Department of Linguistics
University of Maryland
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The Abstractness of Minimal Contrast

B. Elan Drescher
University of Toronto
Introduction

Phonologists working in a variety of theoretical frameworks have independently proposed that ‘minimal contrast’ plays an important role in phonology (Padgett 2003a, Nevins 2004, Calabrese 2005, Campos Astorkiza 2007).
According to the definition proposed by Nevins (2004: 142), a segment S with specification $\alpha F$ is *contrastive* for F if there is another segment $S'$ in the inventory that is featurally identical to S, except that it is $-\alpha F$.

### Minimal Contrast

<table>
<thead>
<tr>
<th>R</th>
<th>S</th>
<th>S'</th>
<th>T</th>
</tr>
</thead>
<tbody>
<tr>
<td>$[-\alpha H]$</td>
<td>$[\alpha H]$</td>
<td>$[\alpha H]$</td>
<td>$[-\alpha H]$</td>
</tr>
</tbody>
</table>
Minimal contrast at the surface

This definition is generally understood as applying to surface phonetic forms.

Minimal pairs: Segments differing only in the feature [voice]

<table>
<thead>
<tr>
<th>p</th>
<th>b</th>
<th>t</th>
<th>d</th>
<th>f</th>
<th>v</th>
<th>m</th>
</tr>
</thead>
<tbody>
<tr>
<td>b</td>
<td>f</td>
<td>s</td>
<td>l</td>
<td>j</td>
<td>x</td>
<td>j</td>
</tr>
</tbody>
</table>

- Segments: *p*, *b*, *t*, *d*, *f*, *v*, *m*
- Minimal pairs: *p* vs. *b*, *t* vs. *d*, *f* vs. *v*, *m* vs. *b*, *l* vs. *j*
Minimal contrast at the surface

Dispersion-Theoretic (DT) approaches (Flemming 2002, 2004, Padgett 2003a, b, Campos Astorkiza 2007) explicitly evaluate contrast with respect to the phonetic surface.

\[ \text{i} \quad \text{more dispersion} \quad \text{u} \]

\[ \text{a} \quad \text{less dispersion} \quad \text{c} \]
Introduction

In this talk I will argue that the notion of minimal phonetic contrast is

• largely illusory

• often nonexistent

• and makes the wrong empirical predictions about the workings of the phonology

where it can be coherently defined.
Introduction

I will argue that phonology is indeed sensitive to contrast, but

- the appropriate level at which minimal contrast holds is at the underlying phonemic level

- and contrastive features must be assigned in an order, following language-particular contrastive hierarchies.
Introduction

That is, the correct notion of minimal contrast is abstract in two distinct ways:

- the level at which minimal contrast is evaluated: not the surface phonetic but at the underlying phonemic level

- regardless of the level, the minimality of contrast does not hold globally over pairwise comparisons, but is relative to the position of the feature in the hierarchy, a concept I will explain in more depth later on.
The Contrastivist Hypothesis

All the analyses to be considered here assume what Hall (2007: 20) calls the *Contrastivist Hypothesis*:

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

It follows that only *contrastive* features can *trigger* phonological processes.

In all the cases to be discussed contrastive features play a special role. The issue will be how to identify which features are contrastive.
The Contrastivist Hypothesis and Minimal Contrast

I will begin with a relatively simple case, Romance metaphony, that shows the importance of the Contrastivist Hypothesis and which seems at first to work well in terms of minimal surface contrast, though it doesn’t really.

The next case involves Lithuanian vowel contrasts. I will argue that a Dispersion Theoretic analysis based on surface contrasts fails, and that again the relevant contrasts are found at an underlying phonemic level.
The Contrastivist Hypothesis and Minimal Contrast

The third case, comparing German and Czech /h/, will show more clearly the problems with minimal pairs even at the underlying level, and the necessity for a contrastive hierarchy of features.

I will then show how a contrastive feature hierarchy accounts for the three cases discussed to here.

The final case is a more extended example, concerning a change in East Slavic. It illustrates the main themes of this talk.
Cases

- Romance metaphony
- Lithuanian vowel contrasts
- German and Czech /h/
- East Slavic post-velar fronting
Metaphony in Iberian Spanish and Italian

Metaphony is a type of vowel harmony in which some high desinential vowels trigger raising of some stressed vowels.

The following are examples of metaphony in Pasiego (Romance, Spain), as given by Dyck (1995), adapted from Penny (1969). Centralization/laxing of unstressed vowels is not shown.
Metaphony (Pasiego)

Desinential /u/ triggers raising of stressed /é/ to [í] and stressed /ó/ to [ú]:

<table>
<thead>
<tr>
<th>Unmetaphonized</th>
<th>Metaphonized</th>
</tr>
</thead>
<tbody>
<tr>
<td>afilit[é]ros ‘needle-cases’</td>
<td>afilit[í]ru ‘needle-case’</td>
</tr>
<tr>
<td>g[ó]rdo ‘fat (neuter)’</td>
<td>g[ú]rdù ‘fat (masculine)’</td>
</tr>
<tr>
<td>ab[jé]rtos ‘open (plural)’</td>
<td>ab[jí]rtu ‘open (plural)’</td>
</tr>
<tr>
<td>k[wé]rpos ‘bodies’</td>
<td>k[wí]rpu ‘body’</td>
</tr>
</tbody>
</table>
Metaphony (Pasiego)

Stressed /í/, /ú/, and /á/ are not affected:

<table>
<thead>
<tr>
<th>Unmetaphonized</th>
<th>Neutral</th>
</tr>
</thead>
<tbody>
<tr>
<td>luz m[í]yos</td>
<td>il m[í]yu</td>
</tr>
<tr>
<td></td>
<td>‘mine (plural)’</td>
</tr>
<tr>
<td>br[á]θos</td>
<td>br[á] θu</td>
</tr>
</tbody>
</table>
Dyck (1995), modifying an earlier observation by Penny (1970), formulates the following generalization about metaphony (raising) triggered by desinential vowels:
Dyck’s Generalization

Desinential high vowels can trigger metaphony only if they contrast with a mid vowel in the same place.

Note that we are referring here to contrasts only among the desinential vowels. In every dialect high vowels contrast with mid vowels in stressed syllables; but dialects have different inventories of desinential vowels, ranging from 3 to 5.
Dyck’s Generalization

Desinential high vowels can trigger metaphony only if they contrast with a mid vowel in the same place.

