Contrastive Feature Hierarchies in Phonology: Variation and Universality

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GURT 2017
March 10-12
Georgetown University

1.

Introduction

Introduction

As a way of addressing the theme of this conference, "Variable Properties: Their Nature and Acquisition," I would like to ask the question: What is variable and what is fixed in phonology?

In particular, I want to focus on phonological representations, and on the nature of features: are features innate and universal, or are they 'emergent' and language particular?

➢ The assumption that features are innate does not seem to leave enough room for the variability that we find;

➢ but the assumption that they are emergent could leave us with too much variation, with no account of why phonologies resemble each other as much as they do.

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Introduction

Modifying a line of thought that can be traced back to Roman Jakobson, I propose that it is the concept of a contrastive feature hierarchy that is universal, not the features themselves or their ordering.

I further adopt the Contrastivist Hypothesis, which holds that only contrastive features can be computed by the phonology.

This hypothesis makes a connection between contrast and phonological activity that has implications for language acquisition.

Introduction

In particular, it implies that learners are guided by phonological activity as well as by surface phonetics in acquiring the feature hierarchy for their language.

I will argue that these principles suffice to account for many of the ways that phonological systems resemble each other.

I will show how contrastive feature hierarchies contribute to accounts of synchronic and diachronic phonology, allowing for considerable variation, but governed by a uniform universal template.

Introduction

The talk is organized as follows:

➢ 1. Introduction

➢ 2. Jakobson's *Kindersprache*: a reconsideration

➢ 3. A theory of phonological contrast

➢ 4. Phonological features: innate or emergent?

➢ 5. Contrastive feature hierarchies: synchronic phonology

➢ 6. Contrastive feature hierarchies: diachronic change

➢ 7. Contrastive feature hierarchies and language acquisition

➢ 8. Conclusions

2.

Jakobson's Kindersprache: a reconsideration

Jakobson's *Kindersprache*
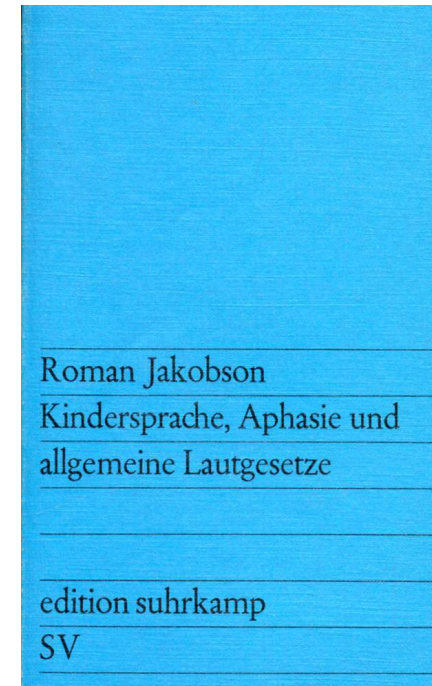
Roman Jakobson's *Kindersprache (*1941), translated into English as *Child Language, Aphasia and Phonological Universals* (1968), is important for its theory of phonological acquisition, as well as for how it connects acquisition to phonological theory more generally.

Fixed order of acquisition

Of the many influential ideas advanced in this book, the one that has attracted much discussion and criticism is the claim that acquisition proceeds in a fixed order.

Jakobson does indeed emphasize this idea throughout the book. For example:

> "The fact that a fixed order must be inherent in language acquisition, and in phonological acquisition in particular, has repeatedly been noticed by observers…" (1968: 20)

Fixed order of acquisition

"Again and again a number of constant features in the succession of acquired phonemes are observed..." (1968: 28)

In some passages, such as the above, Jakobson appears to be claiming that the fixed order of emergence refers to phonemes; for example, he writes that the acquisition of vowels is launched with a wide vowel, *a*, and that the first consonant is generally a labial stop, *p*.

In other places, however, he refers to the emergence of oppositions, that is contrasts, not individual phonemes:

Fixed order of acquisition

Thus, he proposes that in the first vocalic opposition, a more narrow vowel, *i*, is opposed to the wide vowel, *a*.

i

a

Fixed order of acquisition

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In the following stage, either the narrow vowel splits into a palatal, *i*, and velar, *u*…

i   i   u

a

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Fixed order of acquisition

Thus, he proposes that in the first vocalic opposition, a more narrow vowel, *i*, is opposed to the wide vowel, *a*.

In the following stage, either the narrow vowel splits into a palatal, *i*, and velar, *u*…

or a third more central degree of opening, *e*, is introduced.

i

e

a

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Fixed order of acquisition

If the key notion, however, is contrasts, then the predictions about the order of emergence of individual sounds become much more obscure.

/i/

/a/

Fixed order of acquisition

If the key notion, however, is contrasts, then the predictions about the order of emergence of individual sounds become much more obscure.

