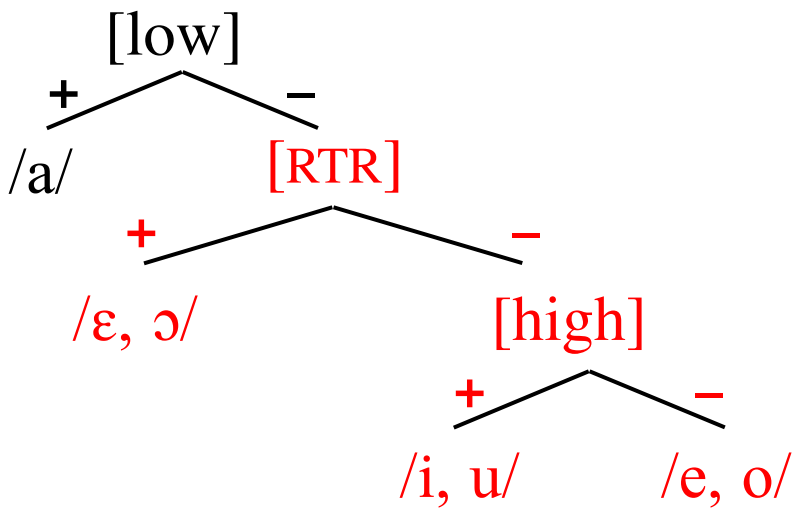


In this language, /a/ is outside the harmony domain, hence transparent and non-triggering, whereas the high vowels are in the scope of the harmonizing feature, hence are expected to block the spread of [+RTR], or be donors of [–RTR].

A Sonority-based Prediction

Looking at this from the point of view of feature ordering, the prediction is that the order [low] > [RTR] > [high] is not permitted.

[low] > [RTR] > [high]



That is, in this language we might expect forms like

oba and orako

as well as forms like

obi *ɔbi and orikɔ *ɔrikɔ

Reply to the Sonority-based Prediction

However, it is not clear that this prediction is correct. Leitch (1996) and Casali (2008) show that there is a lot of variation in the behaviour of /a/ in vowel systems with [RTR/ATR] harmony.

For example, Leitch (1996: 127) observes that in Bolia, a Bantu (C-30) language with a 7-vowel system like that of Yoruba, the low vowel /a/ assimilates completely to a preceding [RTR] mid vowel.

But this assimilation is blocked by a high vowel /i/.

Reply to the Sonority-based Prediction

This pattern appears to go against the sonority-based prediction, recall:

> it will never be the case that a higher sonority noncontrastive vowel (/a/) is transparent while a lower sonority noncontrastive vowel (/i, u/) is not.

However, it should be noted that the behaviour of /a/ in these Bantu languages is completely different than in Yoruba, and the mechanism for the harmony in these languages may also be quite different.

Therefore, it is possible that Nevins's sonority prediction may be saved once we further articulate the specific formal conditions under which it holds.

Reply to the Sonority-based Prediction

If, then, the prediction is correct, note that it is *still* compatible with a feature-ordering approach.

In particular, it would indicate that there are constraints on possible feature ordering, an interesting and welcome result, if true.

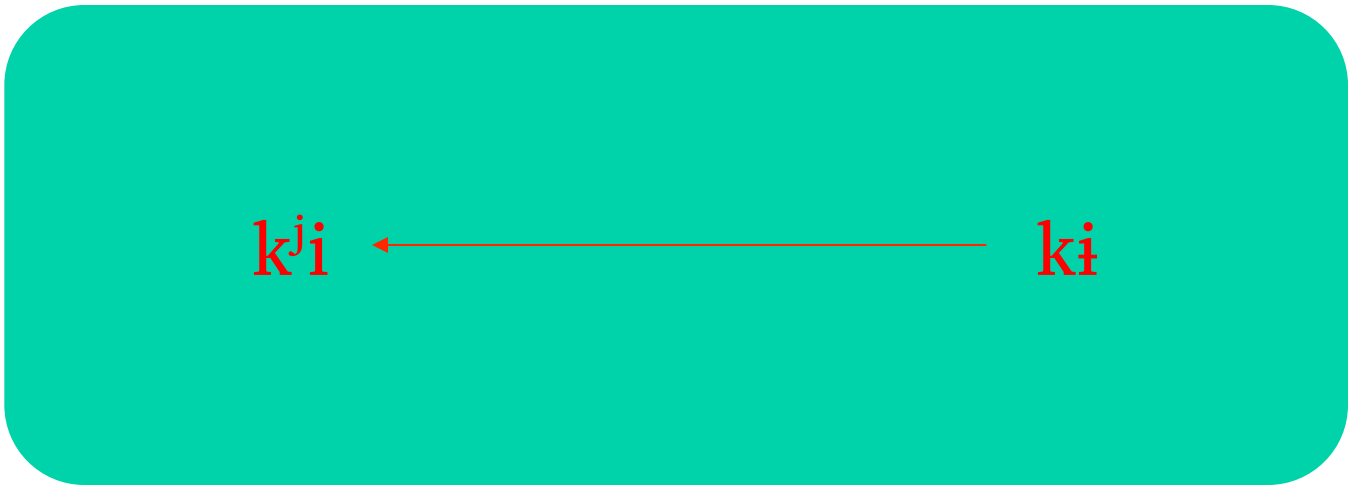
But the point still stands that there is no reason to suppose that Standard Yoruba harmony computes noncontrastive features.

How a Change in the Underlying Contrasts Causes a Diachronic Change:

East Slavic Post-velar Fronting

East Slavic post-velar fronting

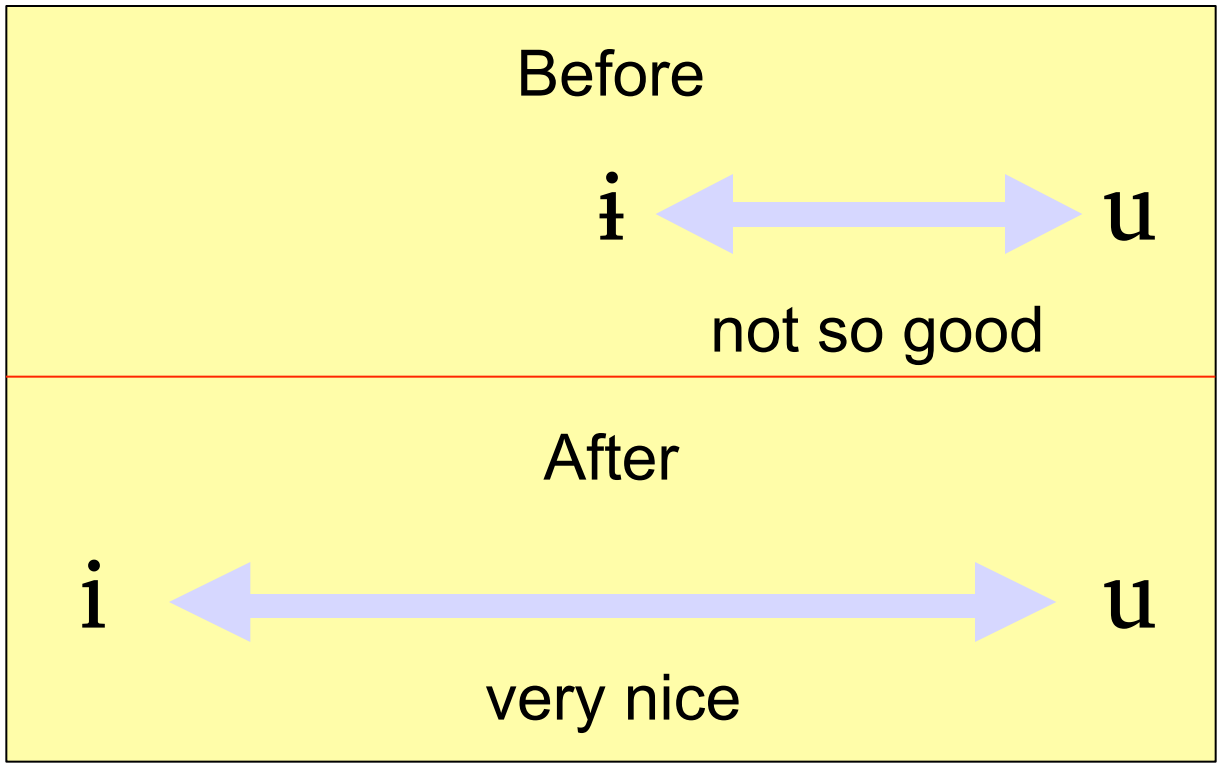
Between the 12th and 14th centuries kɨ fronted to kʲi in East Slavic.



What caused this fronting? Everyone agrees that the lack of contrast at the time between k and kʲ is crucial to accounting for this change.

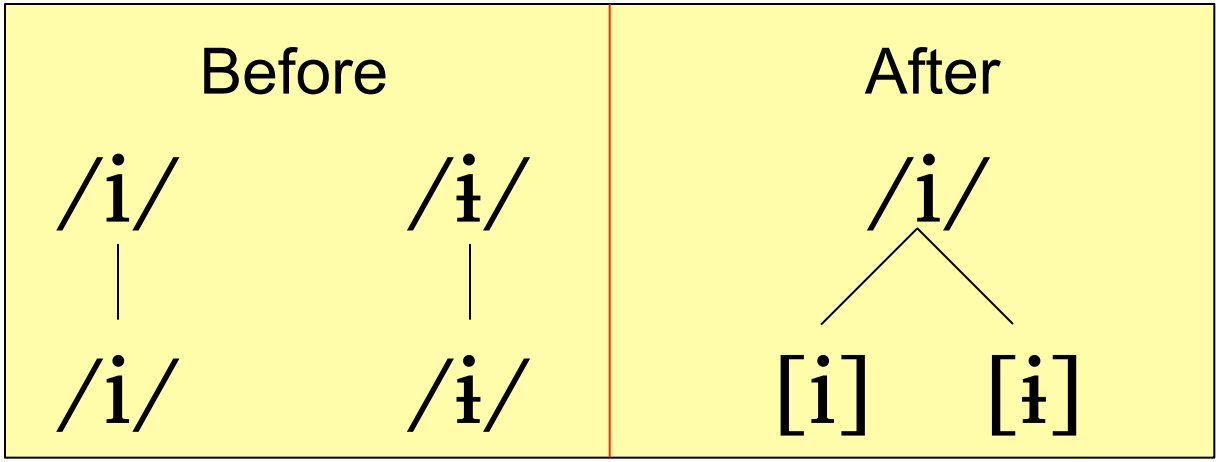
Introduction

Padgett (2003) argues that it was motivated also by the surface distance between i and u.



Introduction

I argue, following Jakobson (1929), that the trigger was the reanalysis of underlying vowel contrasts, whereby the phoneme /ɨ/ became a positional allophone of /i/.



Introduction

At issue is the proper way to incorporate contrast into phonology. I will argue for the following positions:

- Which features does the phonology compute?
  NOT all features but only contrastive features

- How is contrast assessed?
  NOT by minimal pairs but by a contrastive feature hierarchy

- Where does phonology access contrast?
  NOT at the surface but at the underlying form

Introduction

I will begin by giving a fairly standard account of some changes in the history of Slavic that led up to this change.

Then I will discuss both analyses and argue in favour of my approach, which adheres to the framework of Modified Contrastive Specification (Toronto phonology)

Some Slavic Diachrony

Slavic Sound Changes

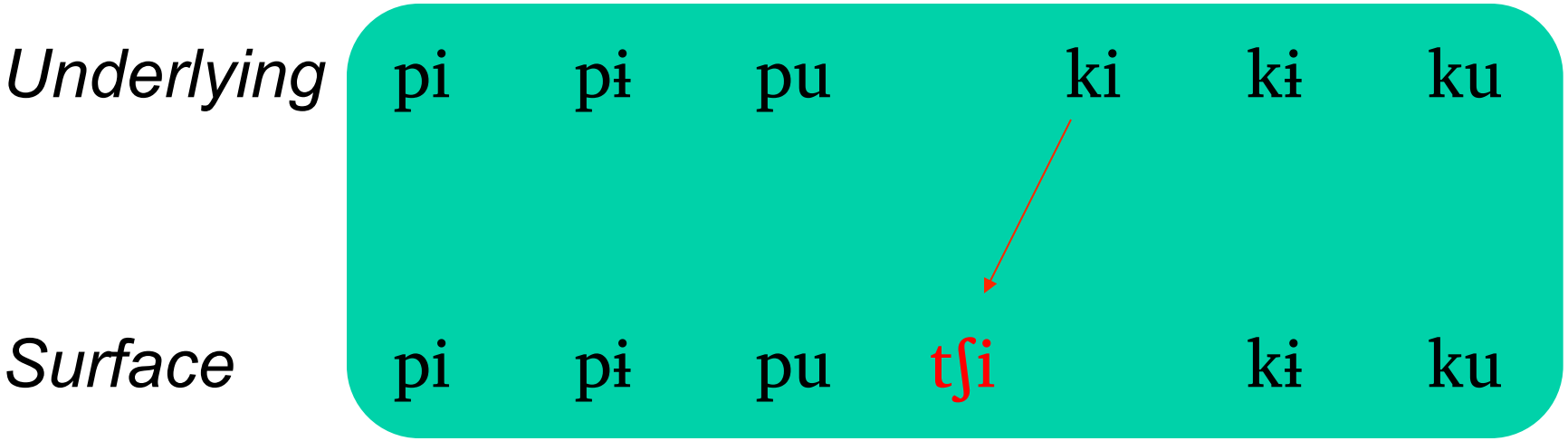
Underlying	pi	pɨ	pu	ki	kɨ	ku
Surface	pi	pɨ	pu	ki	kɨ	ku

Prior to Changes

/i/, /ɨ/, and /u/ are separate phonemes.

/p/ and /k/ occur before all vowels.

Slavic Sound Changes

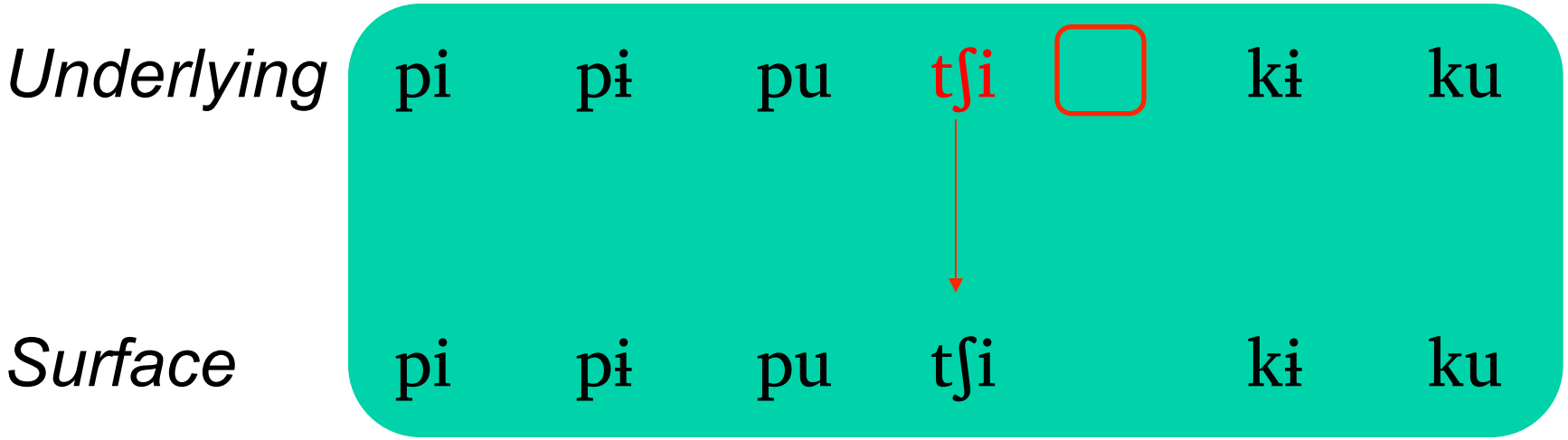


First Velar Palatalization (Common Slavic)

Velar [k] mutates to palatoalveolar [tʃ] before /i/.