Predictions

No raising in dialects with only 3 desinential vowels: there is no contrast between /I/ and /E/ or /U/ and /O/.
Dyck’s Generalization

Desinential high vowels can trigger metaphony only if they contrast with a mid vowel in the same place.

Example

No raising reported in Leonese dialects, where desinences are phonetically [i,a,u] or [e,a,u], depending on the dialect. Thus, it is not sufficient for a desinential vowel to be phonetically high.
Dyck’s Generalization

Desinential high vowels can trigger metaphony only if they contrast with a mid vowel in the same place.

Predictions

In dialects with 4 desinential vowels:

Raising can be triggered by /U/, not by /I/

Raising can be triggered by /I/, not by /U/
Dyck’s Generalization

Desinential high vowels can trigger metaphony only if they contrast with a mid vowel in the same place.

Example

In dialects with 4 desinential vowels:

Raising can be triggered by /U/, not by /I/

In Central Asturias, North Central Asturias, and Santander (Montañese dialects), /u/ contrasts with /o/, but there is only a marginal, archaic contrast between /i/ and /e/. Raising is triggered by [u], not by [i].
Dyck’s Generalization

Desinential high vowels can trigger metaphony only if they contrast with a mid vowel in the same place.

Predictions

In dialects with 5 desinential vowels, both /I/ and /U/ can trigger raising:
Dyck’s Generalization

Desinential high vowels can trigger metaphony only if they contrast with a mid vowel in the same place.

Example

No Spanish dialects are of this type, but there are Italian dialects, such as Servigliano, that have 5 desinential vowels and raising. Both [i] and [u] trigger raising:

```
i  u
e  o
a
```
Desinential high vowels can trigger metaphony only if they contrast with a mid vowel in the same place.

Assumptions

Vowel inventories are divided into stem inventories and desinential inventories. Contrasts in each inventory are assessed separately.
Accounting for Dyck’s Generalization

Desinential high vowels can trigger metaphony only if they contrast with a mid vowel in the same place.

Now we can see that Dyck’s Generalization follows from the Contrastivist Hypothesis: only desinential vowels bearing a contrastive [high] feature can trigger metaphony.

Raising can be triggered by /U/, not by /I/.
We might suppose that the definition of contrast in terms of minimal pairs applies here: [high] is contrastive in /U/ because there is a phoneme /O/ that differs from it only in this feature.

Recall the definition of minimal contrast: two segments that are identical in every feature except one.

<table>
<thead>
<tr>
<th>I/E</th>
<th>U</th>
<th>O</th>
<th>A</th>
</tr>
</thead>
<tbody>
<tr>
<td>[−low]</td>
<td>[−low]</td>
<td>[−low]</td>
<td>[+low]</td>
</tr>
<tr>
<td>[−high]</td>
<td>[+high]</td>
<td>[−high]</td>
<td>[−high]</td>
</tr>
<tr>
<td>[−back]</td>
<td>[+back]</td>
<td>[+back]</td>
<td>[+back]</td>
</tr>
<tr>
<td>[−rnd]</td>
<td>[+rnd]</td>
<td>[+rnd]</td>
<td>[−rnd]</td>
</tr>
</tbody>
</table>

Contrast via Minimal Pairs?
Contrast via Minimal Pairs?

But this is true only of *underlying* representations. On the surface these minimal contrasts are disturbed by further distinctions.
The phonetic values of the desinential vowels do not exhibit minimal contrasts. According to Dyck (1995: 67, 177), the desinences of the dialect of Tudanca are as shown (based on data from Penny 1978 and from the Atlás Lingüístico de la Península Ibérica (ALPI). The high back vowel differs from the mid vowel in more than just height. Pasiego is similar (Penny 1969)
Contrast via Minimal Pairs?

More dramatically, the Italian dialect of Calvello has a four-vowel desinential inventory in which /i/ causes raising.

The identity of the four vowels is revealed under secondary stress. However, all phrase-final vowels in Calvello reduce to schwa (Dyck 1996: 81, Kaze 1989: 24-25).
Contrast via Minimal Pairs?

More dramatically, the Italian dialect of Calvello has a four-vowel desinential inventory in which /i/ causes raising.

The identity of the four vowels is revealed under secondary stress. However, all phrase-final vowels in Calvello reduce to schwa (Dyck 1996: 81, Kaze 1989: 24-25). Clearly, contrast cannot be assessed at the surface.

![Diagram showing Calvello underlying and surface desinential vowels]
The phonetic surface is the *worst* place to look for minimal contrasts

Dispersion and enhancement theorists have argued that poor contrasts tend to be magnified, and minimal contrasts tend to be *enhanced* by other phonetic differences.

In Calvello, phonetics do the opposite, and *neutralize* underlying contrasts.

Either way, the result is that *underlying* minimal contrasts between phonemes tend to be obscured at the surface.
Cases

- Romance metaphony
- Lithuanian vowel contrasts
- German and Czech /h/
- East Slavic post-velar fronting
Contrast in Lithuanian Vowels

Campos Astorkiza (2007) also proposes a special role for minimal contrast, two sounds that differ in just one property.

She argues that minimal contrast can influence phonetic effects.

For example, phonetic modification of vowel duration (lengthening before a voiced sound and shortening before a voiceless sound) can be minimized when there is a phonological vowel-length contrast, so as not to neutralize the contrast.
Contrast in Lithuanian Vowels

Campos Astorkiza reports that in Lithuanian, the effects of the voicing of final consonants are greater on the vowel /eː/, which has no short counterpart, than on the other long vowels, which have short counterparts.

<table>
<thead>
<tr>
<th></th>
<th>Front</th>
<th>Back</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Short</td>
<td>Long</td>
</tr>
<tr>
<td>High</td>
<td>i</td>
<td>iː</td>
</tr>
<tr>
<td>Mid</td>
<td></td>
<td>eː</td>
</tr>
<tr>
<td>Low</td>
<td>æ</td>
<td>æː</td>
</tr>
</tbody>
</table>
Lithuanian Vowels

I assume that the facts and basic analysis of the Lithuanian vowel system are correct.

However, Campos Astorkiza (2007) incorrectly tries to define the relevant contrasts as applying to surface phonetic dimensions, rather than to underlying phonemic representations.

This analysis leads to many problems.
Lithuanian Vowels

Campos Astorkiza (2007: 81) defines a contrast-coindexing function that is supposed to apply to minimally contrastive segments that are able to distinguish minimal pairs of words.