This is because a contrast between a wider (lower) and narrower (higher) vowel can be phonetically realized in a variety of ways: the phonemic labels '/a/' and '/i/' can each represent a wide range of phonetic vowels.
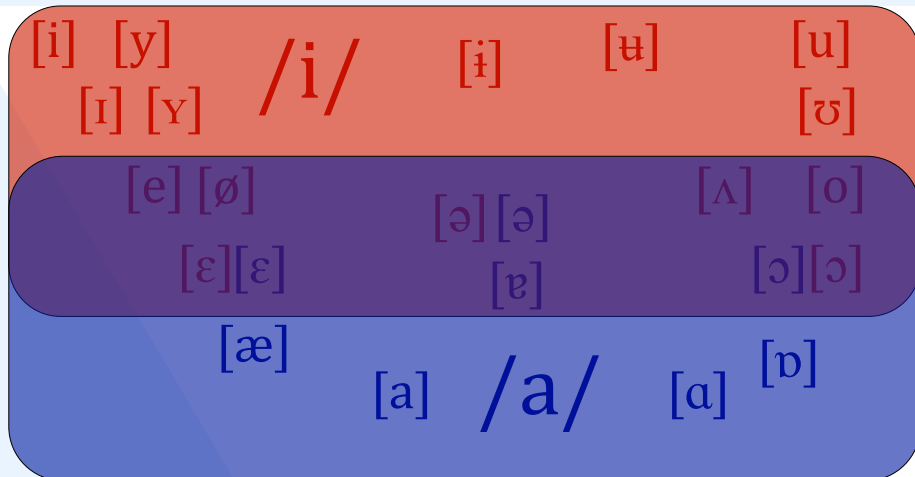
Also, the boundary between two such phonemes can vary considerably from language to language.

Fixed order of acquisition

Hence the apocryphal tale recounted by Hyman (2008), about Jakobson giving a lecture in which he asserts that in all languages the child's first word is *pa*.

A member of the audience objects that *his* child's first utterance was *t∫ɪk*.

Jakobson replies, "phonetic [t∫ɪk], yes, but phonologically /pa/!"

This may be a joke, but there is truth to the notion that an emphasis on contrasts can overshadow the individual sounds that participate in a contrast.

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Jakobson's better idea

This makes it harder than one might suppose to test Jakobson's predictions about a fixed order of acquisition (Ingram 1988).

Nevertheless, it appears that child phonology shows more variation, even within a single language, than Jakobson 1941 allows (Menn & Vihman 2011; Bohn, this conference).

But the claim that acquisition of phonology proceeds in a fixed order is not the only idea put forward in *Kindersprache*.

More consequential, in my view, is the notion that contrasts are crucial and that they develop in a hierarchical order.

Emergence of contrasts

In particular, Jakobson proposes that learners begin with broad contrasts that are split by stages into progressively finer ones. He observes (1968: 65):

"This system is by its very nature closely related to those stratified phenomena which modern psychology uncovers in the different areas of the realm of the mind."

"Development proceeds 'from an undifferentiated original condition to a greater and greater differentiation and separation'." (citing E. Jaensch, *Zeitschr. f. Psychol.* 1928)
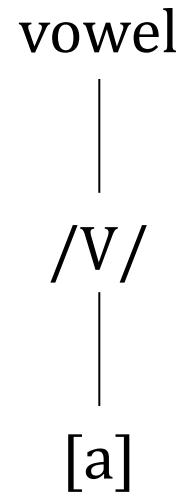
Acquisition sequences (vowels)

vowel
|
/V/

With this basic idea in mind, consider again the acquisition of vowel systems set out in Jakobson 1941 and its sequel, Jakobson & Halle 1956.

At the first stage, there is only a single vowel. As there are no contrasts, we can simply designate it /V/.
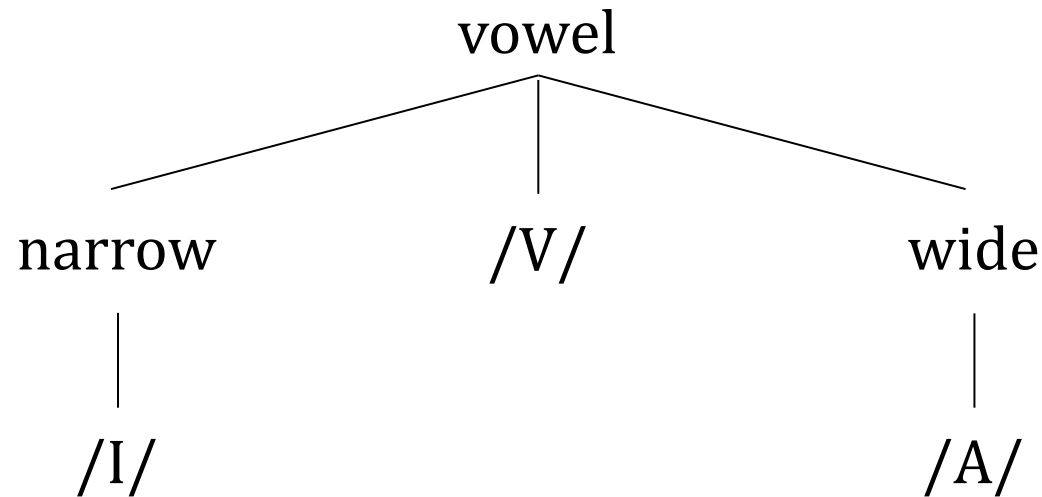
Acquisition sequences (vowels)

vowel

|

/V/

|

[a]

Jakobson & Halle write that this lone vowel is the maximally open vowel [a], the 'optimal vowel'.

But we don't need to be that specific: we can understand this to be a default value, or a typical but not obligatory instantiation.