This begins as a phonetic change.

Slavic Sound Changes



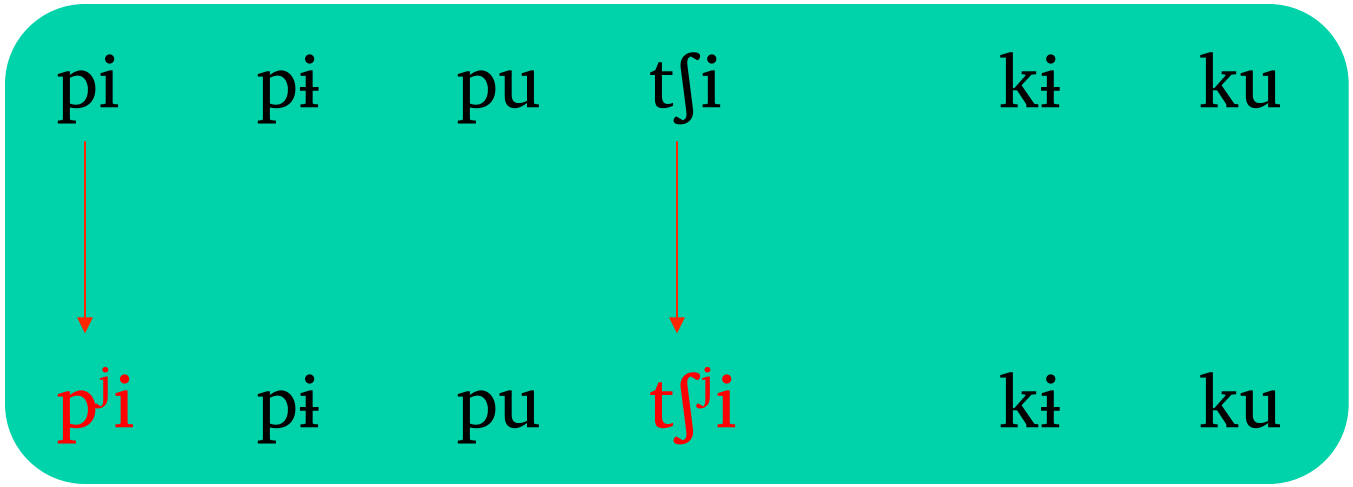
First Velar Palatalization (Common Slavic)

At some point [tʃ] is reanalyzed as /tʃ/,

losing its connection to /k/.

This left a gap in the phonotactics, as now there was no /ki/.

Slavic Sound Changes



Palatalization of Consonants Before Front Vowels (Post-Common Slavic)

This change begins as a predictable allophonic palatalization.

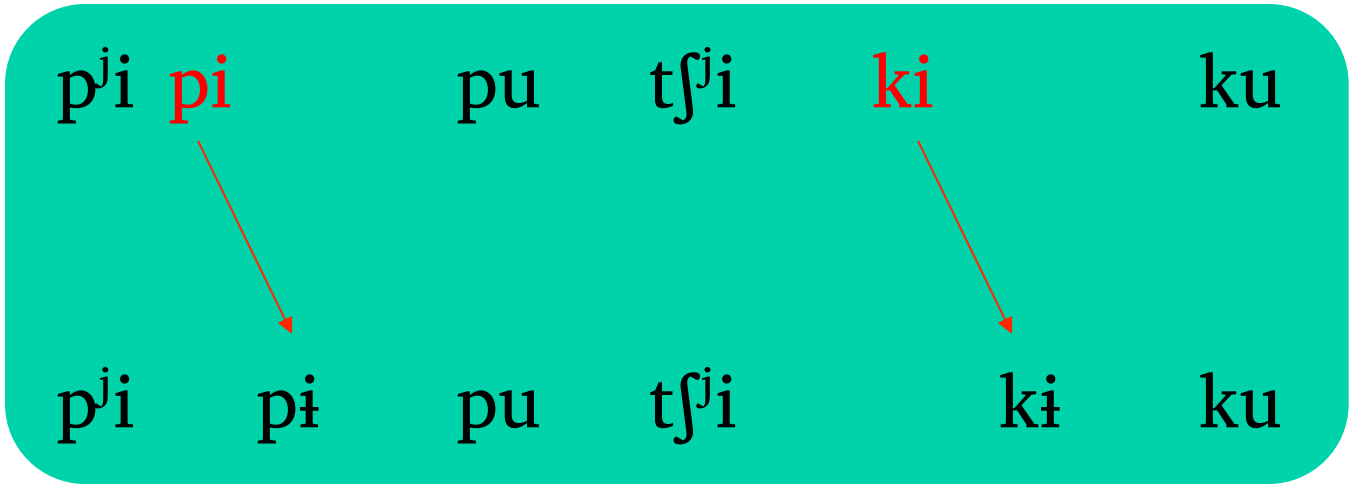
Consequences of the Fall of the Jers (Early East Slavic)

Underlying	pʲi	pɨ	pu	tʃʲi	kɨ	ku
Surface	pʲi	pɨ	pu	tʃʲi	kɨ	ku

Palatalized consonants become phonemic

The surface loss of short high front and back vowels (*jers*) made palatalization opaque and led to a reanalysis of palatalized consonants as underlying.

Consequences of the Fall of the Jers (Early East Slavic)



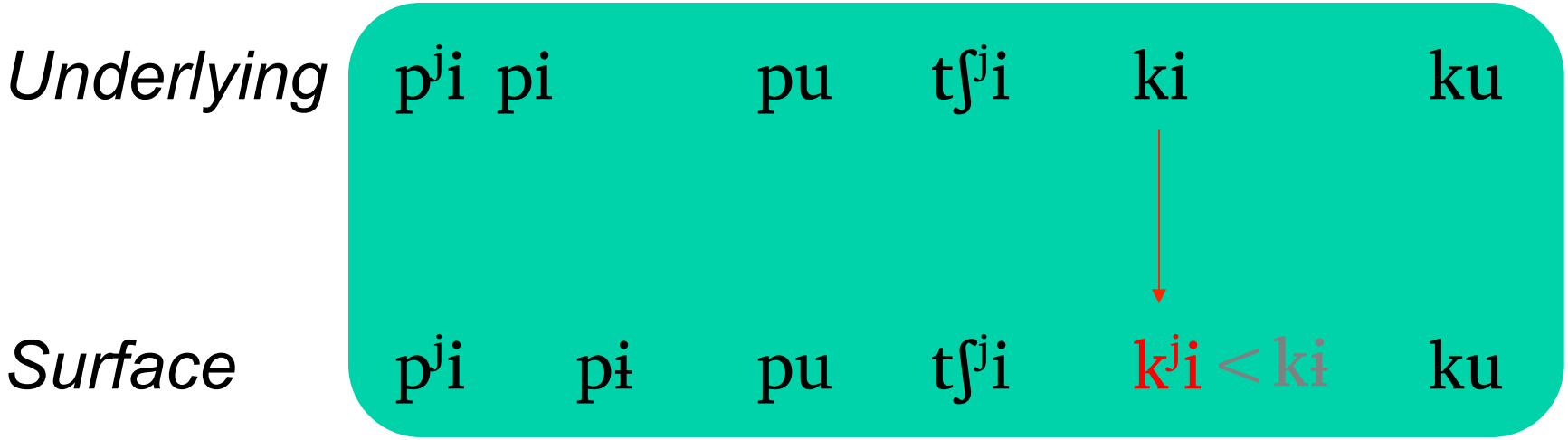
/ɨ/ becomes an allophone of /i/

Due to the above and other changes,

[ɨ] occurs only after non-palatalized consonants,

in complementary distribution with [i].

Why Post-Velar fronting?



Post-Velar Fronting (East Slavic)

What caused [kɨ] to front to [kʲi]?

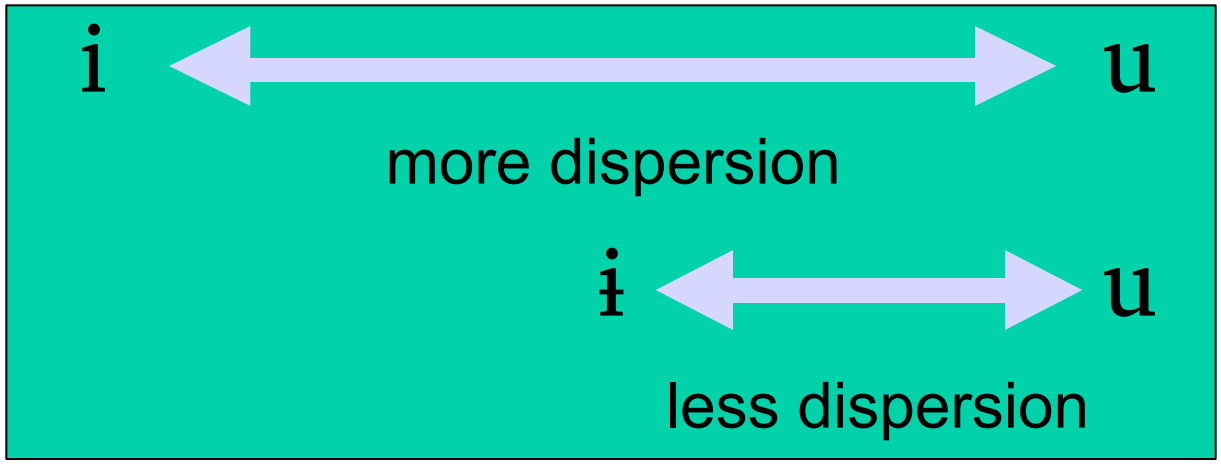
A Dispersion Theory Analysis

(Padgett 2003)

A Dispersion Theory Analysis

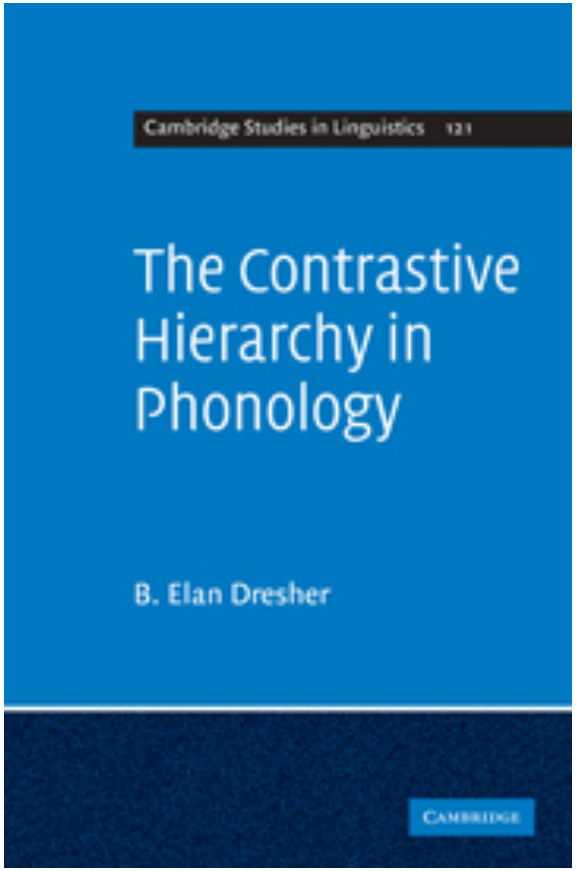
(Padgett 2003)

Padgett (2003) looks at surface phonetic contrasts and proposes that the key to the change of kɨ to k^{j}i is that k^{j}i makes a better perceptual contrast with ku than does kɨ.



Formal Implementation of the DT Analysis

I have argued elsewhere (Dresher 2009*) that there are technical problems with the DT analysis, but I will not dwell on these here.



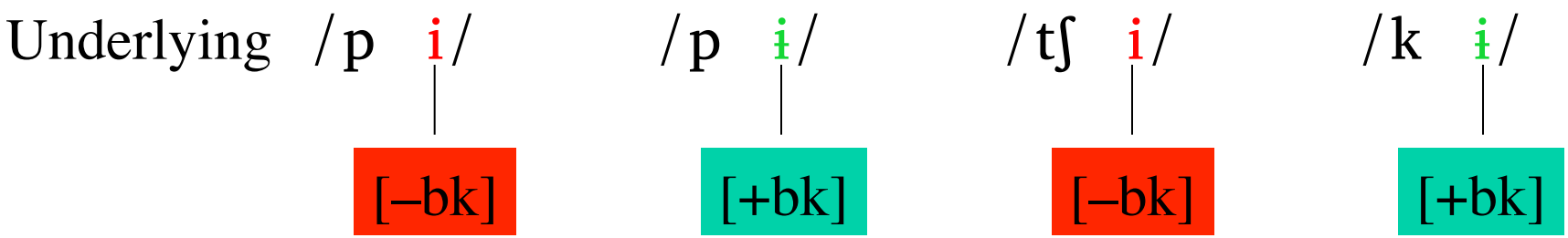
*See pages 218–220.

Modified Contrastive Specification

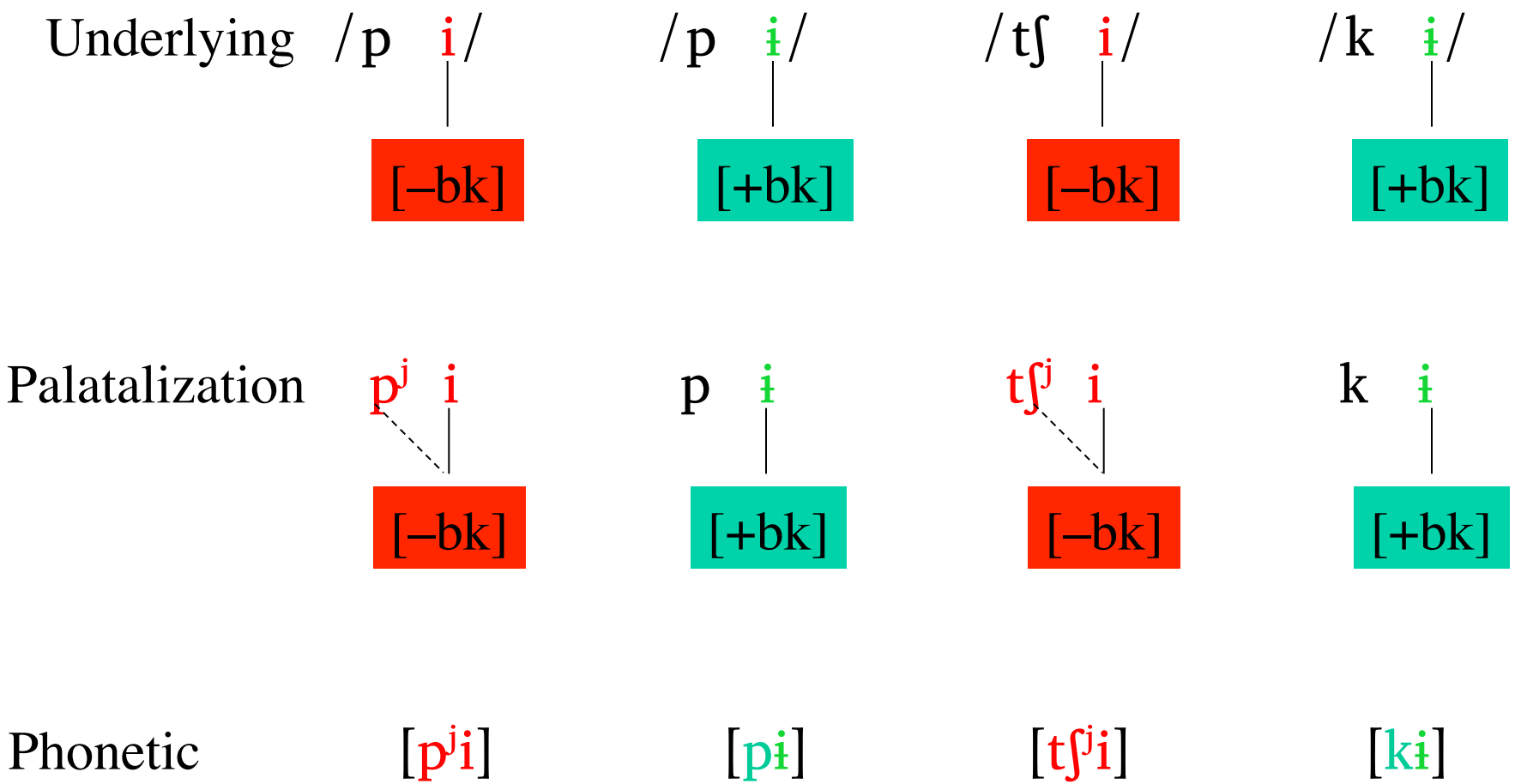
The theory of the contrastive hierarchy suggests a different solution to post-velar fronting, one which is closer to the spirit of Jakobson's (1929) analysis. In keeping with generative grammar, it requires paying attention to the succession of *grammars*, not just to changing surface forms.