She wishes to designate as a minimal pair Lithuanian words that differ only in that one contains a long vowel where the other has its short counterpart, and that the long-short vowel pair should be contrast-coindexed as differing only with respect to duration. A hypothetical example is shown here:

\[ \text{liːta} \quad \text{līta} \]
Lithuanian Vowels

Minimal contrasts apply in straightforward fashion as long as we stick to *phonemic* representations of Lithuanian vowels. Campos Astorkiza adopts a conventional phonemic analysis that distinguishes vowels along three dimensions:

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td></td>
<td>Short</td>
<td>Long</td>
</tr>
<tr>
<td>High</td>
<td>i</td>
<td>iː</td>
</tr>
<tr>
<td>Mid</td>
<td></td>
<td>eː</td>
</tr>
<tr>
<td>Low</td>
<td>æ</td>
<td>æː</td>
</tr>
</tbody>
</table>

Phonemic analysis (Campos Astorkiza 2007: 32)
Lithuanian Vowels

- Height: three contrastive categories, high, mid, and low

<table>
<thead>
<tr>
<th>Phonemic analysis (Campos Astorkiza 2007: 32)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Front</td>
</tr>
<tr>
<td>Short</td>
</tr>
<tr>
<td>High</td>
</tr>
<tr>
<td>Mid</td>
</tr>
<tr>
<td>Low</td>
</tr>
</tbody>
</table>
Lithuanian Vowels

- Height
- Backness: two contrastive categories, front and back

Phonemic analysis (Campos Astorkiza 2007: 32)

<table>
<thead>
<tr>
<th></th>
<th>Front</th>
<th>Back</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Short</td>
<td>Long</td>
</tr>
<tr>
<td>High</td>
<td>i</td>
<td>iː</td>
</tr>
<tr>
<td>Mid</td>
<td>eː</td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>æ</td>
<td>æː</td>
</tr>
</tbody>
</table>
Lithuanian Vowels

- Height
- Backness
- Length: 2 categories, short and long

Phonemic analysis (Campos Astorkiza 2007: 32)

Front | Back
--- | ---
Short | Long | Short | Long
High | i | iː | u | uː
Mid | æ | æː | a | oː
Low | æ | æː | a | aː
In terms of phonetics, however, Lithuanian long vowels do not differ from their short counterparts only with respect to duration.

Phonemic values (Campos Astorkiza 2007: 32)

\[
\begin{array}{cccc}
\text{i} & \text{iː} & \text{u} & \text{uː} \\
\text{æ} & \text{æː} & \text{a} & \text{aː} \\
\text{eː} & (\text{o}) & \text{oː} \\
\end{array}
\]
Lithuanian Vowels

Each pair displays a further phonetic difference that is potentially contrastive in some other language:

Phonetic values (Campos Astorkiza 2007: 32)
Lithuanian Vowels

- Compared to their short vowel counterparts, the long high vowels are either higher, or tenser, or have more advanced tongue root, or any two or three of these.

Phonetic values (Campos Astorkiza 2007: 32)

<table>
<thead>
<tr>
<th>[+ATR]/[tense]</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>[-ATR]/[lax]</td>
<td></td>
</tr>
<tr>
<td>iː</td>
<td>uː</td>
</tr>
<tr>
<td>ɪ</td>
<td>ʊ</td>
</tr>
<tr>
<td>eː</td>
<td>oː</td>
</tr>
<tr>
<td>æː</td>
<td>a</td>
</tr>
<tr>
<td>æː</td>
<td>aː</td>
</tr>
</tbody>
</table>
The front short low vowel is higher than its long counterpart, and the short back (or central) low vowel is less retracted than its long counterpart.

Phonetic values (Campos Astorkiza 2007: 32)
Lithuanian Vowels

Further, the non-low vowels contrast in roundness as well as backness.

Phonetic values (Campos Astorkiza 2007: 32)
Moreover, there is no phonetic basis to limit the number of front-back contrasts to two categories, rather than three, which appears to be closer to phonetic reality.

Phonetic values (Campos Astorkiza 2007: 32)
The phonetic surface is the worst place to look for minimal contrasts

It is apparent that the minimal contrasts Campos Astorkiza requires for her analysis do not exist at the phonetic surface.

What is needed is a theory that can assign the minimal contrasts identified by the phonemic analysis. To do this we must forget about the phonetic surface and take a more abstract approach to minimal contrast.
Problems with Minimal Pairs

Trying to evaluate contrast at the surface rather than at a more abstract level of representation is not the only problem with the minimal pairs method.

Consider again the definition of minimal contrast (Nevins, Campos Astorkiza, Padgett, etc.):
A segment $S$ with specification $\alpha F$ is *contrastive* for $F$ if there is another segment $S'$ in the inventory that is featurally identical to $S$, except that it is $-\alpha F$.

\[
\begin{array}{|c|c|c|c|}
\hline
\text{R} & \text{S} & \text{S'} & \text{T} \\
\hline
\hline
\end{array}
\]
Lithuanian Vowels

Now consider again Campos Astorkiza’s *phonemic* analysis of Lithuanian vowels. This time I use the more realistic phonetic symbols.

Assuming the analysis shown is correct, the question arises: How does one arrive at this categorization over the other possibilities I mentioned earlier?

<table>
<thead>
<tr>
<th></th>
<th>Front</th>
<th>Back</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Short</td>
<td>Long</td>
</tr>
<tr>
<td>High</td>
<td>ɪ</td>
<td>ɪː</td>
</tr>
<tr>
<td>Mid</td>
<td></td>
<td>ɛː</td>
</tr>
<tr>
<td>Low</td>
<td>ɛ</td>
<td>æː</td>
</tr>
</tbody>
</table>
Lithuanian Vowels

That is, how does one decide that the relevant contrast in the non-low vowels is backness and not lip rounding? Why does length take precedence over tension in the high vowels, and over height and backness in the low vowels?

<table>
<thead>
<tr>
<th></th>
<th>Front</th>
<th></th>
<th>Back</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Short</td>
<td>Long</td>
<td>Short</td>
</tr>
<tr>
<td>High</td>
<td>i</td>
<td>iː</td>
<td>u</td>
</tr>
<tr>
<td>Mid</td>
<td></td>
<td>eː</td>
<td>(ɔ)</td>
</tr>
<tr>
<td>Low</td>
<td>e</td>
<td>æː</td>
<td>a</td>
</tr>
</tbody>
</table>
Minimal Contrast

None of these decisions follow from looking for minimal pairs starting from fully specified features.

[back] and [round] do the same contrastive work below, as do [long] and [ATR]. There are thus no minimal pairs here.