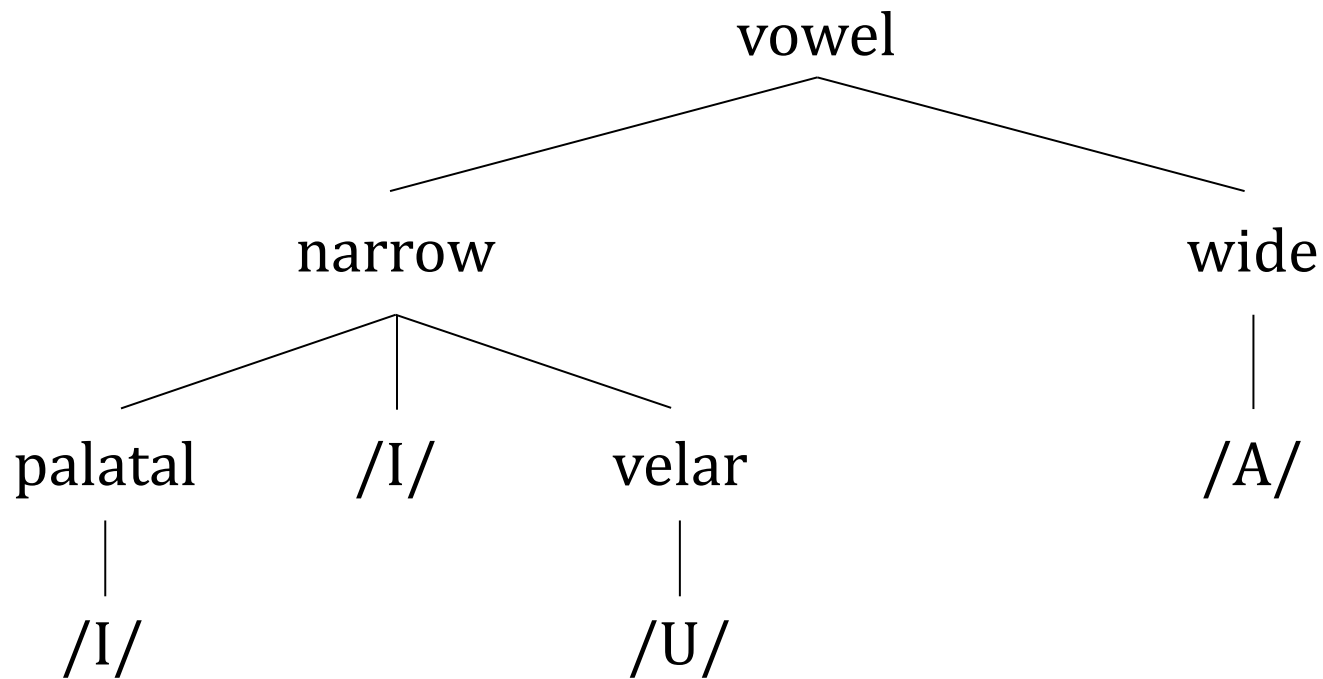For contrastive purposes, any phonetic vowel will fit (e.g. [ɪ^k]!).

Acquisition sequences (vowels)

```
                    vowel
          ┌───────────┼───────────┐
        narrow       /V/         wide
          │                       │
         /I/                     /A/
```

In the next stage, as mentioned, it is proposed that the single vowel splits into a narrow (high) vowel /I/, which is typically [i], and a wide (low) vowel, /A/, typically [a].

I will continue to understand these values as defaults; I use capital letters to represent vowels that fit the contrastive labels that characterize them.

Acquisition sequences (vowels)

```
                        vowel
                       /      \
                  narrow        wide
                 /  |  \           |
          palatal  /I/  velar     /A/
             |            |
            /I/          /U/
```

In the next stage the narrow vowel splits into a palatal (front) vowel /I/ and a velar (back or round) vowel /U/, typically [u].

Jakobson (1968: 49) observes that this stage corresponds to the common 3-vowel system /i, a, u/.

Three-vowel systems

Of course, systems designated as /i, a, u/ vary considerably in their phonetic realizations.

Dresher & Rice (2015) survey some 3-vowel systems that are included in an online phonological database called PHOIBLE (Moran, McCloy & Wright 2014).

It lists 12 Pama-Nyungan (Australia) 3-vowel languages. Of these, 8 are given as /i, a, u/.

The other 4 are listed as having different inventories:

/i, ɑ, u/
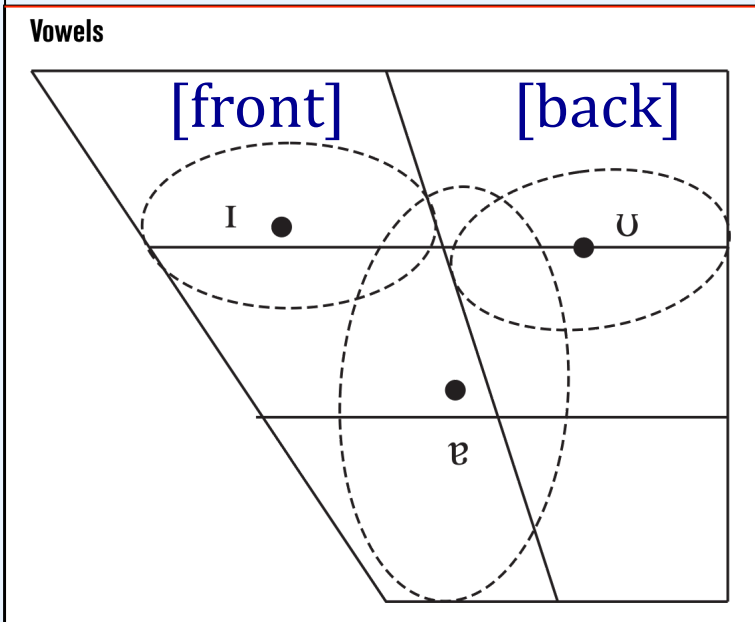/ɪ, a, ʊ/
/ɪ, ɐ, ʊ/
/i, a, ə/

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Three-vowel systems

We found that there are no principled criteria for distinguishing between these systems: distinctions between /i/ ~ /ɪ/, /a/ ~ /ɑ/ ~ /ɐ/, and /u/ ~ /ʊ/ ~ /ə/ do not necessarily indicate significant differences between the languages.
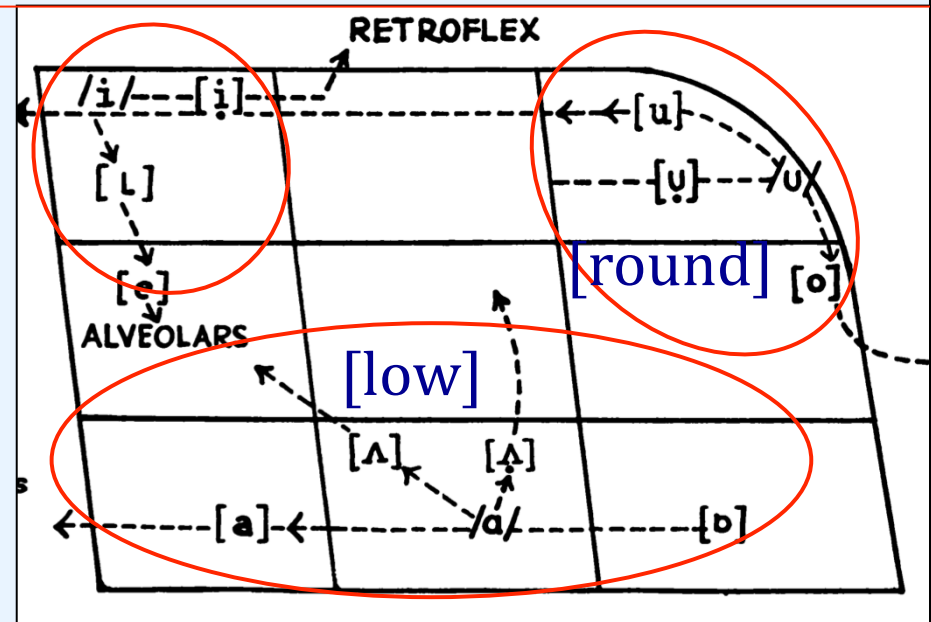
Conversely, the inventories designated /i, a, u/ exhibit considerable variation in the phonetic ranges covered by their 3 vowels.

Compare, for example, the vowel systems of two dialects of the Western Desert Language of central Australia: Pitjantjatjara (Tabain & Butcher 2014)and Antakarinya (Douglas 1955).

Some three-vowel systems

Vowels

[front] [back]

I •   U •

ɐ •

RETROFLEX

/i/---[i]---→

←←[u]
---[ʊ]---
[round] [o]

[ʟ]

[ə]

ALVEOLARS

[low]

[ʌ] [ʌ]

←---[a]-←------/a/---------[ɒ]

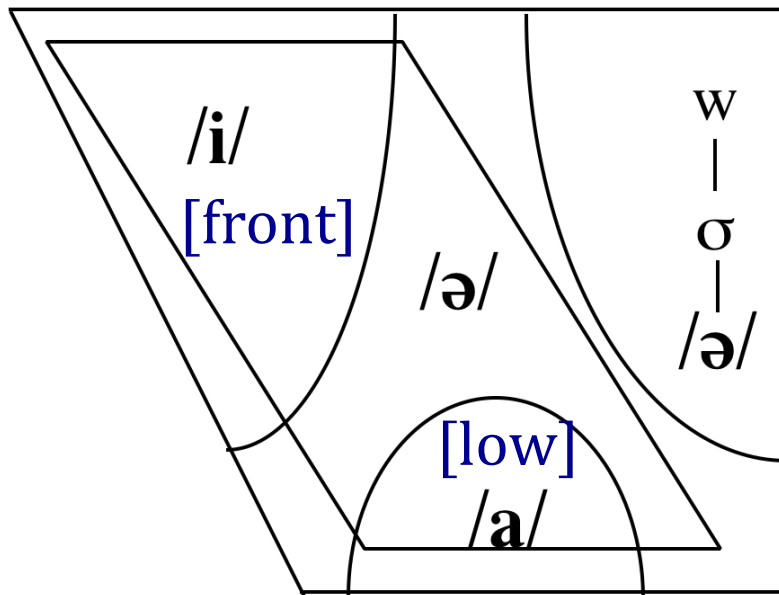Pitjantjatjara   Antakarinya

The distributions of the vowels in the two languages are different, particularly that of the low vowel.

These distributions suggest that the languages may have different contrastive features, derived from different contrastive splits.

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Some three-vowel systems

Western Arrarnta

/i/
[front]
/ə/
/a/
[low]

w
|
σ
|
/ə/

Here are the vowel ranges of another Pama-Nyungan language, Western Arrarnta (Anderson 2000).

The vowel /a/ is restricted to a very small space; we infer it is [low].

/i/ "varies in quality from [ɛ] to [i]." We can assign it [front].

/ə/ is "extremely variable" in height and backness, with unrounded and rounded allophones (so it could be written /u/). It also appears to be the epenthetic vowel.