Based on the traditional chronology given earlier, I assume the following sequence of grammars, starting with Common Slavic, after First Velar Palatalization (FVP) but before the East Slavic post-velar fronting:

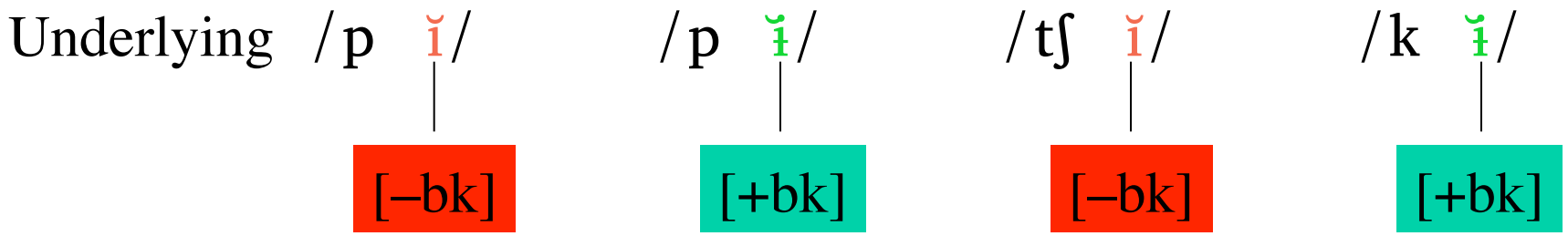
Stage 1: Vowels, not consonants, are contrastively [back]



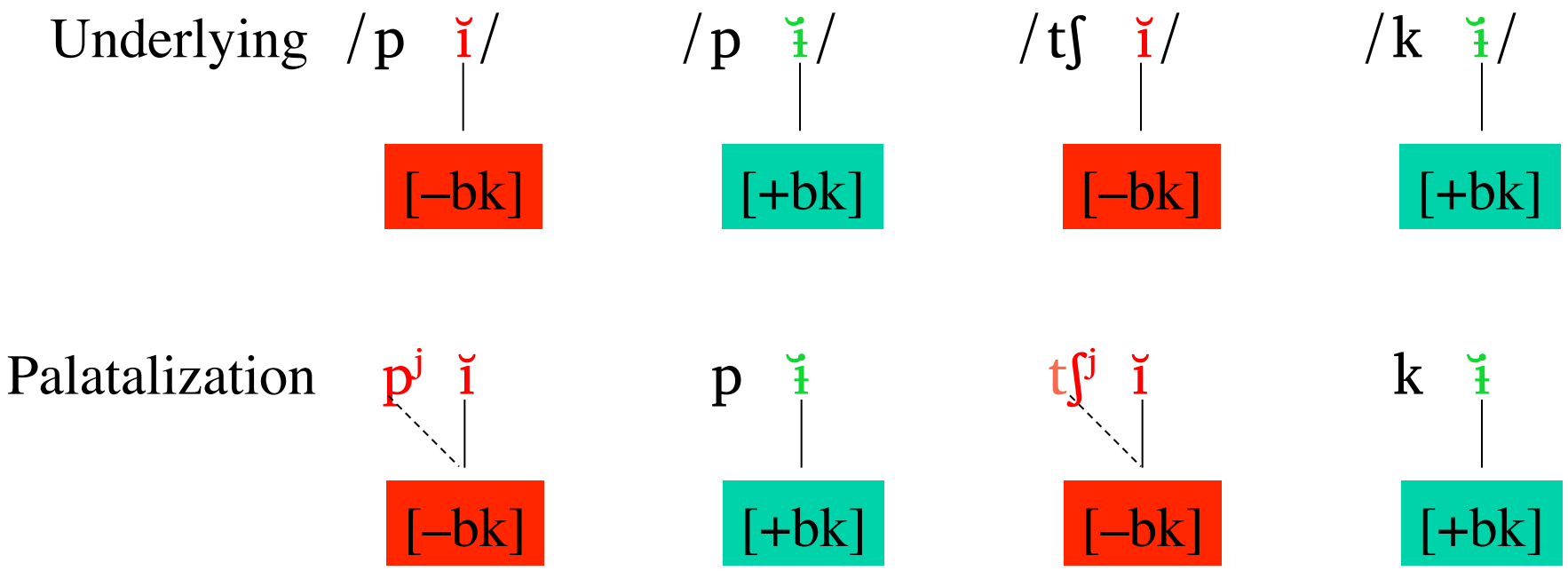
Stage 1: [–back] vowels cause preceding consonants to palatalize allophonically.



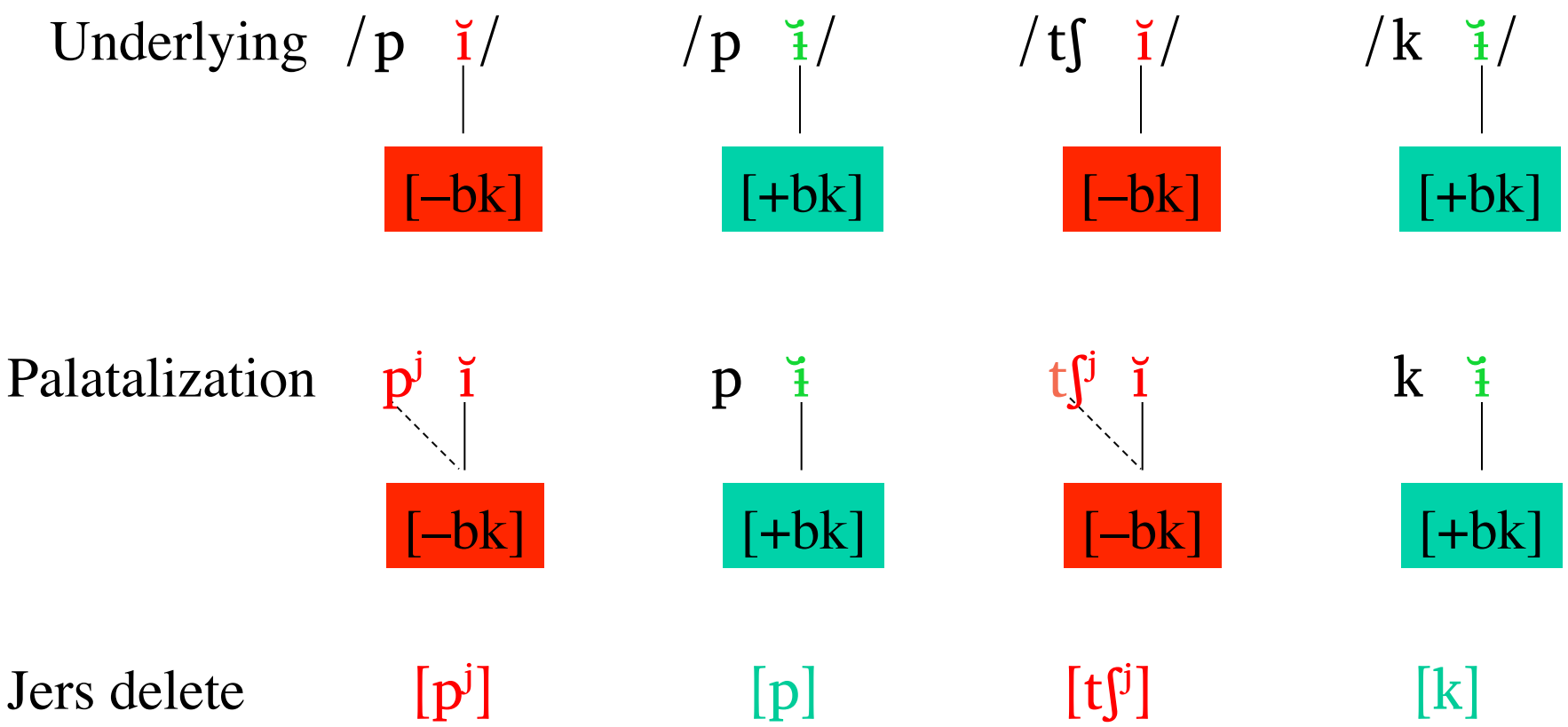
Stage 2: There were two ultra-short vowels called jers: one was a front vowel and the other was a back vowel.



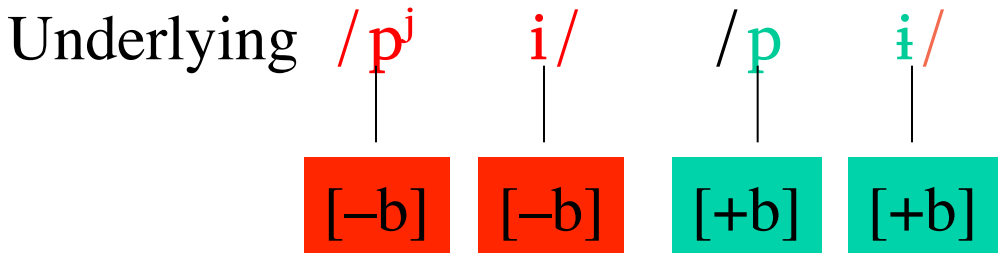
Stage 2: The front jer palatalized like other front vowels, the back one did not.



Stage 2: The fall of the jers made palatalization opaque and led to the reanalysis of palatalized consonants as underlying.



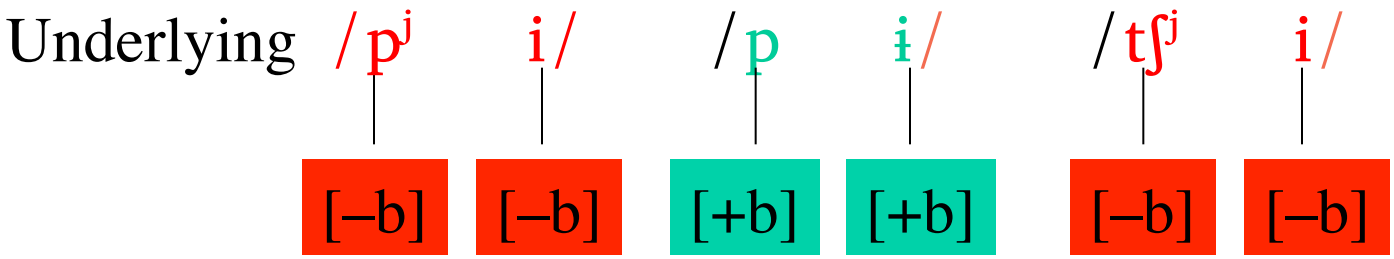
Stage 3: Vowels and *paired* consonants are contrastively [back].



Palatalization — —

Phonetic [pʲi] [pɨ]

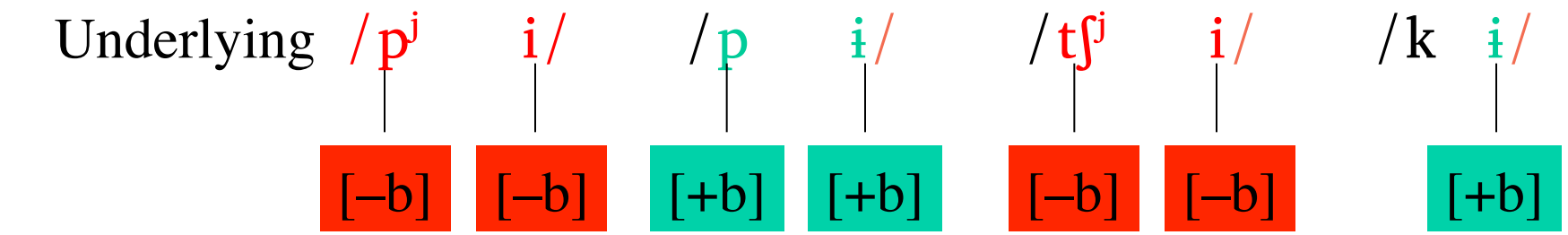
Stage 3: Some coronals, like /tʃʲ/, are unpaired, but function as contrastively [–back].



Palatalization — — —

Phonetic [pʲi] [pi̟] [tʃʲi]

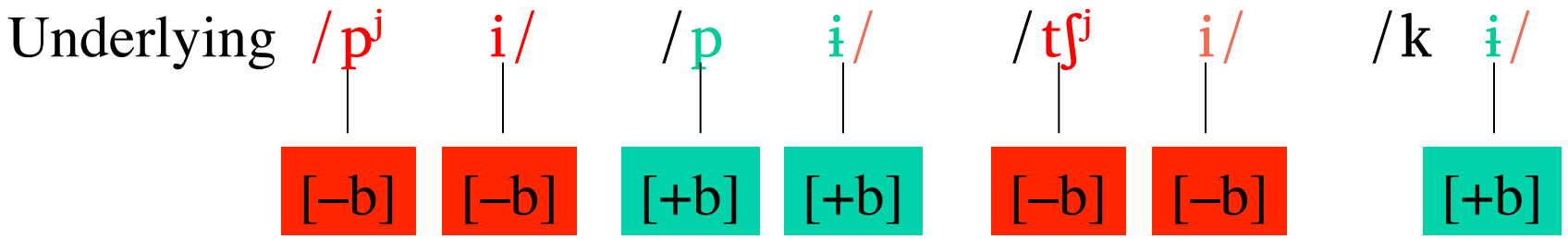
Stage 3: Velars are unpaired, but they are *not* contrastively [back]. Why the difference between /tʃʲ/ and /k/?