<table>
<thead>
<tr>
<th></th>
<th>i</th>
<th>iː</th>
<th>u</th>
<th>uː</th>
</tr>
</thead>
<tbody>
<tr>
<td>[back]</td>
<td>−</td>
<td>−</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>[round]</td>
<td>−</td>
<td>−</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>[long]</td>
<td>−</td>
<td>+</td>
<td>−</td>
<td>+</td>
</tr>
<tr>
<td>[ATR]</td>
<td>−</td>
<td>+</td>
<td>−</td>
<td>+</td>
</tr>
</tbody>
</table>
Minimal Contrast

We need some procedure to decide which feature in each pair takes precedence: [back] or [round], and [long] or [ATR].

<table>
<thead>
<tr>
<th></th>
<th>i</th>
<th>iː</th>
<th>u</th>
<th>uː</th>
</tr>
</thead>
<tbody>
<tr>
<td>[back]</td>
<td>−</td>
<td>−</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>[round]</td>
<td>−</td>
<td>−</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>[long]</td>
<td>−</td>
<td>+</td>
<td>−</td>
<td>+</td>
</tr>
<tr>
<td>[ATR]</td>
<td>−</td>
<td>+</td>
<td>−</td>
<td>+</td>
</tr>
</tbody>
</table>
Minimal Contrast

We need some procedure to decide which feature in each pair takes precedence: [back] or [round], and [long] or [ATR].

We can choose [back] and [long], as assumed above.

<table>
<thead>
<tr>
<th></th>
<th>i</th>
<th>iː</th>
<th>u</th>
<th>uː</th>
</tr>
</thead>
<tbody>
<tr>
<td>[back]</td>
<td>−</td>
<td>−</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>[long]</td>
<td>−</td>
<td>+</td>
<td>−</td>
<td>+</td>
</tr>
</tbody>
</table>
Minimal Contrast

Or we could pick other features, say [round] and [ATR].

There are presumably empirical reasons for the other analysis, though no arguments are presented in this case.

<table>
<thead>
<tr>
<th></th>
<th>i</th>
<th>iː</th>
<th>u</th>
<th>uː</th>
</tr>
</thead>
<tbody>
<tr>
<td>[round]</td>
<td>−</td>
<td>−</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>[ATR]</td>
<td>−</td>
<td>+</td>
<td>−</td>
<td>+</td>
</tr>
</tbody>
</table>
Minimal Contrast

Whichever we pick, the required minimal pairs are the *result* of a phonemic analysis, and do not exist prior to it.

<table>
<thead>
<tr>
<th></th>
<th>i</th>
<th>iː</th>
<th>u</th>
<th>uː</th>
</tr>
</thead>
<tbody>
<tr>
<td>[back]</td>
<td>−</td>
<td>−</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>[round]</td>
<td>−</td>
<td>−</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>[long]</td>
<td>−</td>
<td>+</td>
<td>−</td>
<td>+</td>
</tr>
<tr>
<td>[ATR]</td>
<td>−</td>
<td>+</td>
<td>−</td>
<td>+</td>
</tr>
</tbody>
</table>
Cases

• Romance metaphony

• Lithuanian vowel contrasts

• German and Czech /h/

• East Slavic post-velar fronting
Problems with Minimal Pairs

Before offering a solution to this problem, it may be instructive to see one more example which illustrates the problem very clearly.

Let’s compare Trubetzkoy’s (1939/1969) analyses of German $h$ and Czech $ɦ$: 
Problems with Minimal Pairs

According to Trubetzkoy (1969: 69), German h does not enter into a unique minimal contrast with any other phoneme.
According to Trubetzkoy (1969: 69), German *h* does not enter into a unique minimal contrast with any other phoneme.

In particular, it is not in a minimal contrast with *x*: *h* is laryngeal and *x* is dorsal, and so there is no set of features that the two share exclusively.

### Problems with Minimal Pairs

<table>
<thead>
<tr>
<th>p</th>
<th>pf</th>
<th>t</th>
<th>ts</th>
<th>k</th>
</tr>
</thead>
<tbody>
<tr>
<td>b</td>
<td>d</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>f</td>
<td>s</td>
<td>j</td>
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</tr>
<tr>
<td>v</td>
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</tr>
<tr>
<td>m</td>
<td>n</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>l</td>
<td></td>
<td></td>
<td>r</td>
</tr>
</tbody>
</table>

In particular, it is not in a minimal contrast with *x*: *h* is laryngeal and *x* is dorsal, and so there is no set of features that the two share exclusively.
Problems with Minimal Pairs

Looking at the Czech consonant inventory, one might suppose that Czech ļ is similarly isolated.
Looking at the Czech consonant inventory, one might suppose that Czech ɦ is similarly isolated.

However, Trubetzkoy (1969: 124) proposes that Czech h (or more properly, ɦ), forms a minimal contrast with x.
The reason is that the distinction between these phonemes can be neutralized, for they behave phonologically like a voiced-voiceless pair, like the other such pairs in Czech.
Problems with Minimal Pairs

“The h in Czech thus does not belong to a special laryngeal series, which does not even exist in that language. It belongs to the guttural series, for which, from the standpoint of the Czech phonological system, only the fact that lips and tip of tongue do not participate is relevant”. (1969: 124)
Problems with Minimal Pairs

That is, ř and x form a minimally contrastive pair in Czech, but we have to *abstract away* from differences that are not deemed to be phonologically relevant.
Contrast via Feature Ordering

An elegant solution to this problem is hinted at by Trubetzkoy and was subsequently developed by Jakobson and his collaborators.

This approach assigns precedence relations by ordering the features.
Contrast via Feature Ordering

In German, for example, the place feature distinguishing /h/ from /x/ takes precedence over other features that could distinguish /h/ from other consonants.
In Czech, this feature is ordered lower in the hierarchy, too low to be contrastive for /ɦ/.