This distribution is consistent with /ə/ being non-low and non-front; in Jakobson's terms, narrow and velar, that is, /U/.
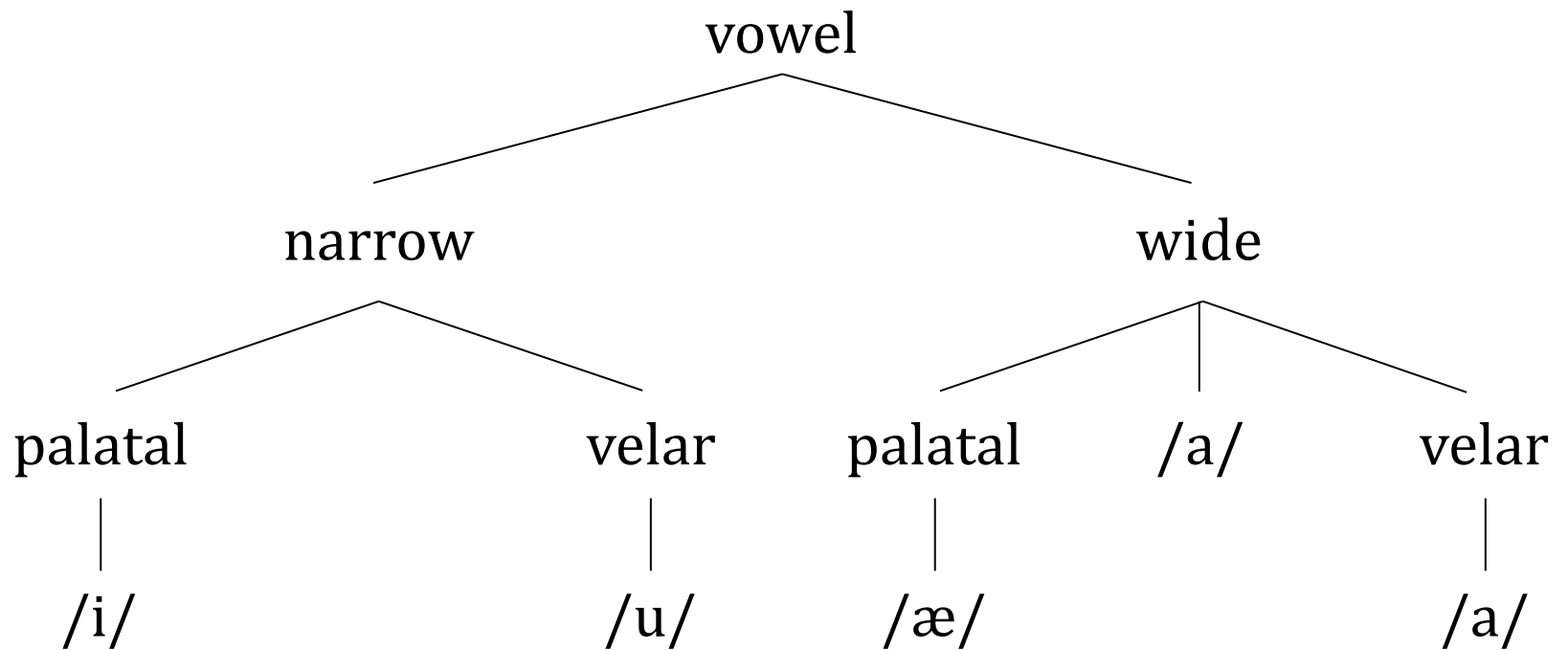
Three-vowel systems

We conclude, then, that the characterization of many three-vowel systems as /i, a, u/ may conceal the fact that they are very diverse.

Similarly, the first stages of phonological acquisition may not be as unvarying as proposed by Jakobson (1941) and Jakobson & Halle (1956).

On the other side, if Jakobson's basic idea about the development of contrasts is correct, then all three-vowel systems are similar in being characterized by two features, even if these features are not the same in each case, or even universal.