Palatalization — — — —

Phonetic [pʲi] [pi̟] [tʃʲi] [ki̟]

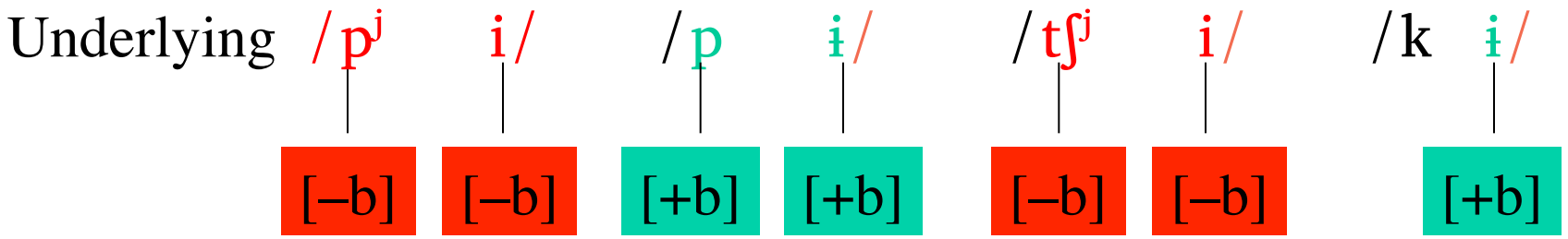
Stage 3: The contrastive status of unpaired consonants depends on the contrastive hierarchy.



Palatalization — — — —

Phonetic [pʲi] [pɨ] [tʃʲ] [kɨ]

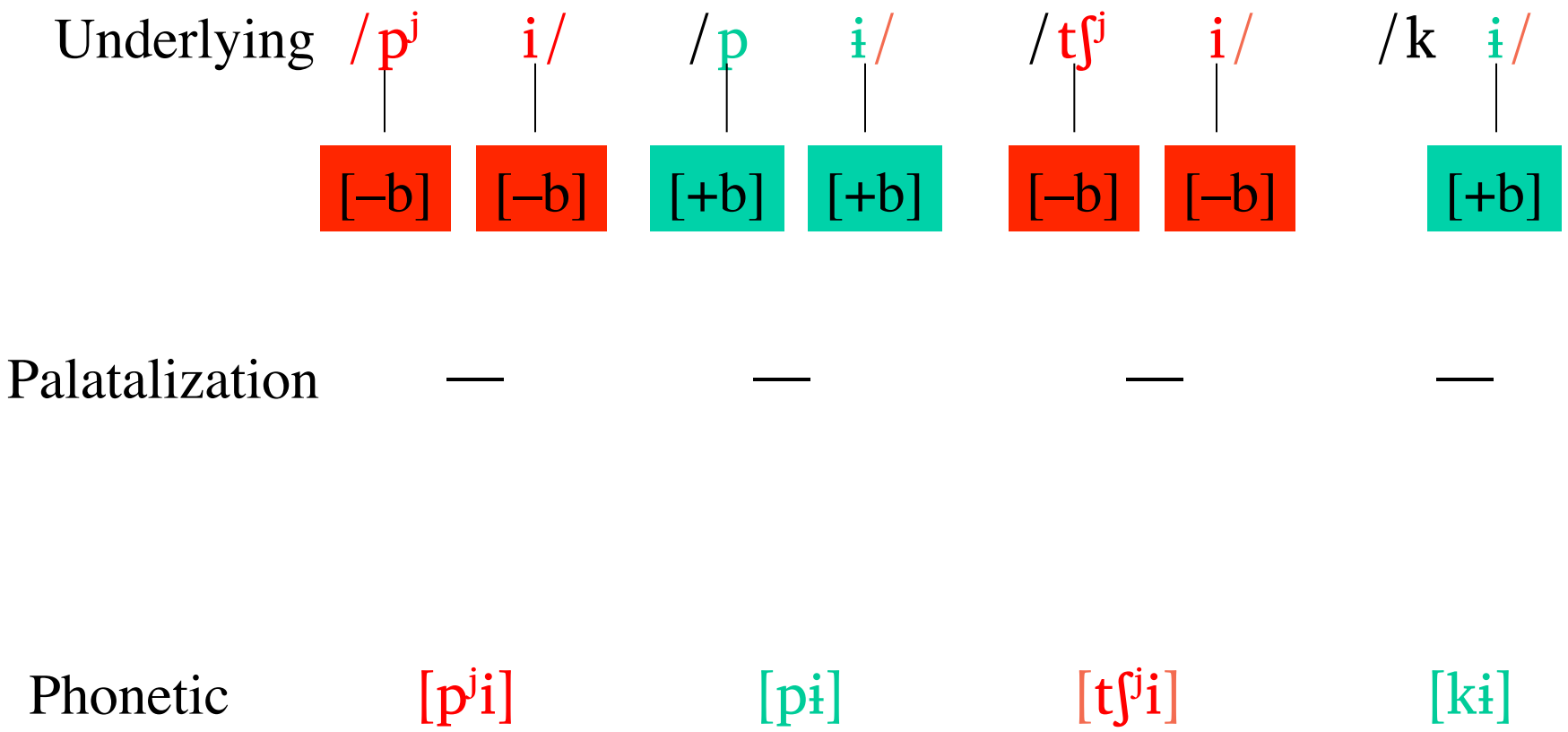
Stage 3: I will show why unpaired coronals are contrastive for [back] while velars are not contrastively [+back].



Palatalization — — — —

Phonetic [pʲi] [pi̟] [tʃʲi] [ki̟]

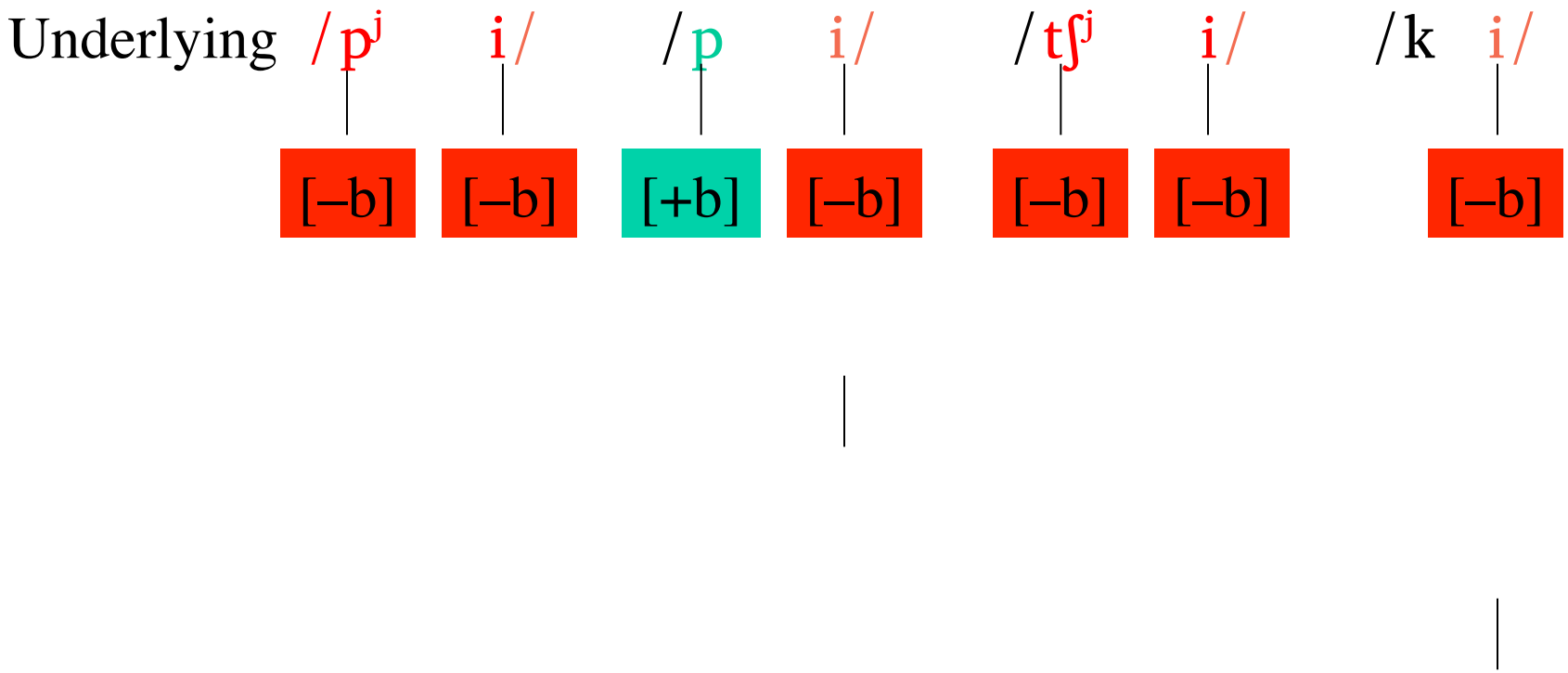
Stage 3: For now let us assume this result.



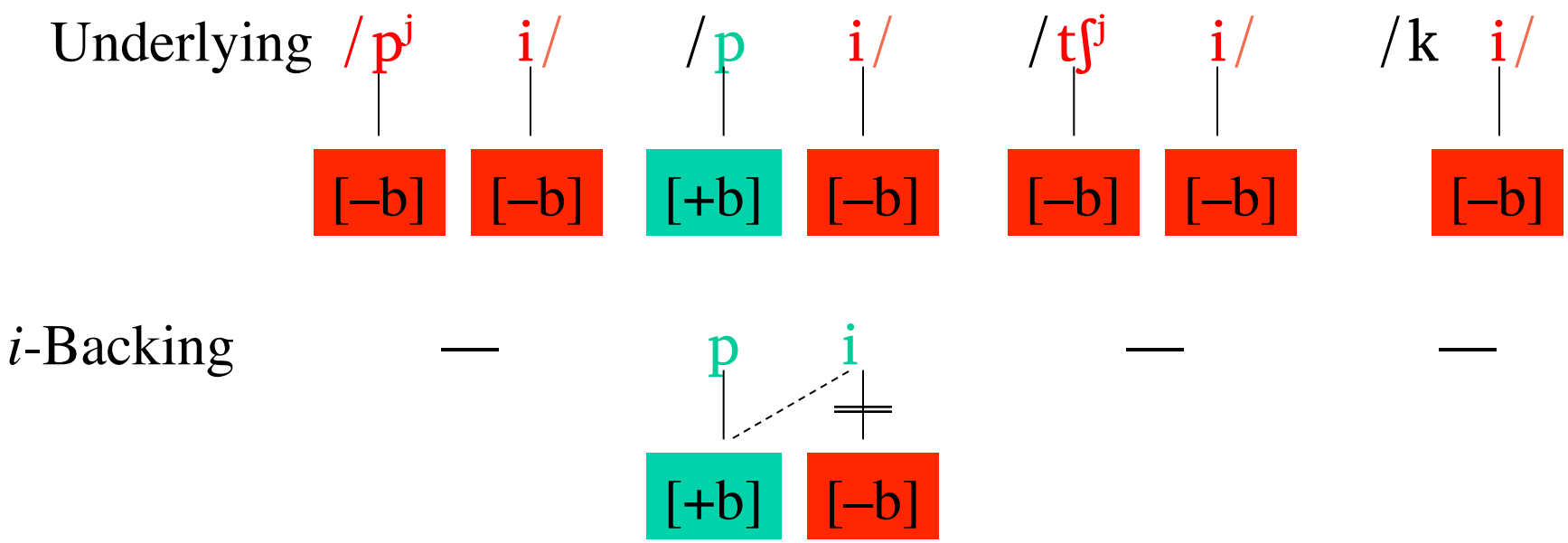
Stage 4: The regularity whereby [ɨ] followed back consonants and [i] occurred elsewhere led to a reanalysis:

Phonetic	[pʲi]	[pɨ]	[tʃʲi]]	[kɨ]

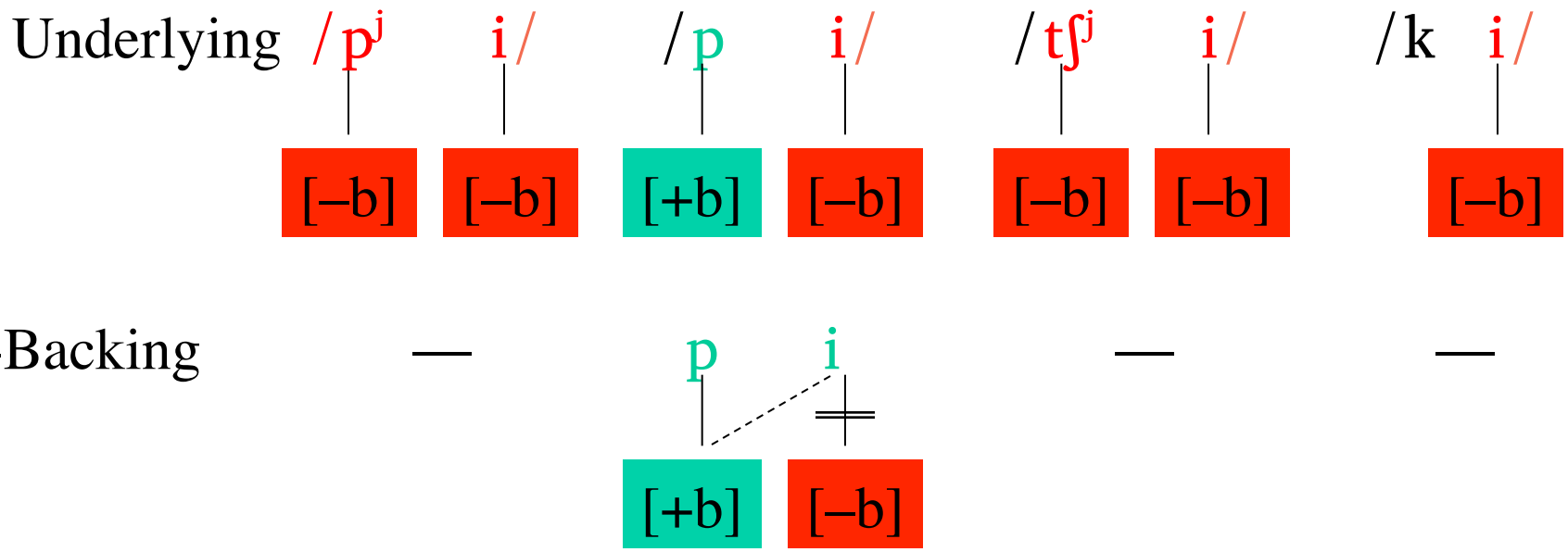
Stage 4: /ɨ/ is reanalyzed as a [+back] allophone of [–back] /i/