<table>
<thead>
<tr>
<th>p</th>
<th>t</th>
<th>ts</th>
<th>c</th>
<th>tʃ</th>
<th>k</th>
</tr>
</thead>
<tbody>
<tr>
<td>b</td>
<td>d</td>
<td>j</td>
<td>j</td>
<td>j</td>
<td>g</td>
</tr>
<tr>
<td>f</td>
<td>s</td>
<td>f</td>
<td>x</td>
<td>f</td>
<td></td>
</tr>
<tr>
<td>v</td>
<td>z</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>m</td>
<td>n</td>
<td>j</td>
<td>j</td>
<td>j</td>
<td></td>
</tr>
<tr>
<td>r</td>
<td>r</td>
<td>r</td>
<td>r</td>
<td>r</td>
<td></td>
</tr>
<tr>
<td>l</td>
<td>j</td>
<td>j</td>
<td>j</td>
<td>j</td>
<td></td>
</tr>
</tbody>
</table>
Contrastive specification by a hierarchy of features

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, select a 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 ordered list of features is called the contrastive hierarchy for the language in question.
Contrastive specification by a hierarchy of features

All the cases that have been attributed to minimal pairs can be accounted for in terms of feature ordering.
Following Dyck (1995), the order of the features in Romance vowel systems is \([\text{low}] > [\text{labial}] > [\text{high}]\). This explains why a phonetically high vowel must contrast with a mid vowel to receive a contrastive feature \([\text{high}]\). In the four-vowel system shown above, only /U/ is contrastively [+high].
The first division of the vowels is made by [back]. At this point there are only two distinct vowels, represented as [–back] /I/ and [+back] /U/. [back] is minimally contrastive, since no other feature distinguishes these vowels.
Each subset of vowels is then divided by [low]. This contrast is also minimal. Note that the addition of this contrast has the effect of making [back] no longer a minimal contrast for all vowels.
Similarly, the addition of further contrastive and non-contrastive features makes earlier features non-minimally contrastive.
What Determines the Feature Order?

This approach requires us to put the features in an order, which raises the question: where does the ordering come from?

Jakobson and Halle (1956) proposed that the ordering is basically universal, with certain choices being allowed at specified points.

But the order does not appear to be entirely universal. I will adopt the following hypothesis:
Feature Hierarchy Variability Hypothesis

- Like other aspects of linguistic theory, the hierarchy of features is subject to parametric variation.

It follows that the contrastive hierarchies of different languages may be different, even if their segmental inventories look similar.
How does One Know What the Order is?

So how do we know what the order is in any given language?

The Contrastivist Hypothesis suggests an answer: If only contrastive features are active in the phonology, then if we find an active feature, we should suppose it’s contrastive.

The Contrastivist Hypothesis is falsified to the extent that we find more active features than can be contrastive.
Cases

- Romance metaphony
- Lithuanian vowel contrasts
- German and Czech /h/
- East Slavic post-velar fronting
Between the 12th and 14th centuries $ki$ fronted to $k^ji$ in East Slavic.