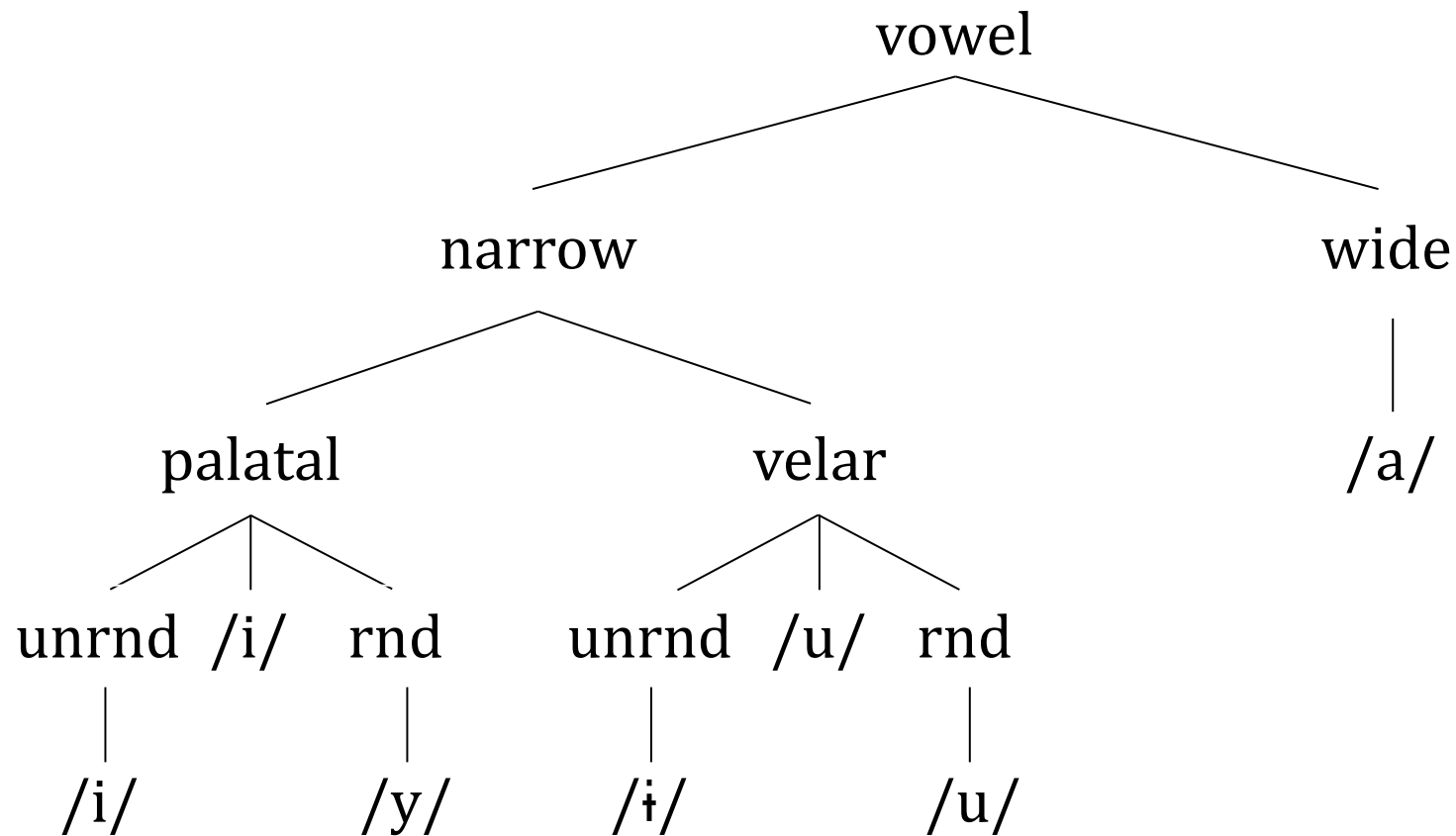In other words, three-vowel systems are "phonetically, all over the place; but phonologically, /i, a, u/!"

Acquisition sequences (vowels)

```
                          vowel
              _____
             /                                \
          narrow                             wide
        ____|____                      _____|_____
       /         \                    /       |       \
   palatal      velar            palatal     /a/     velar
      |           |                 |                   |
     /i/         /u/               /æ/                 /a/
```

After the first two stages, Jakobson & Halle allow variation in the order of acquisition of vowel contrasts.

The wide branch can be expanded to parallel the narrow one.

Acquisition sequences (vowels)


```
                        vowel
                       /     \
                 narrow       wide
                 /    \          |
          palatal      velar    /a/
          /    \       /    \
    unrnd /i/ rnd  unrnd /u/ rnd
      |        |     |        |
     /i/      /y/   /ɨ/      /u/
```

Or the narrow vowels can develop a rounding contrast in one or both branches.
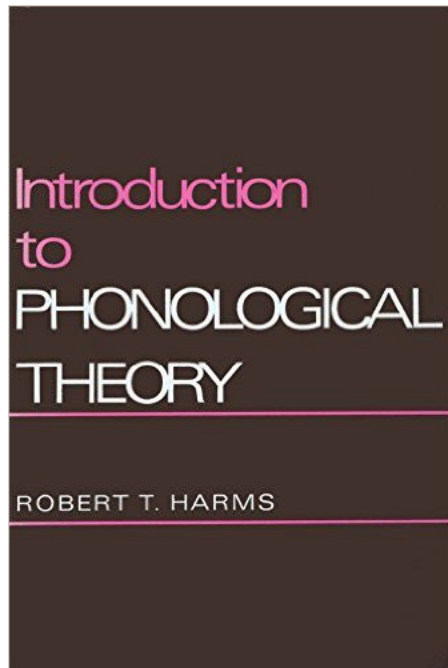
History of 'branching trees' in phonology

Continuing in this fashion we will arrive at a complete inventory of the phonemes in a language, with each phoneme assigned a set of contrastive properties that distinguish it from every other one.

In a number of publications I have tried to reconstruct a history of 'branching trees' in phonology (Dresher 2009, 2015, 2016).

Early, though inexplicit, examples can be found in the work of Jakobson (1931b) and Trubetzkoy (1939) in the 1930s, and continuing with Jakobson 1941 and Jakobson & Lotz 1949.

Then more explicitly in Jakobson, Fant & Halle 1952, Cherry, Halle & Jakobson 1953, Jakobson & Halle 1956, and Halle 1959.

The Golden Age of branching trees

This approach was imported into early versions of the theory of Generative Phonology; it is featured prominently in the first Generative Phonology textbook by Robert T. Harms in 1968.