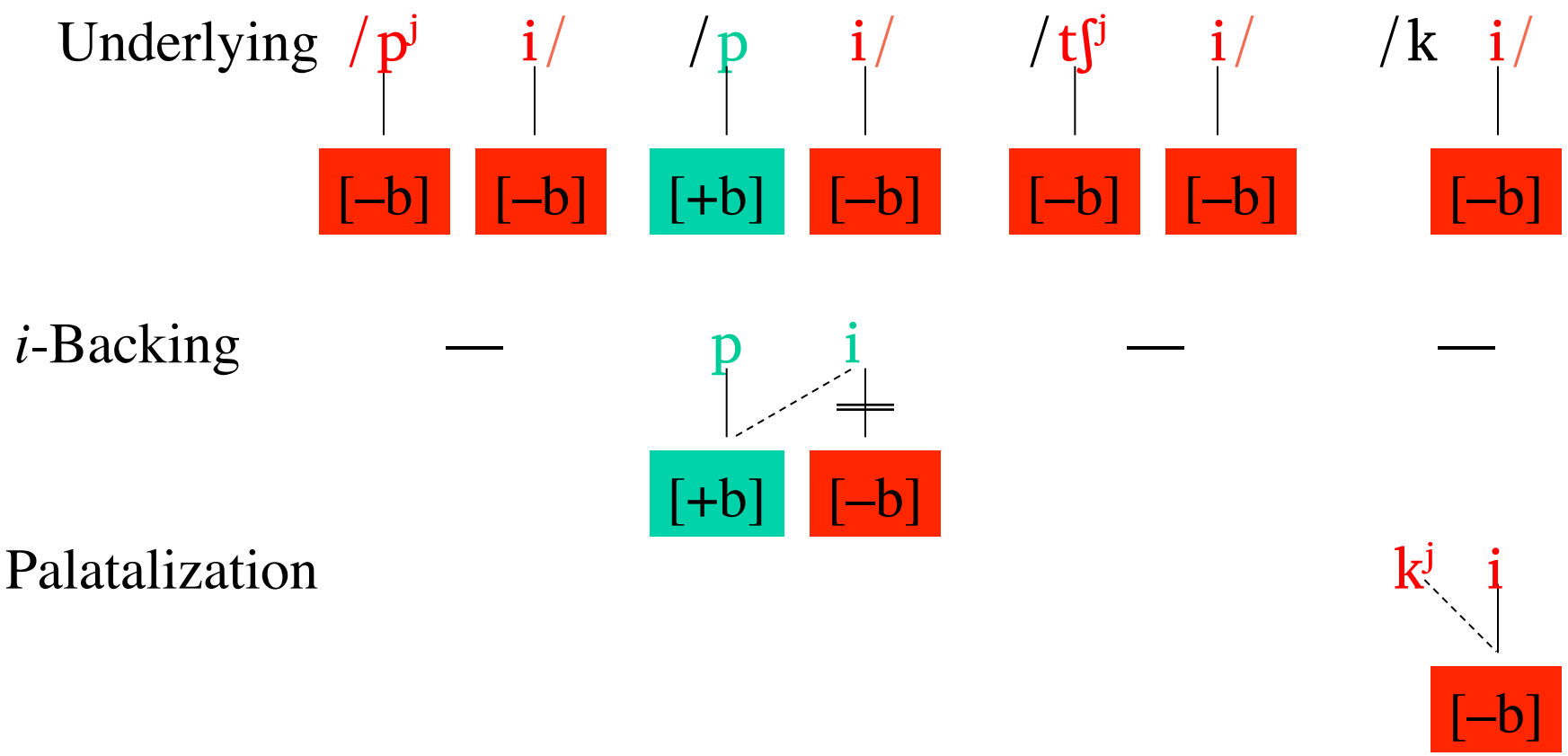
Stage 4: The reanalysis requires a rule that backs /i/ to [ɨ] after a [+back] consonant.



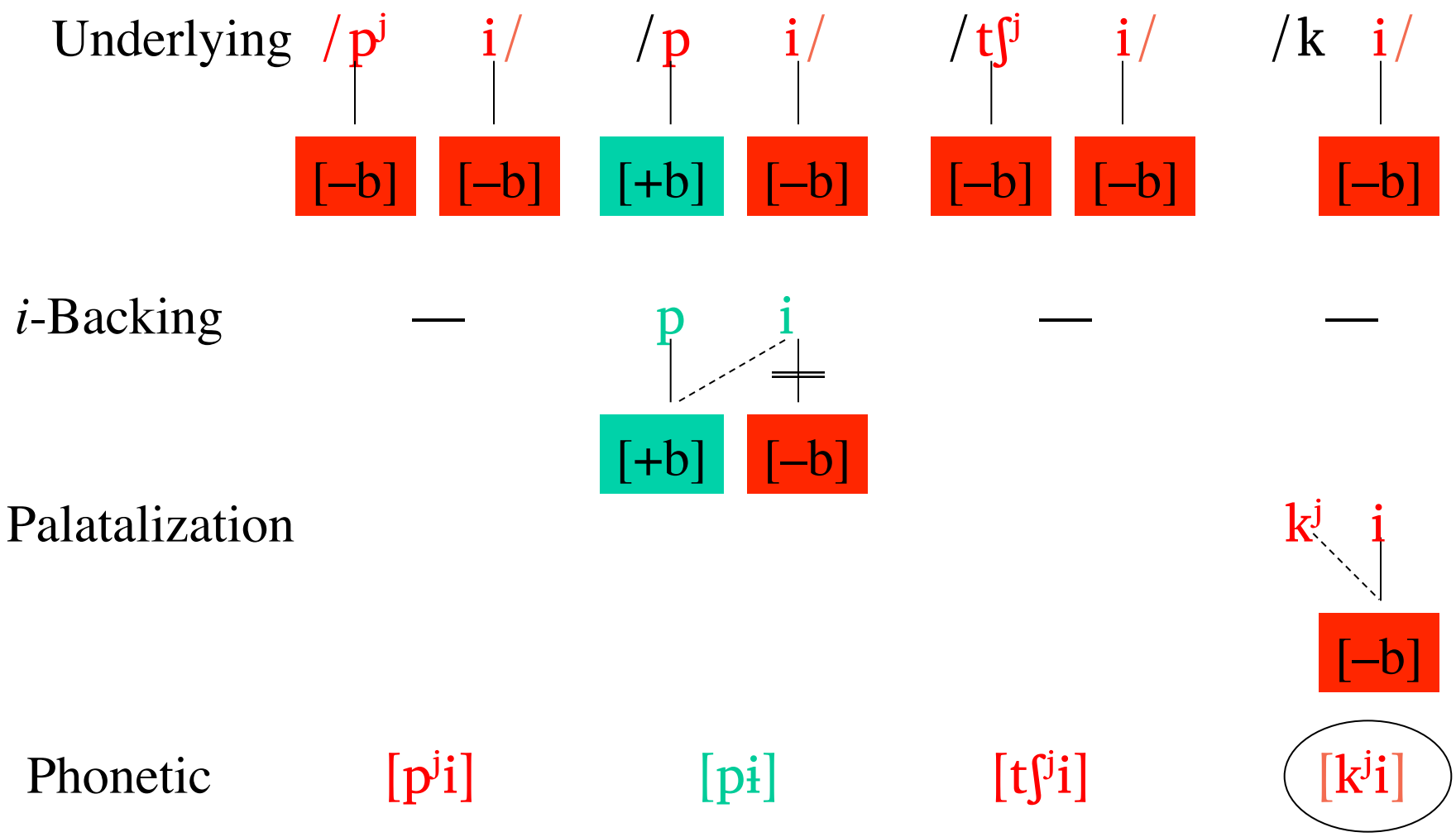
Stage 4: But /k/ has no contrastive [+back] feature that can affect the vowel.



Stage 4: Instead, /i/ palatalizes the /k/.



Stage 4: The consequence is post-velar fronting: it appears that [kɨ] > [kʲi].

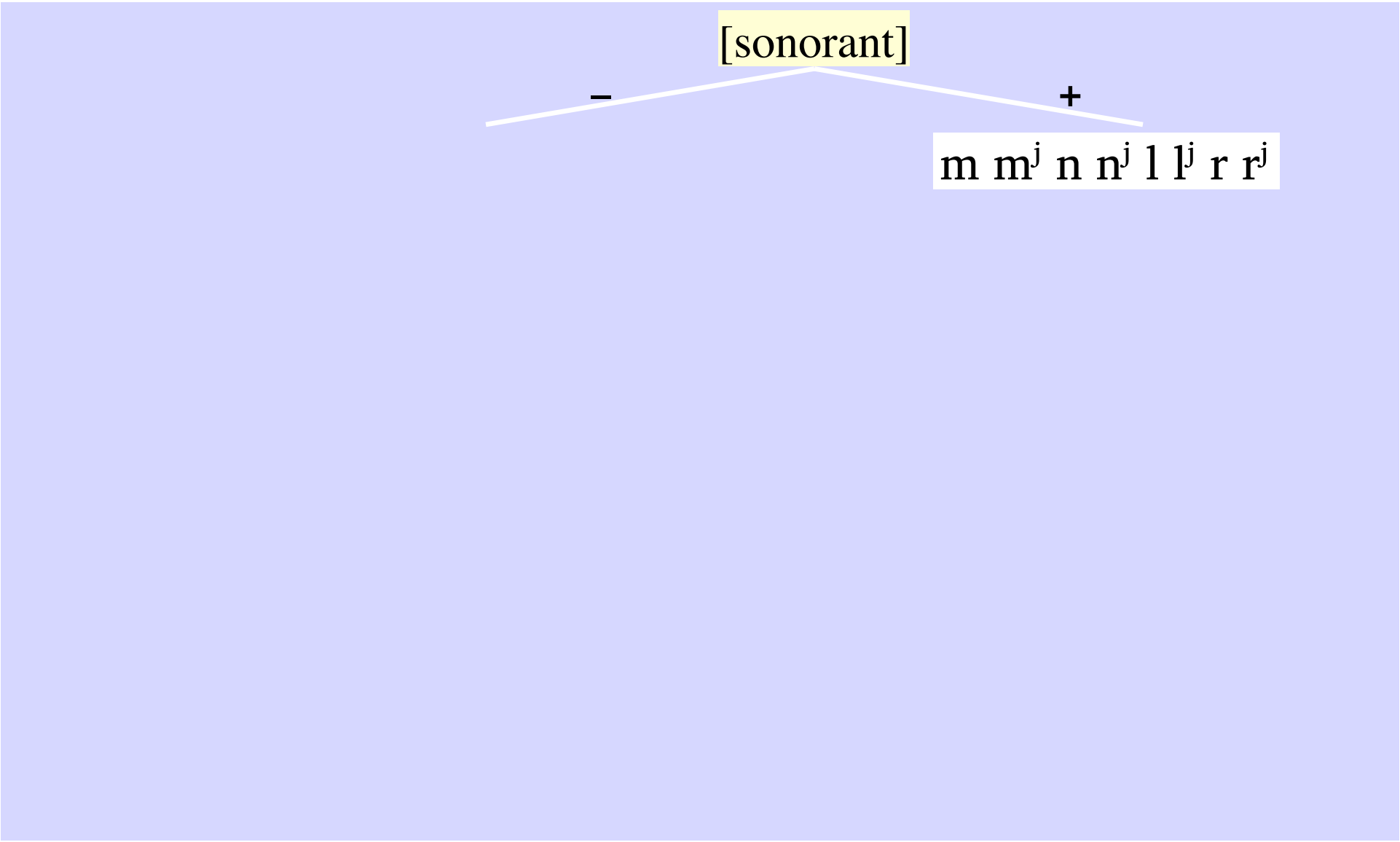


A Contrastive Hierarchy Analysis

This is essentially Jakobson's (1929) analysis, in which the crucial event that provoked post-velar fronting was the reanalysis of [ɨ] as an allophone of /i/, not the lack of dispersion between [i] and [u].

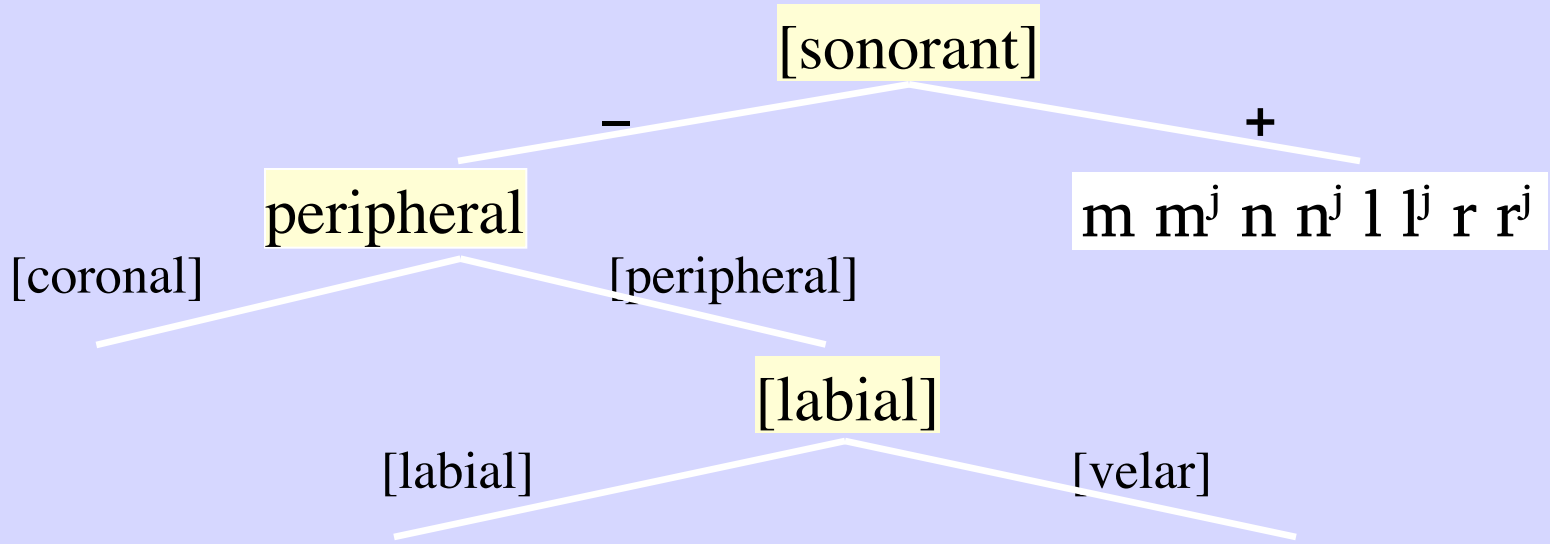
This analysis is based on a contrastive feature hierarchy for Russian that should apply to other aspects of Russian phonology, such as voicing:

Contrastive Hierarchy for Early Russian Consonants



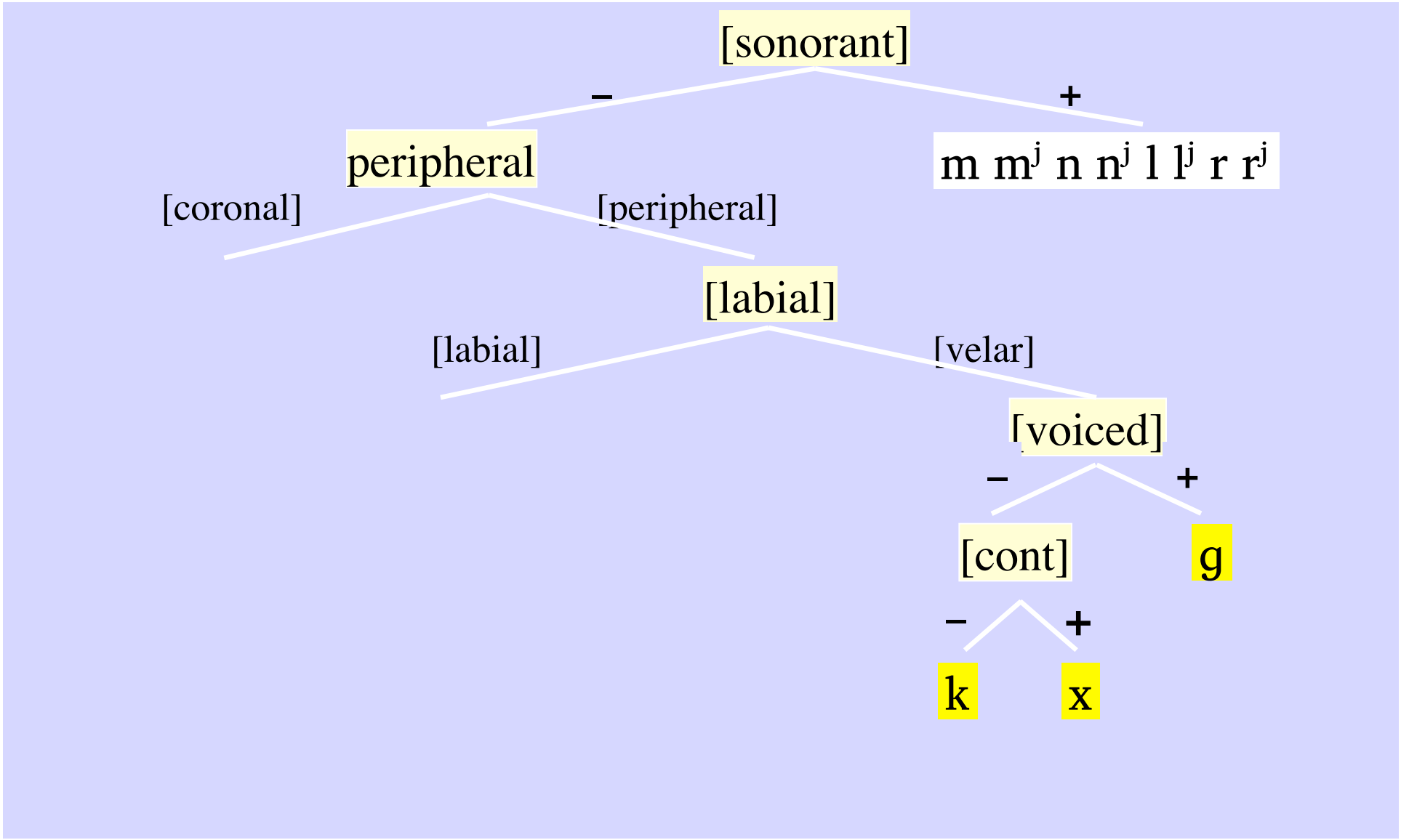
The first contrast is between sonorants and obstruents. Voicing is now not contrastive among the sonorants, which are all voiced.