What caused this fronting? Everyone agrees that the lack of contrast at the time between $k$ and $k^j$ is crucial to accounting for this change.
Padgett (2003) argues that it was motivated also by the surface distance between \( \text{i} \) and \( \text{u} \).
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**

```
Before
/i/    /ɨ/
     |
/i/    /i/

After
/i/

[i] [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

Surface

Prior to Changes

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

/p/ and /k/ occur before all vowels.
First Velar Palatalization (Common Slavic)

Velar [k] mutates to palatoalveolar [tʃ] before /i/. This begins as a phonetic change.
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

Underlying: pi, pi, pu, tʃi, ki, ku

Surface: pʲi, pi, pu, tʃʲi, ki, ku

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)

<table>
<thead>
<tr>
<th>Underlying</th>
<th>Surface</th>
</tr>
</thead>
<tbody>
<tr>
<td>pʲi pi pu tʃʲi ki ku</td>
<td>pʲi pi pu tʃʲi ki ku</td>
</tr>
</tbody>
</table>

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)

/i/ becomes an allophone of /i/

Due to the above and other changes,
[i] occurs only after non-palatalized consonants,
in complementary distribution with [i].
Why Post-Velar fronting?

Post-Velar Fronting (East Slavic)

What caused [kᵢ] to front to [kʲᵢ]?
A Dispersion Theory Analysis
(Padgett 2003)
Padgett (2003) looks at surface phonetic contrasts and proposes that the key to the change of $ki$ to $k^ji$ is that $k^ji$ makes a better perceptual contrast with $ku$ than does $ki$. 

![Diagram showing dispersion]

More dispersion

Less dispersion
Formal Implementation of the DT Analysis

The formal implementation of this analysis requires elaborate and problematic machinery.

Padgett follows Flemming (1995/2004) in assuming that possible inputs and candidate forms within OT can include not only individual forms, but sets of forms.

In Ní Chiosáin and Padgett’s (2001) interpretation, the objects of analysis are taken to be entire languages.

Padgett (2003: 51) writes that ‘this daunting prospect is made manageable by means of extreme idealization.’
The idealization starts by limiting the set of relevant ‘words’ to the ones below:

<table>
<thead>
<tr>
<th>pi</th>
<th>pi</th>
<th>pu</th>
<th>pau</th>
</tr>
</thead>
<tbody>
<tr>
<td>pi'</td>
<td>pi'</td>
<td>pu'</td>
<td>p'au</td>
</tr>
<tr>
<td>tsi</td>
<td>tsi</td>
<td>tsu</td>
<td>tsau</td>
</tr>
<tr>
<td>tsi'</td>
<td>tsi'</td>
<td>tsu'</td>
<td>ts'au</td>
</tr>
<tr>
<td>ki</td>
<td>ki</td>
<td>ku</td>
<td>kau</td>
</tr>
<tr>
<td>k'i</td>
<td>k'i</td>
<td>k'u</td>
<td>k'au</td>
</tr>
</tbody>
</table>
Padgett posits a family of Space constraints that penalize sets of forms that do not allow for sufficient perceptual contrast along designated dimensions.

As part of the extreme idealization of his analysis, Padgett restricts attention to the colour dimension, that is the properties of backness and roundness that are primarily signalled by the second vowel formant:

\[ \text{Space}_{\text{Color}} \geq 1/2: \text{Potential minimal pairs differing in vowel color differ by at least 1/2 of the full vowel color range.} \]

A potential minimal pair is a pair of words having the same number of segments, and all but one of whose corresponding segments are identical.
Prior to post-velar fronting

Padgett supposes that prior to post-velar fronting, underlying forms were essentially the same as the surface forms that obtained after the First Velar Palatalization. (He omits the palatalization in word 1, [p'i₁], though he agrees with standard accounts that it was palatalized).

\[ \begin{array}{c}
p_i_1 \ p_i_2 \ p_u_3 \\
k_i_5 \ k_u_6 \\
tʃᵢ₄ \end{array} \]
Prior to post-velar fronting  
**IDENT(COLOR) >> SPACE**

<table>
<thead>
<tr>
<th>pi₁</th>
<th>pi₂</th>
<th>pu₃</th>
<th>ki₅</th>
<th>ku₆</th>
<th>Ident-Color</th>
<th>Space-Color</th>
<th>At this stage it was more important to retain underlying values of [back] and [round] (<strong>IDENT_{COLOR}</strong>)...</th>
</tr>
</thead>
<tbody>
<tr>
<td>tʃᵢ₄</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>***</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>a.</th>
<th>pi₁</th>
<th>pi₂</th>
<th>pu₃</th>
<th>ki₅</th>
<th>ku₆</th>
<th>Ident-Color</th>
<th>Space-Color</th>
<th>At this stage it was more important to retain underlying values of [back] and [round] (<strong>IDENT_{COLOR}</strong>)...</th>
</tr>
</thead>
<tbody>
<tr>
<td>tʃᵢ₄</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>***</td>
<td></td>
</tr>
</tbody>
</table>
Prior to post-velar fronting

**Ident(Color) >> Space**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>Ident-Color</th>
<th>Space-Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>$\pi_1 \ pi_2 \ pu_3$</td>
<td>$ki_5$ $ku_6$</td>
<td>$t^ji_4$</td>
</tr>
<tr>
<td>b.</td>
<td>$\pi_1 \ pi_2 \ pu_3$</td>
<td>$k^ji_5$ $ku_6$</td>
<td>$t^ji_4$</td>
</tr>
</tbody>
</table>

At this stage it was more important to retain underlying values of [back] and [round] (IDENT\(_{COLOR}\))... than to maximize the separation along the color dimension (SPACE\(_{COLOR}\)).
Post-velar fronting
\textbf{SPACE} $>>$ \textbf{IDENT} (COLOR)

<table>
<thead>
<tr>
<th>$\pi_1$</th>
<th>$\pi_2$</th>
<th>$\pu_3$</th>
<th>$\ki_5$</th>
<th>$\ku_6$</th>
<th>$\tji_4$</th>
<th>Space-Color</th>
<th>Ident-Color</th>
<th>Padgett proposes that what precipitated post-velar fronting was a reranking of the \textbf{SPACE} and \textbf{IDENT} constraints.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>
### Post-velar fronting

**SPACE >> IDENT(COLOR)**

<table>
<thead>
<tr>
<th></th>
<th>Space-Color</th>
<th>Ident-Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>pi₁ pi₂ pu₃ ki₅ ku₆</td>
<td>***!</td>
</tr>
<tr>
<td>b.</td>
<td>pi₁ pi₂ pu₃ kʲi₅ ku₆</td>
<td>**</td>
</tr>
<tr>
<td></td>
<td>tʃʲi₄</td>
<td></td>
</tr>
</tbody>
</table>
Problems with the DT Analysis

Padgett’s DT analysis runs into a number of conceptual and technical problems.
Limiting the set of ‘words’

First, Padgett presents no principle that could justify limiting the analysis to the ‘words’ below. Choosing a different set would lead to a different analysis with a different outcome.

<table>
<thead>
<tr>
<th>pi</th>
<th>pᵢ</th>
<th>pu</th>
<th>pau</th>
</tr>
</thead>
<tbody>
<tr>
<td>pᵢ</td>
<td>pᵢ</td>
<td>pᵢ</td>
<td>pᵢ</td>
</tr>
<tr>
<td>tsᵢ</td>
<td>tsᵢ</td>
<td>tsᵢ</td>
<td>tsᵢ</td>
</tr>
<tr>
<td>tsᵢ</td>
<td>tsᵢ</td>
<td>tsᵢ</td>
<td>tsᵢ</td>
</tr>
<tr>
<td>ki</td>
<td>ki</td>
<td>ku</td>
<td>kau</td>
</tr>
<tr>
<td>kᵢ</td>
<td>kᵢ</td>
<td>kᵢ</td>
<td>kᵢ</td>
</tr>
</tbody>
</table>
Limiting the set of ‘words’

Note in particular the unprincipled decision to designate all labials and coronals apart from \textit{tʃ} as \textit{p}, while velars are designated as \textit{k}.

<table>