The decline of the branching trees
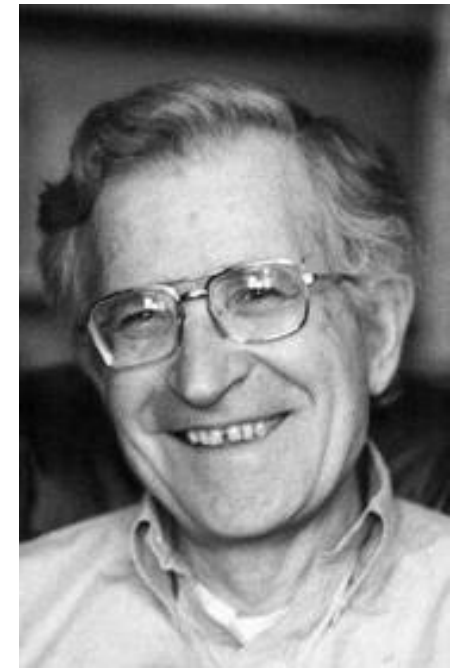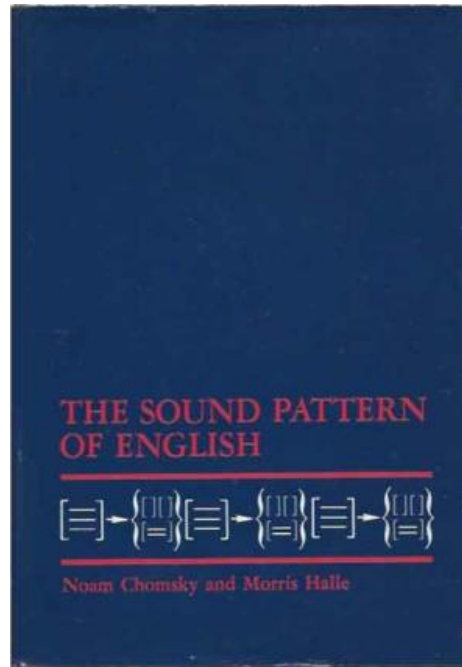
Nevertheless, for reasons that made sense at the time, branching trees were omitted from Chomsky & Halle's *Sound Pattern of English* (1968), and disappeared from mainstream phonological theory for the rest of the century.

Branching trees in child language

In child language studies, however, branching trees continued to be used, for they are a natural way to describe developing phonological inventories (Pye, Ingram and List 1987; Ingram 1988; 1989; Levelt 1989; Dinnsen et al. 1990; Dinnsen 1992; 1996; see Dresher 1998a for a review).

Fikkert (1994) presents observed acquisition sequences in the development of Dutch onsets that follows this general scheme.
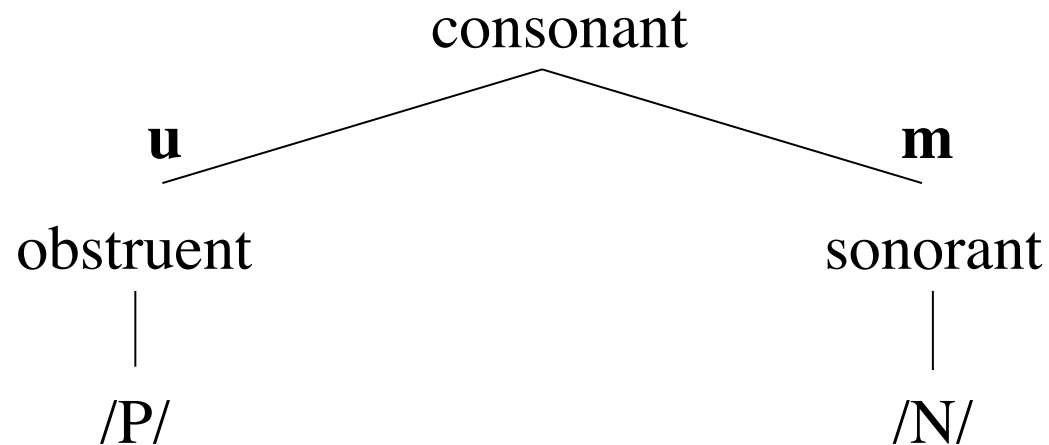
Development of Dutch onset consonants