Contrastive Hierarchy for Early Russian Consonants



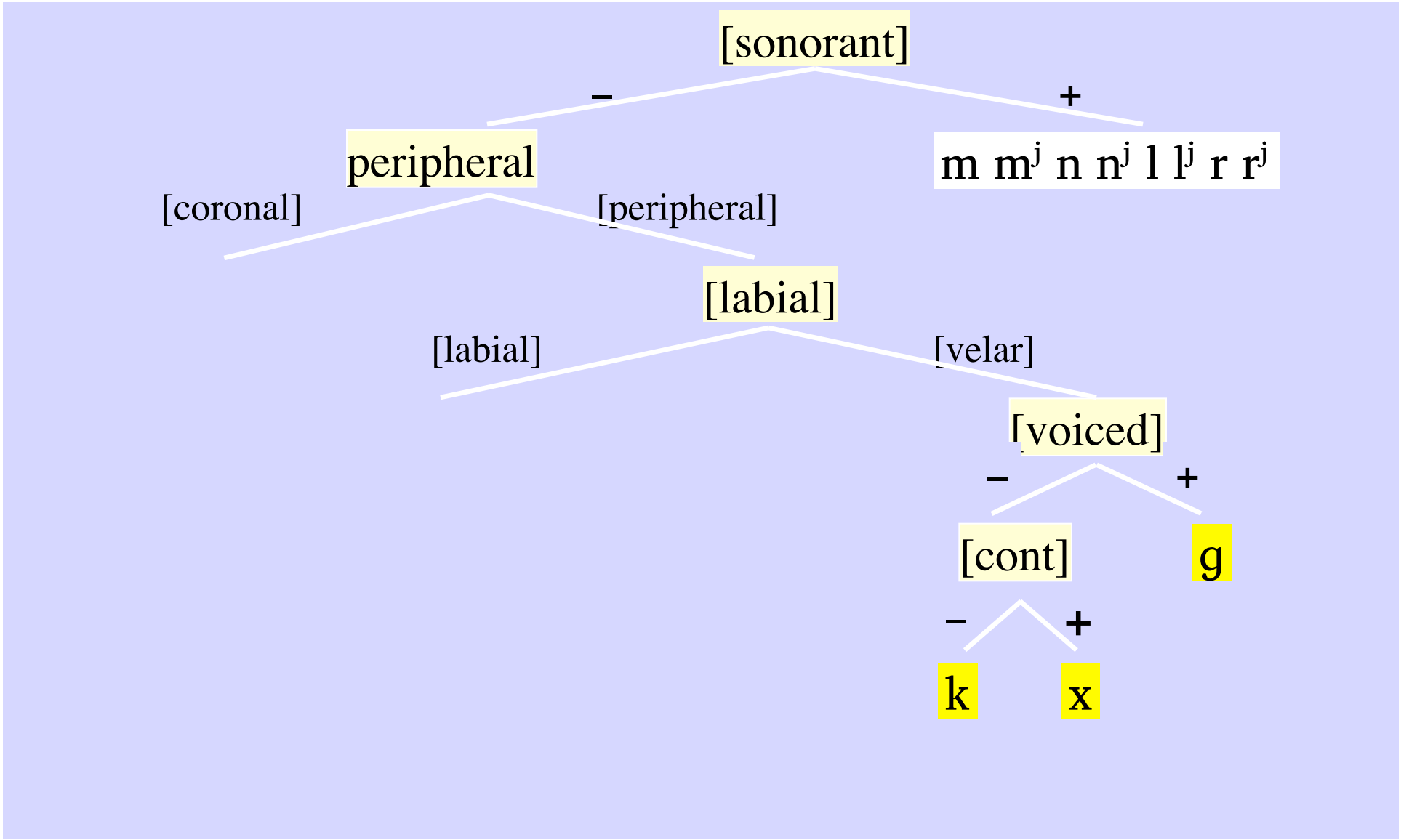
I assume that the place features [peripheral] and [labial] come next. [–peripheral] = [coronal] and [–labial] = [velar].

Contrastive Hierarchy for Early Russian Consonants



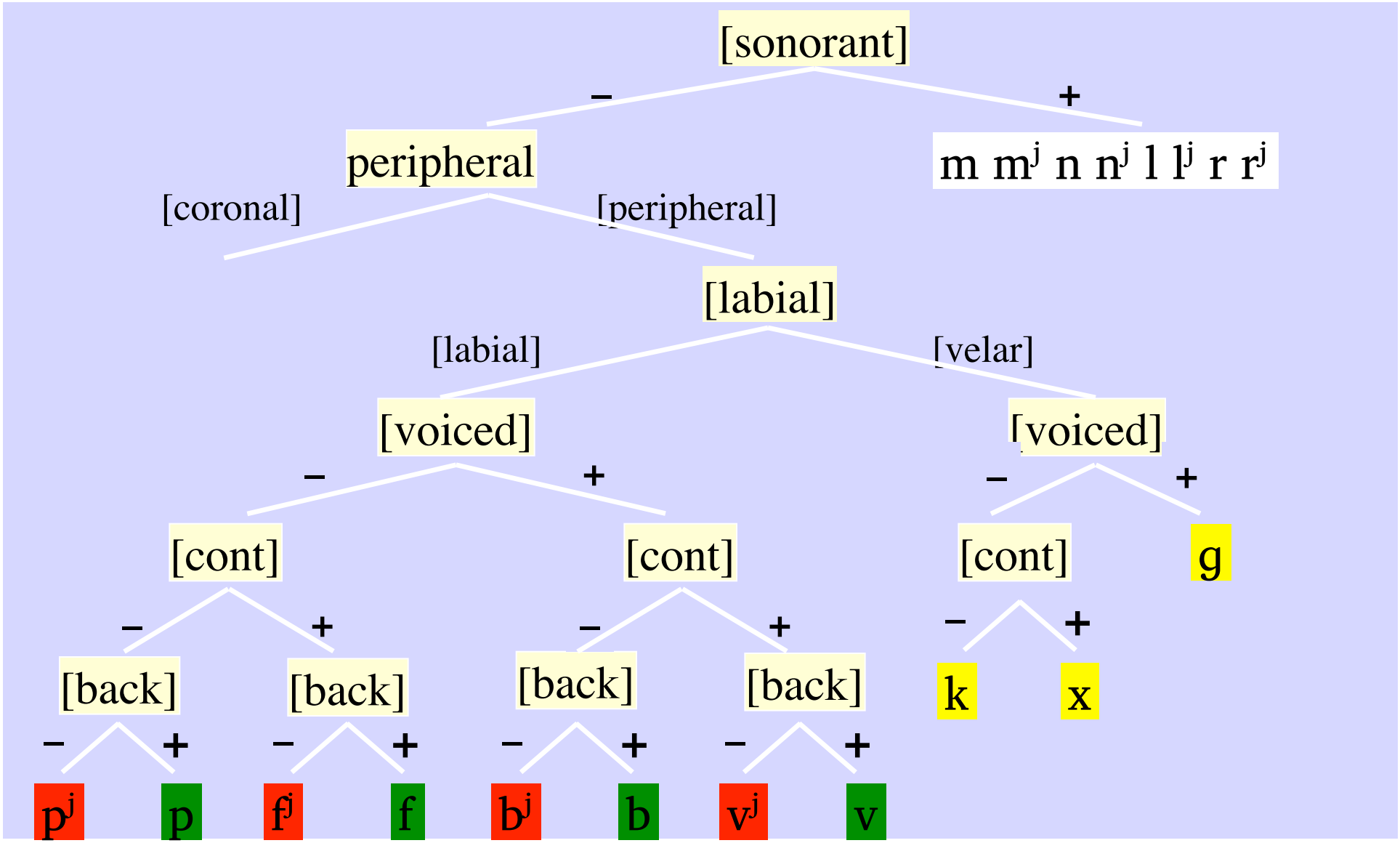
We know that the velars have contrastive specifications for [voiced] and [continuant]. They receive no further features.

Contrastive Hierarchy for Early Russian Consonants



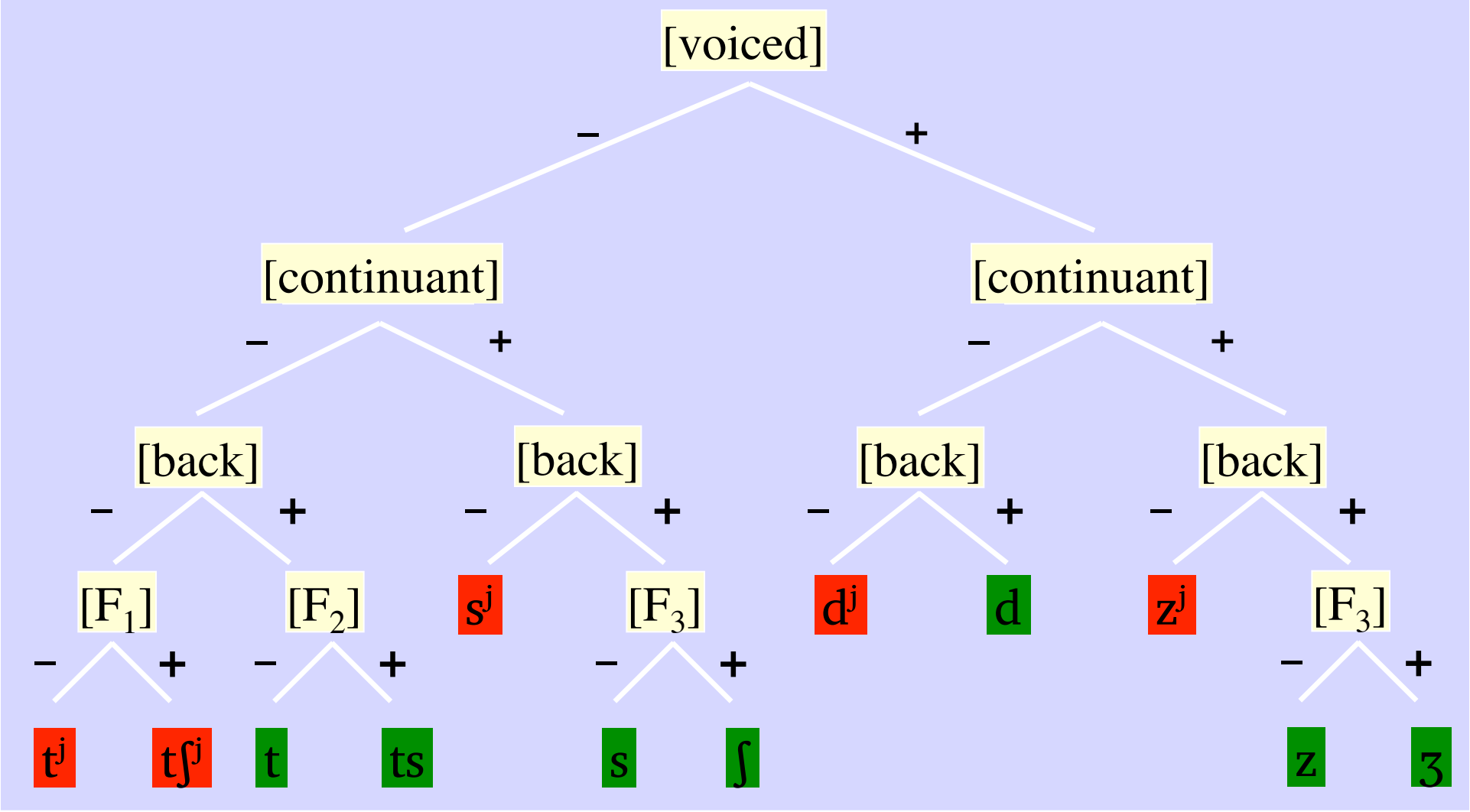
In particular, they receive no contrastive specifications for [back].