<thead>
<tr>
<th>( \pi )</th>
<th>( \pi^j )</th>
<th>( \text{pu} )</th>
<th>( \text{pau} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{p}^j \iota )</td>
<td>( \text{p}^j \iota )</td>
<td>( \text{p}^j \u’)</td>
<td>( \text{p}^j \a’u )</td>
</tr>
<tr>
<td>( \text{t} \iota )</td>
<td>( \text{t} \iota )</td>
<td>( \text{t} \u’)</td>
<td>( \text{t} \a’u )</td>
</tr>
<tr>
<td>( \text{t}^j \iota )</td>
<td>( \text{t}^j \iota )</td>
<td>( \text{t}^j \u’)</td>
<td>( \text{t}^j \a’u )</td>
</tr>
<tr>
<td>( \kappa )</td>
<td>( \kappa )</td>
<td>( \kappa \u’)</td>
<td>( \kappa \a’u )</td>
</tr>
<tr>
<td>( \kappa^j \iota )</td>
<td>( \kappa^j \iota )</td>
<td>( \kappa^j \u’)</td>
<td>( \kappa^j \a’u )</td>
</tr>
</tbody>
</table>
Limiting the set of ‘words’

It is stretching the meaning of ‘idealization’ to apply it to this type of case.

<table>
<thead>
<tr>
<th>pi</th>
<th>pi</th>
<th>pu</th>
<th>pau</th>
</tr>
</thead>
<tbody>
<tr>
<td>p'j'i</td>
<td>p'j'i</td>
<td>p'j'u</td>
<td>p'j'au</td>
</tr>
<tr>
<td>tj'i</td>
<td>tj'i</td>
<td>ts'j'u</td>
<td>ts'j'au</td>
</tr>
<tr>
<td>ki</td>
<td>ki</td>
<td>ku</td>
<td>kau</td>
</tr>
<tr>
<td>kj'i</td>
<td>kj'i</td>
<td>kj'u</td>
<td>kj'au</td>
</tr>
</tbody>
</table>
Limiting the Space dimensions

Second, the DT analysis also imposes an arbitrary limitation on which space dimensions are evaluated for dispersion.

Only the distance between vowels on the color dimension (front/back and round/unround) is considered.
Limiting the Space dimensions

Second, the DT analysis also imposes an arbitrary limitation on which space dimensions are evaluated for dispersion.

But the distance between the consonants is not considered. In fact, the second candidate, though having better vowel dispersion, does much worse in the consonants.
Limiting the Space dimensions

Second, the DT analysis also imposes an arbitrary limitation on which space dimensions are evaluated for dispersion.

\[
\begin{array}{ccc}
\pi_1 & \pi_2 & \text{pu}_3 \\
\text{ki}_5 & \text{ku}_6 \\
\text{tʃʲi}_4 & & \\
\end{array}
\]

We can’t argue that this contrast is somehow not salient or important; on the contrary, we know with certainty that /kʲi/ can be confused with /tʃʲi/: this actually happened in the First Velar Palatalization!
Problems with Minimal Pairs

Third, there is a technical problem with the notion of ‘minimal pair’. Recall that space constraints only value the dispersion of potential minimal pairs.

A potential minimal pair is defined as a pair of words having the same number of segments, and *all but one* of whose corresponding segments are identical.
Problems with Minimal Pairs

Third, there is a technical problem with the notion of ‘minimal pair’. Recall that space constraints only value the dispersion of potential minimal pairs.

By this definition $ki$ and $ku$ are a minimal pair, differing only in the vowel;

But $kj$ and $ku$ differ in the vowel and in the consonant, and so are not a minimal pair. Therefore, the SPACE constraint should not apply.
Problems with Minimal Pairs

Third, there is a technical problem with the notion of ‘minimal pair’. Recall that space constraints only value the dispersion of potential minimal pairs.

<table>
<thead>
<tr>
<th>pi₁</th>
<th>pi₂</th>
<th>pu₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>ki₅</td>
<td></td>
<td></td>
</tr>
<tr>
<td>tʃi₄</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The same problem arises with /pʲi/, once we restore the missing palatalization that Padgett omits from his tableaux.

<table>
<thead>
<tr>
<th>pi₁</th>
<th>pi₂</th>
<th>pu₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>kʲi₅</td>
<td></td>
<td></td>
</tr>
<tr>
<td>tʃi₄</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Problems with Minimal Pairs**

Third, there is a technical problem with the notion of ‘minimal pair’. Recall that space constraints only value the dispersion of potential minimal pairs.

<table>
<thead>
<tr>
<th>/pʲi_1/</th>
<th>/pʲi_2/</th>
<th>/pu_3/</th>
</tr>
</thead>
<tbody>
<tr>
<td>kʲi_5</td>
<td>ku_6</td>
<td></td>
</tr>
<tr>
<td>tʃʲi_4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The same problem arises with /pʲi/, once we restore the missing palatalization that Padgett omits from his tableaux.

<table>
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<th>/pʲi_1/</th>
<th>/pʲi_2/</th>
<th>/pu_3/</th>
</tr>
</thead>
<tbody>
<tr>
<td>kʲi_5</td>
<td>ku_6</td>
<td></td>
</tr>
<tr>
<td>tʃʲi_4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

/pʲi/ differs from /pʲi/ and /pu/ in both the vowel and consonant.
Disregard of Phonemic Status

A fourth problem with Padgett’s approach is its total disregard for the phonemic status of segments.

Padgett (2003) writes that his analysis is inspired by Jakobson (1929); but the key to Jakobson’s analysis is a change in the phonemic status of the vowel ɨ.

In Padgett’s surface-oriented approach it makes no difference if ɨ is an independent phoneme or an allophone of /i/.
Richness of the Base

Padgett (2003) does not want to rely on the phonemic status of [ɨ] because of his understanding of the concept of richness of the base (Prince and Smolensky 2004).

Padgett’s reasoning can be reconstructed along the following lines: If [ɨ] derives from the phoneme /i/, then according to richness of the base we require a solution that works no matter which allophone we put in the input; in particular, the solution should work if [ɨ] corresponds to input /i/.

Therefore, he rejects any analysis (like Jakobson’s) that crucially depends on [ɨ] deriving from underlying /i/, that is, a vowel specified [–back].
Richness of the Base

Ironically, it turns out that in order to account for a sequence of historical changes, Padgett himself must abandon richness of the base.

This is because he wants to guarantee the stability of a historical change: for example, that when [kʲi] changes to [tʃʲi], that subsequently the input to [tʃʲi] will remain /tʃʲi/, and will not revert to /kʲi/.

Therefore he adopts, ‘as an expository convenience’, the *synchronic base hypothesis* (Hutton 1996, Holt 1997), which holds that the input at each historical stage is the output of the previous stage.
Rejection of Structuralism

The synchronic base hypothesis is a rejection not only of richness of the base; it amounts to a reversion to pre-structuralist 19th century neogrammarian theory.

Jakobson argued that historical change is influenced by the phonemic status of segments, a position elaborated on in generative grammar, notably by Kiparsky.

On this view, diachronic changes are the surface reflection of changes to the grammar, and the cause of any particular change must be understood with respect to the grammar as a whole.
Modified Contrastive Specification

The theory of the contrastive hierarchy suggests a different solution to post-velar fronting, one that does not require the problematic selection of sets of inputs, and 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]

Underlying /p ɨ/ /p ɨ/ /tʃ ɨ/ /k ɨ/

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

Underlying  /p i/  /p i/  /tʃ i/  /k i/

[-bk] [+bk] [-bk] [+bk]

Palatalization  pʲ i  p i  tʃʲ i  k i

[-bk] [+bk] [-bk] [+bk]

Phonetic  [pʲi]  [pʲi]  [tʃʲi]  [ki]
Stage 2: There were two ultra-short vowels called jers: one was a front vowel and the other was a back vowel.

Underlying /p ɨ̆/  /p ɨ/  /tʃ ɨ/  /k ɨ̆/  

[–bk]  [+bk]  [–bk]  [+bk]
Stage 2: The front jer palatalized like other front vowels, the back one did not.

Underlying: /p ɨ̆/ /p ɨ̆/ /tʃ ɨ̆/ /k ɨ̆/

Palatalization: pʲ ɨ̆ p ɨ̆ tʃʲ ɨ̆ k ɨ̆
Stage 2: The fall of the jers made palatalization opaque and led to the reanalysis of palatalized consonants as underlying.

<table>
<thead>
<tr>
<th>Underlying</th>
<th>/p ɪ/</th>
<th>/p ɪ/</th>
<th>/tʃ ɪ/</th>
<th>/k ɪ/</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="-bk" alt="Palatalization" /></td>
<td><img src="+bk" alt="Palatalization" /></td>
<td><img src="-bk" alt="Palatalization" /></td>
<td><img src="+bk" alt="Palatalization" /></td>
<td></td>
</tr>
<tr>
<td>Jers delete</td>
<td>[pʲ]</td>
<td>[p]</td>
<td>[tʃʲ]</td>
<td>[k]</td>
</tr>
</tbody>
</table>
Stage 3: Vowels and paired consonants are contrastively [back].

Underlying /pʲ\ i/ /p i/

Palatalization — —

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

<table>
<thead>
<tr>
<th>Underlying</th>
<th>/pʲ</th>
<th>i/</th>
<th>/p</th>
<th>i/</th>
<th>/tʃʲ</th>
<th>i/</th>
</tr>
</thead>
<tbody>
<tr>
<td>Palatalization</td>
<td>[–b]</td>
<td>[–b]</td>
<td>[+b]</td>
<td>[+b]</td>
<td>[–b]</td>
<td>[–b]</td>
</tr>
<tr>
<td>Phonetic</td>
<td>[pʲi]</td>
<td>[pʲ]</td>
<td>[tʃʲi]</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Stage 3: Velars are **unpaired**, but they are *not* contrastively [back]. Why the difference between /tʃʲ/ and /k/?

<table>
<thead>
<tr>
<th>Underlying</th>
<th>/pʲi/</th>
<th>/p i/</th>
<th>/tʃʲi/</th>
<th>/k i/</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[-b]</td>
<td>[-b]</td>
<td>[+b]</td>
<td>[-b]</td>
</tr>
<tr>
<td></td>
<td>[-b]</td>
<td>[+b]</td>
<td>[-b]</td>
<td>[-b]</td>
</tr>
<tr>
<td></td>
<td>[+]</td>
<td>[+]</td>
<td>[+]</td>
<td>[+]</td>
</tr>
</tbody>
</table>

Palatalization

-...

Phonetic

/pʲi/  /pʲi/  /tʃʲi/  /ki/
Stage 3: The contrastive status of unpaired consonants depends on the contrastive hierarchy.

<table>
<thead>
<tr>
<th>Underlying</th>
<th>/pʲ</th>
<th>i/</th>
<th>/p</th>
<th>i/</th>
<th>/tʃʲ</th>
<th>i/</th>
<th>/k</th>
<th>i/</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[–b]</td>
<td></td>
<td>[+b]</td>
<td></td>
<td>[–b]</td>
<td></td>
<td>[+b]</td>
<td></td>
</tr>
</tbody>
</table>

Palatalization — — — — — —

<table>
<thead>
<tr>
<th>Phonetic</th>
<th>[pʲi]</th>
<th>[pɨ]</th>
<th>[tʃʲ]</th>
<th>[kɨ]</th>
</tr>
</thead>
</table>
Stage 3: I will show why unpaired coronals are contrastive for [back] while velars are not contrastively [+back].

<table>
<thead>
<tr>
<th>Underlying</th>
<th>/pʲi/</th>
<th>/p i/</th>
<th>/tʃʲi i/</th>
<th>/k i/</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[+b]</td>
<td>[+b]</td>
<td>[+b]</td>
<td>[-b]</td>
</tr>
<tr>
<td>Palatalization</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Phonetic</td>
<td>[pʲi]</td>
<td>[pʲi]</td>
<td>[tʃʲi]</td>
<td>[kʲi]</td>
</tr>
</tbody>
</table>
Stage 3: For now let us assume this result.

Underlying: /pʲi/ /p i/ /tʃʲi/ i/ /k i/

Palatalization: [−b] [−b] [+b] [+b] [−b] [−b] [+b]

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

Phonetic: [pʲi]  [pɨ]  [tʃɨi]  [kɨ]
Stage 4: /i/ 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.

Underlying /pʲ/i/ /p/i/ /tʲ/i/ /k/i/

[-b] [-b] [+b] [-b] [-b] [-b] [-b]

i-Backing ------ p i ------ ------

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

<table>
<thead>
<tr>
<th>Underlying</th>
<th>pʲ</th>
<th>i/</th>
<th>p</th>
<th>i/</th>
<th>tʃʲ</th>
<th>i/</th>
<th>k</th>
<th>i/</th>
</tr>
</thead>
<tbody>
<tr>
<td>[-b]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>[-b]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>[+b]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>[-b]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

i-Backing

---

p | i
---

[+b] | [-b]
Stage 4: Instead, /i/ palatalizes the /k/.

<table>
<thead>
<tr>
<th>Underlying</th>
<th>/p^j/</th>
<th>i/</th>
<th>/p</th>
<th>i/</th>
<th>/t^j/</th>
<th>i/</th>
<th>/k</th>
<th>i/</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[-b]</td>
<td>[-b]</td>
<td>[+b]</td>
<td>[-b]</td>
<td>[-b]</td>
<td>[-b]</td>
<td>[-b]</td>
<td></td>
</tr>
</tbody>
</table>

i-Backing

<table>
<thead>
<tr>
<th>Palatalization</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>[+b] [-b]</td>
</tr>
</tbody>
</table>

Palatalization

<table>
<thead>
<tr>
<th></th>
<th>k^j</th>
<th>i</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[-b]</td>
<td></td>
</tr>
</tbody>
</table>
Stage 4: The consequence is post-velar fronting: it appears that \([\text{k}i] > [\text{k}^j\text{i}]\).
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 [ɨ] and [u].

Rather than an arbitrary selection of ‘words’ and arbitrary restriction of the dimensions of contrast for this problem alone, this analysis is based on a contrastive feature hierarchy for Russian that should apply to other aspects of Russian phonology, such as voicing:
The first contrast is between sonorants and obstruents. Voicing is now not contrastive among the sonorants, which are all voiced.
I assume that the place features [peripheral] and [labial] come next. [−peripheral] = [coronal] and [−labial] = [velar].
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].
The same ordering applies in the labials. Since they are all paired, they all receive contrastive values of [back].
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 [F₁],
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~/tʲ/ 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.
[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

[sonorant]

peripheral

[coronal]

[voiced]

[cont]

[back]

p^j p f^j f b^j b v^j v

see next slide

[labial]

[velar]

[labial]

m m^j n n^j l l^j r r^j

[k x]
But [cont] is lower. In the velars, ‘unpaired’ /g/ has no contrastive value for this feature.
[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.
The evidence from different phonological processes converges on a single consistent feature hierarchy.
For a more complete account please see:
I am grateful to members of the project on *Markedness and the Contrastive Hierarchy in Phonology* at the University of Toronto (Drescher and Rice 2002):

www.chass.utoronto.ca/~contrast/

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