Contrastive Hierarchy for Early Russian Consonants



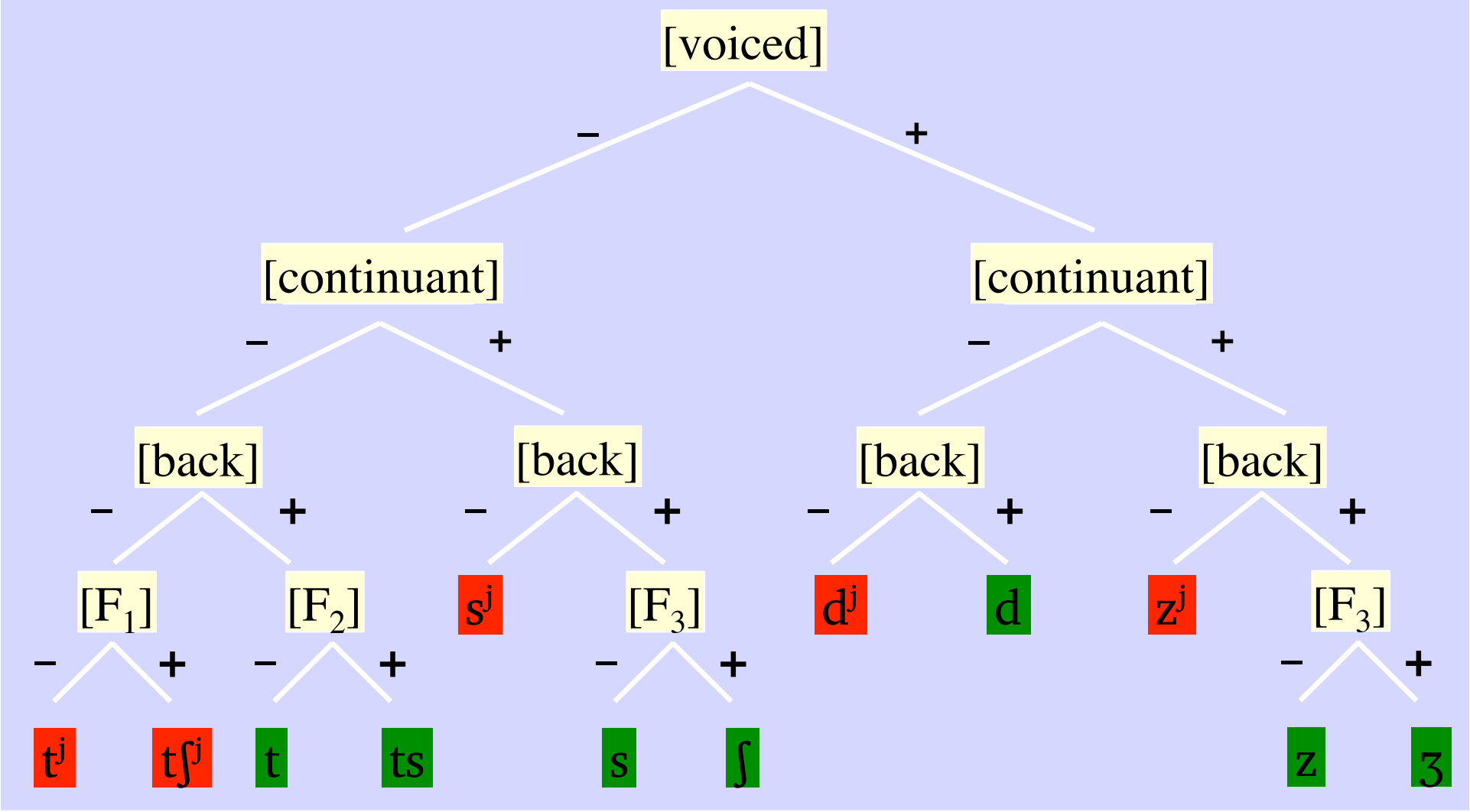
The same ordering applies in the labials. Since they are all paired, they all receive contrastive values of [back].

Contrastive Hierarchy for Early Russian Coronals



The coronals are more interesting. There are more contrasts in the coronals than in the velars; if we assume that the feature [back] is ordered ahead of some other features, designated here as [F_i],

Contrastive Hierarchy for Early Russian Coronals



the result is that all the coronals receive contrastive values of [back]. This explains why the 'unpaired' coronals act as if they are contrastively palatalized or nonpalatalized, unlike the velars.

Russian 'Paired Consonants'

Russian has two types of 'paired' consonants: palatalized ~ nonpalatalized (involving the feature [back]); and voiced ~ voiceless ([voiced]).

Paired consonants are contrastive for the relevant feature in any theory: /t/~/d/ contrast only in voicing, and /t/~/t^{j}/ contrast only in palatalization.

Russian 'Unpaired Consonants'

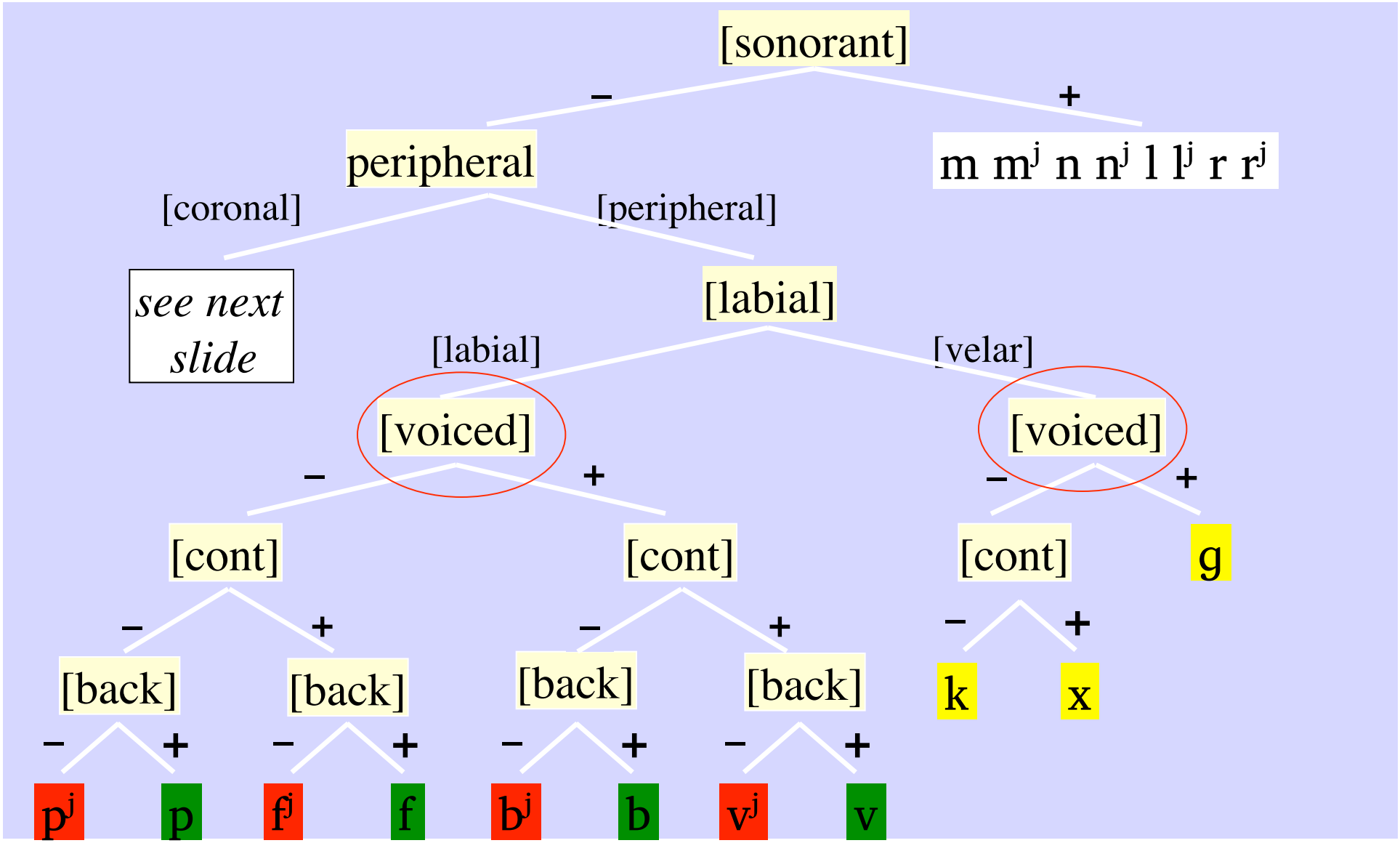
But the unpaired consonants are *not* all noncontrastive for each feature.

In the case of voicing, the famous unpaired voiceless consonants /ts, tʃ, x/ all act as if they are contrastively voiceless.

In the case of palatalization, the unpaired velars are not contrastive, but the unpaired coronal consonants act as if they *are*.

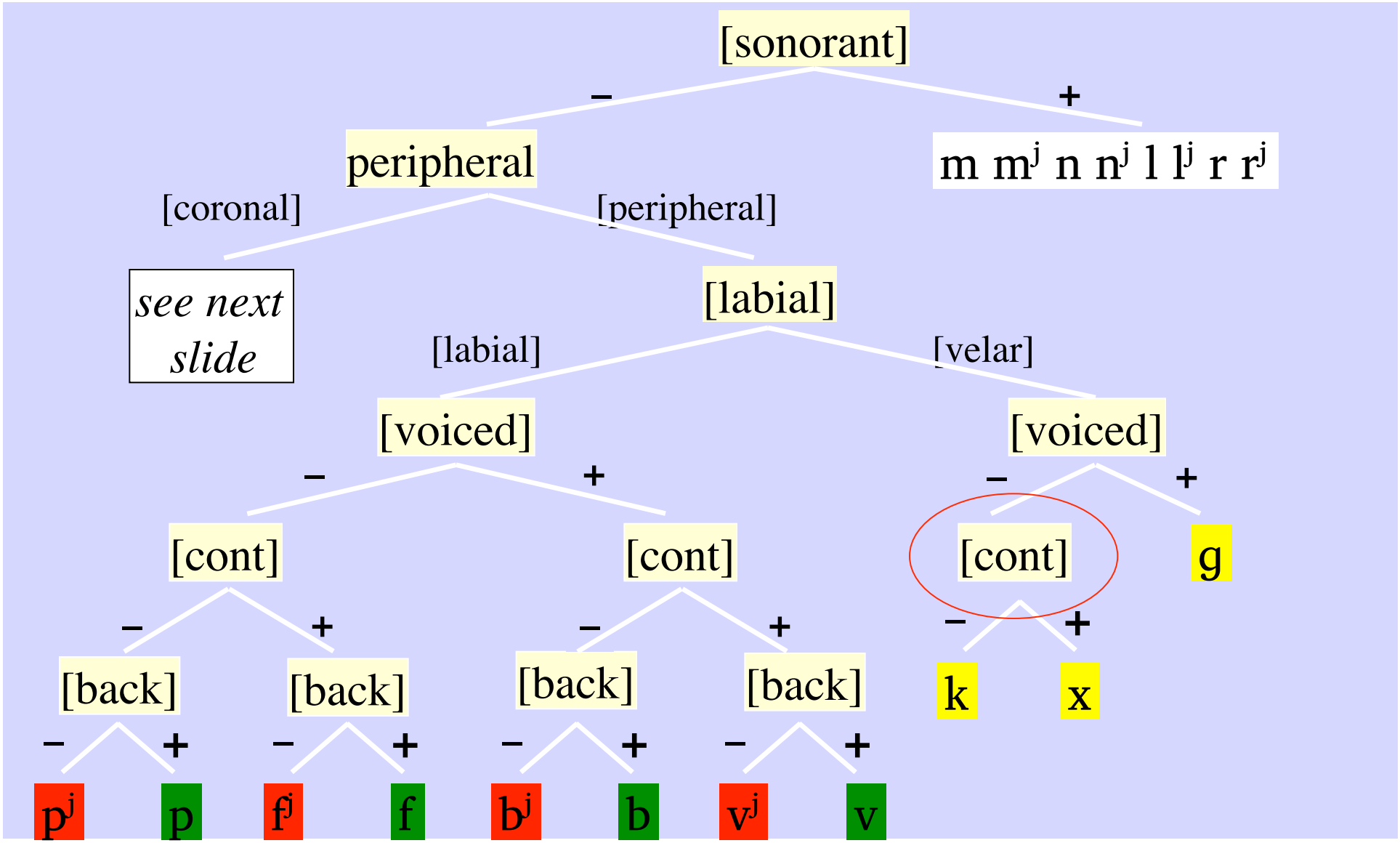
'Minimal pairs' cannot explain this, but the contrastive hierarchy for Russian shows why this is so.

Contrastive Hierarchy for Early Russian Consonants



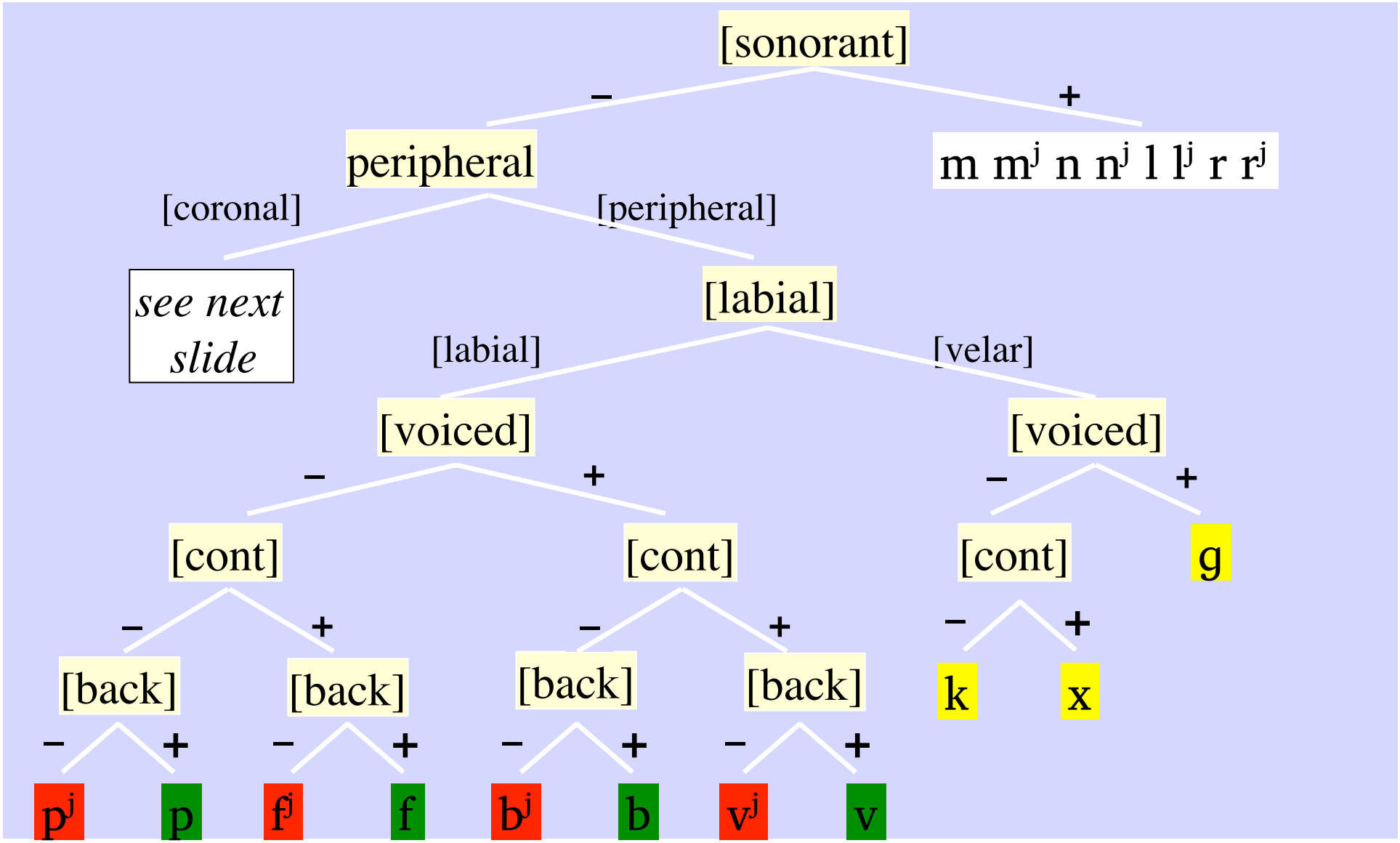
[voiced] is sufficiently high in the order to take scope over all obstruents, so paired and unpaired consonants function alike.

Contrastive Hierarchy for Early Russian Consonants



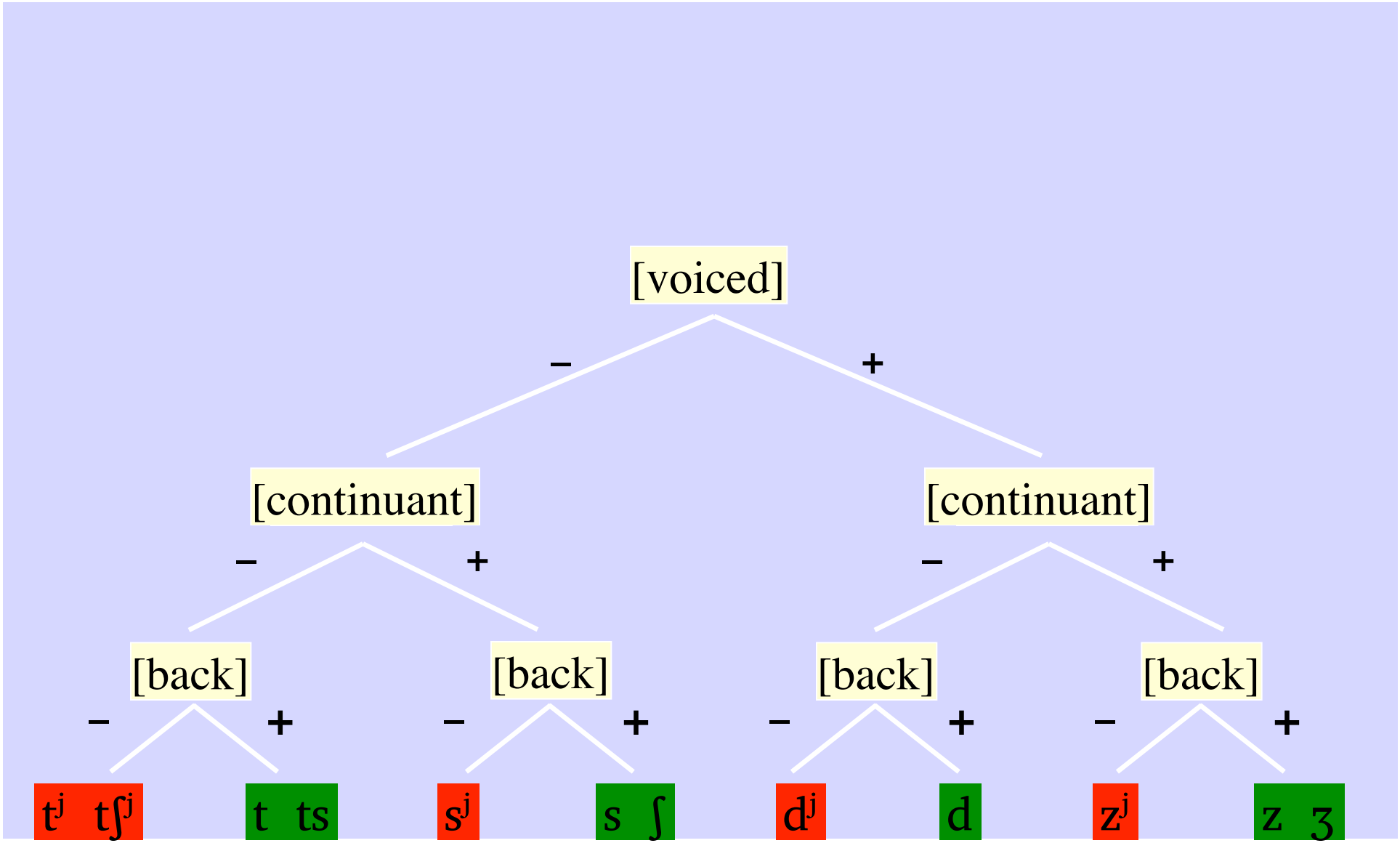
But [cont] is lower. In the velars, 'unpaired' /g/ has no contrastive value for this feature.

Contrastive Hierarchy for Early Russian Consonants



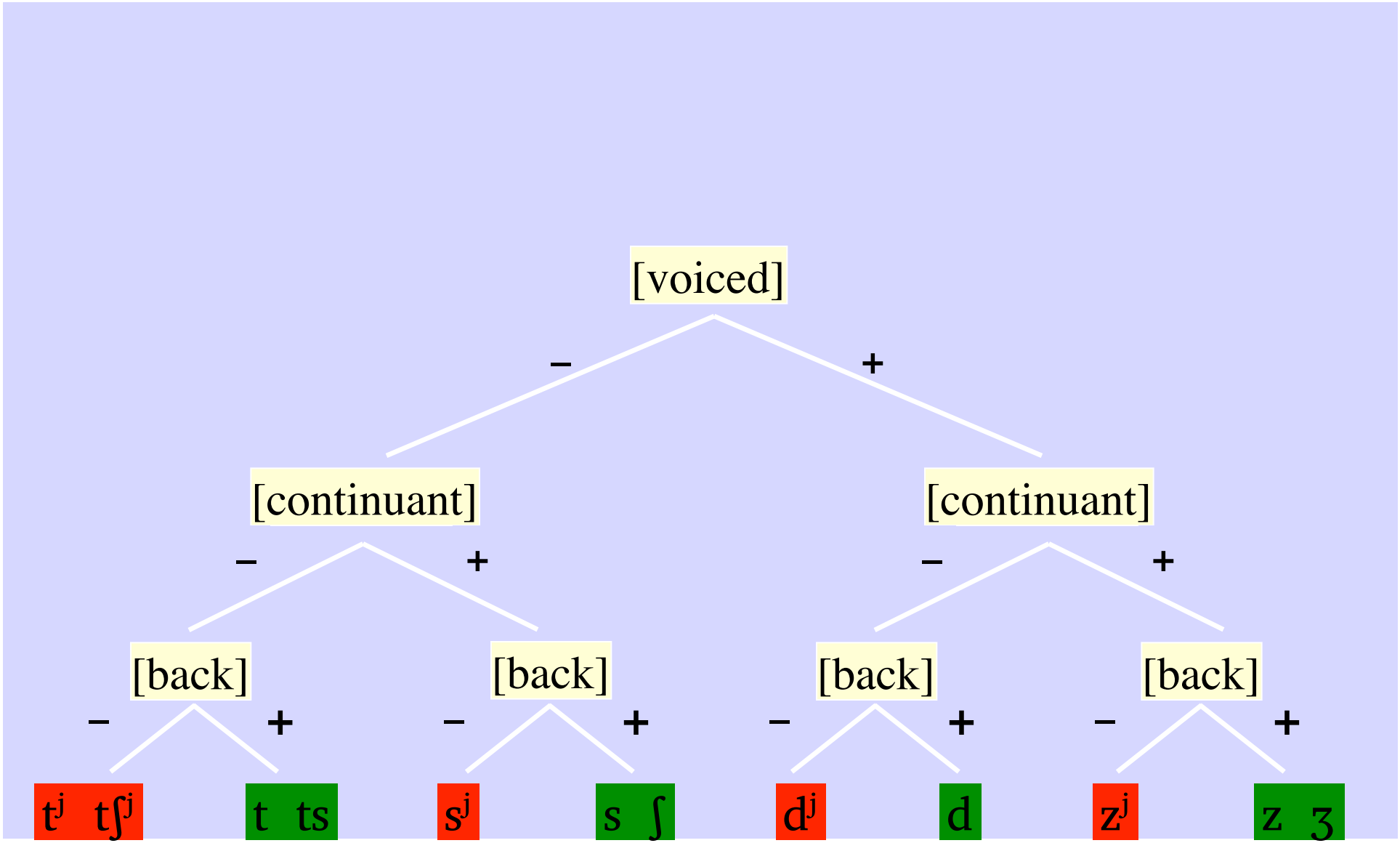
[back] is even lower. In the velars, the segments run out before it can apply, and all velars have no contrastive value for this feature.

Contrastive Hierarchy for Early Russian Coronals



There are more coronals, so all three of these features are contrastive in all coronals.

Contrastive Hierarchy for Early Russian Coronals



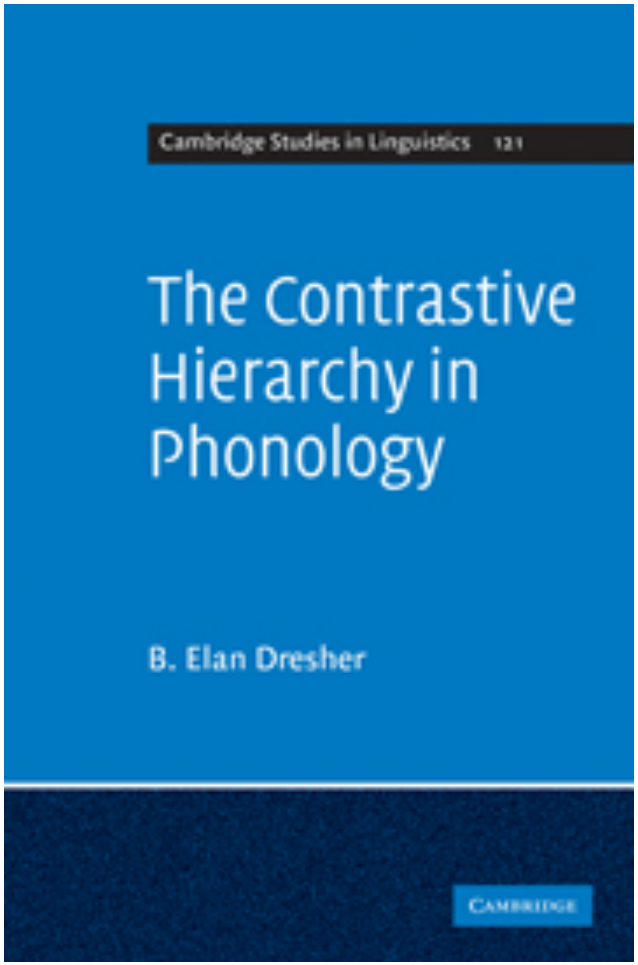
The evidence from different phonological processes converges on a single consistent feature hierarchy.

I am grateful to 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/

This research was supported in part by grants 410-2003-0913 and 410-08-2645 from the Social Sciences and Humanities Research Council of Canada.

For a more complete account please see:



References

Anderson, John M. 2005. Old English *i*-umlaut (for the umpteenth time). *English Language and Linguistics* 9: 195–227.

Anderson, John M. and Colin Ewen. 1987. *Principles of Dependency Phonology*. Cambridge: Cambridge University Press.

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

Avery, Peter and Keren Rice. 1989. Segment structure and coronal underspecification. *Phonology* 6: 179–200.

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

Campos-Astorkiza, Rebeka. 2009. *The role and representation of minimal contrast and the phonetics-phonology interaction. (Studies in Theoretical Linguistics 41)*. Munich: Lincom Europa.

Carr, Philip, Jacques Durand and Colin J. Ewen (eds.). 2005. *Headhood, elements, specification and contrastivity: Phonological papers in honour of John Anderson*. Amsterdam: John Benjamins.

Carvalho, Joaquim Brandão de. 2011. Contrastive hierarchies, privative features, and Portuguese vowels. *Linguística : Revista de Estudos Linguísticos da Universidade do Porto* 6: 51–66. Casali, Roderic F. 2008. ATR harmony in African languages. *Language and Linguistics Compass* 2/3: 496–549.

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

Clements, G. N. 2003. Feature economy in sound systems. *Phonology* 20: 287–333.

Clements, G. N. 2009. The role of features in phonological inventories. In Eric Raimy and Charles Cairns (eds.), *Contemporary views on architecture and representations in phonological theory,* 19–68. Cambridge, Mass.: MIT Press.

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

Dresher, B. Elan. 1998. On contrast and redundancy. Paper presented at the annual meeting of the Canadian Linguistic Association, May, Ottawa. Ms., University of Toronto.

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: Cambridge University Press.*

Dresher, B. Elan, Glyne L. Piggott and Keren Rice. 1994. Contrast in phonology: Overview. *Toronto Working Papers in Linguistics* 13: iii–xvii.

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

Flemming, Edward. 2004. Contrast and perceptual distinctiveness. In Bruce Hayes, Robert Kirchner & Donca Steriade (eds.), *Phonetically-based Phonology*, 232–276. Cambridge: Cambridge University Press.

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

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

Hulst, Harry van der. 1995. Radical CV Phonology: The categorial gesture. In Jacques Durand and 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 and Bernard Laks (eds.) *Current trends in phonology: Models and methods*, 333–361. Salford: European Studies Research Institute (ESRI).

Hulst, Harry van der. 2005. The molecular structure of phonological segments. In Carr et al. (2005), 193–234.

Hyman, Larry M. 2001. Vowel harmony in Gunu. *Studies in African Linguistics* 30: 146–170.

Hyman, Larry M. 2002. On the limits of phonetic determinism in phonology: *NC revisited. In Elizabeth Hume and Keith Johnson (eds.) *The role of perception in phonology*, 141–185. New York: Academic Press.

Hyman, Larry M. 2003. 'Abstract' vowel harmony in Kàlɔ̀ŋ: A system-driven account. In Patrick Sauzet and Anne Zribi-Hertz (eds.) *Typologie des langues d'Afrique et universaux de la grammaire*, 85–112. Paris: l'Harmattan.

Jakobson, Roman. 1929. Remarques sur l'évolution phonologique du Russe compaŕee à celle des autres langues slaves. *Travaux du Cercle Linguistique de Prague* 2. Reprinted in Roman Jakobson, *Selected writings I. Phonological studies*, 7–116. The Hague: Mouton, 1962.

Jakobson, Roman, C. Gunnar M. Fant and 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 and Morris Halle. 1956. *Fundamentals of Language.* The Hague: Mouton.

Jakobson, Roman and John Lotz. 1949. Notes on the French phonemic pattern. *Word* 5: 151–158.

Leitch, Myles. 1996. Vowel harmonies of the Congo basin: an Optimality Theory analysis of variation in the Bantu zone C. Doctoral dissertation, Department of Linguistics, University of British Columbia.

Liljencrants, Johan & Björn Lindblom. 1972. Numerical simulation of vowel quality systems: The role of perceptual contrast. *Language* 48: 839–862.

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. 2005. Similarity and contrast in consonant harmony systems. *Toronto Working Papers in Linguistics (Special Issue on Similarity in Phonology)* 24: 169–182.

Mackenzie, Sara. 2009. Contrast and similarity in consonant harmony processes. Doctoral dissertation, University of Toronto.

Morén, Bruce. 2003. The Parallel Structures Model of feature geometry. In Johanna Brugman and Anastasia Riehl, (eds.). *Working Papers of the Cornell Phonetics Laboratory*, vol. 15, 194–270. Ithaca, New York.

Morén, Bruce. 2006. Consonant-vowel interactions in Serbian: Features, representations and constraint interactions. *Lingua* 116: 1198–1244.

Nevins, Andrew. 2010. *Locality in vowel harmony*. Cambridge, MA: MIT Press.

Ọla Orie, Ọlanikeẹ. 2001. An alignment-based account of vowel harmony in Ife Yoruba. *Journal of African Languages and Linguistics* 22: 117–43.

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

Reh, Mechthild. 1996. *Anywa language: Description and internal reconstruction*. Cologne: Rüdiger Köppe Verlag.

Saussure, Ferdinand de. ([1916] 1972). *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.

Scheer, Tobias. 2010. How to marry (structuralist) contrast and (generative) processing (review of Dresher 2009, *The contrastive hierarchy in phonology*). *Lingua* 120: 2522–2534.

Trubetzkoy, N. S. 2001. A theory of phonological oppositions. In Anatoly Liberman (ed.), *Studies in general linguistics and language structure*, 14–21. Translated by Marvin Taylor & Anatoly Liberman. Durham, NC: Duke University Press. [First published as Essai d'une théorie des oppositions phonologiques. *Journal de Psychologie Normale et Pathologique* 33 (1936): 5–18.]

Tucker, Archibald. 1994. *A grammar of Kenya Luo (Dholuo)*. Cologne: Rüdiger Köppe Verlag.

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