consonant
|
/P/

Stage 1

There are no contrasts. The value of the consonant defaults
to the least marked onset, namely an obstruent plosive.
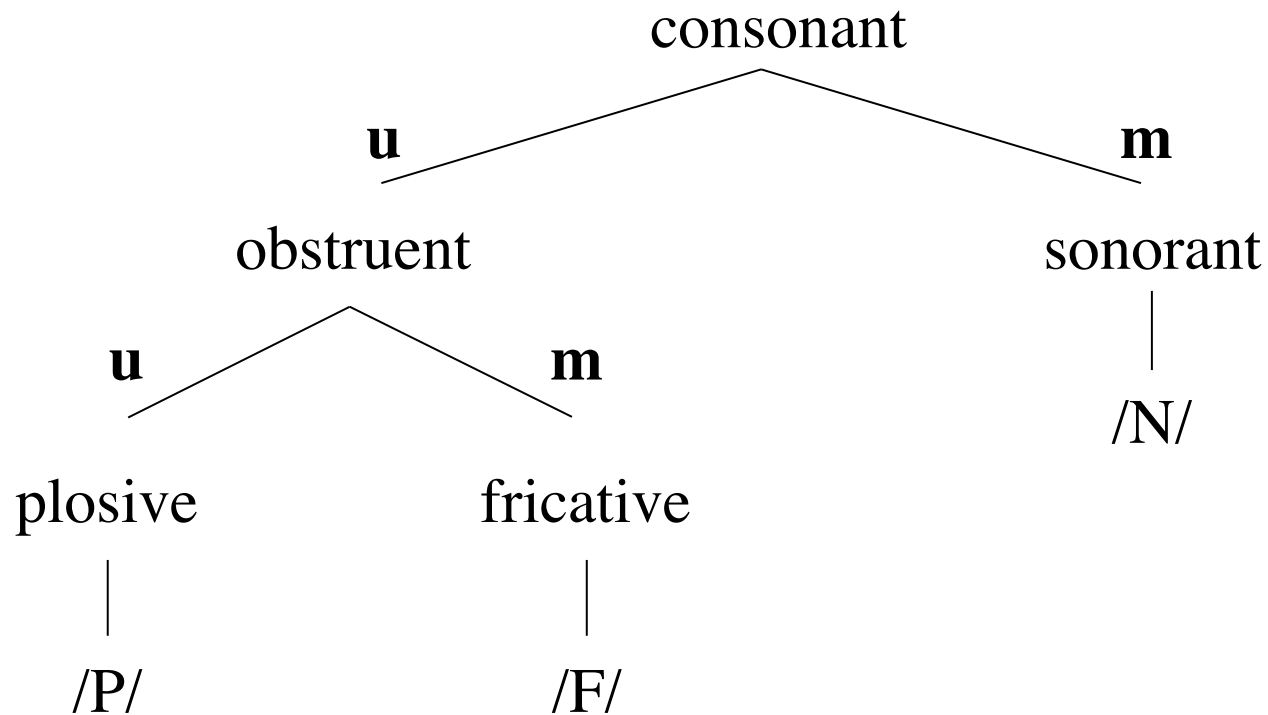
Development of Dutch onset consonants

Stage 2

The first contrast is between obstruent and sonorant. The former remains the unmarked option (**u**). The sonorant defaults to nasal.

Development of Dutch onset consonants

consonant

u   **m**

obstruent   sonorant

u   **m**

plosive   fricative   /N/

/P/   /F/

Stage 3a

At this point children differ. Some expand the obstruent branch first, bringing in marked (**m**) fricatives in contrast with plosives.

Development of Dutch onset consonants

consonant

u   **m**

obstruent   sonorant

/P/   **u**   **m**

nasal   liquid/glide

/N/   /L/J/
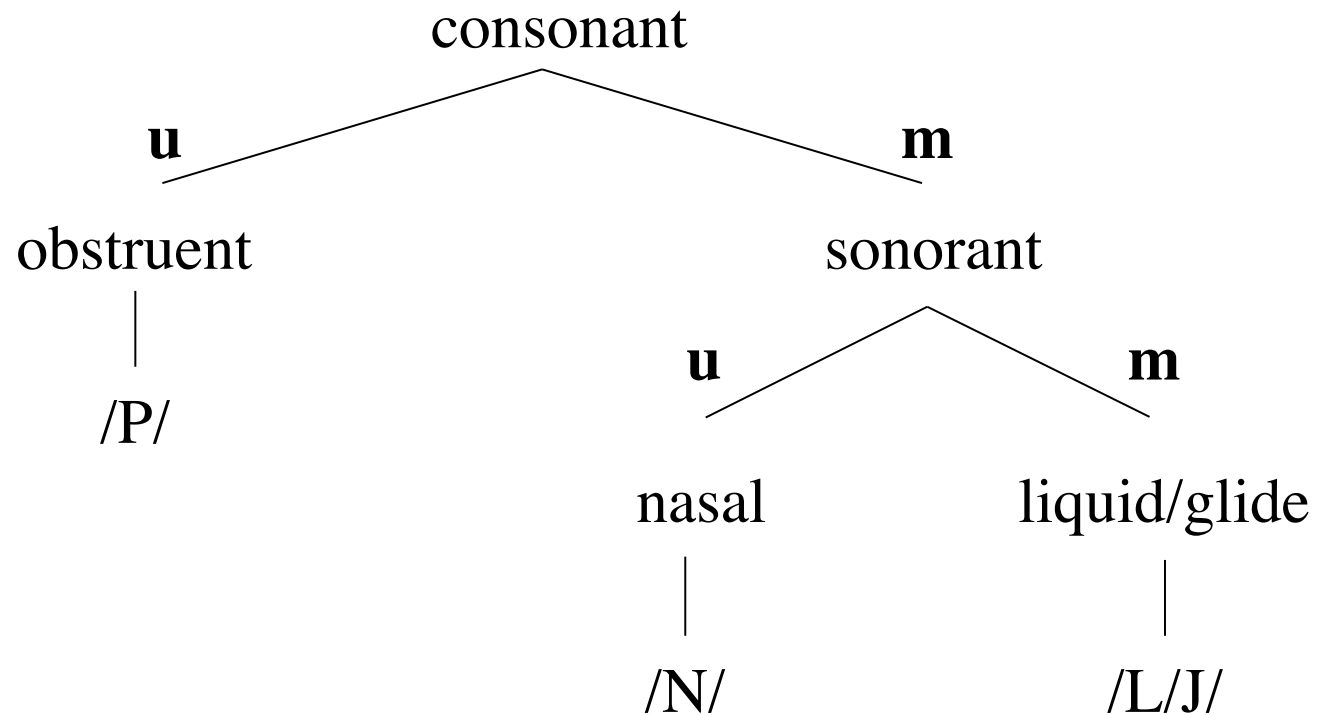
Stage 3b

Others expand the sonorant branch, introducing marked sonorants
(either liquids or glides).

Development of Dutch onset consonants
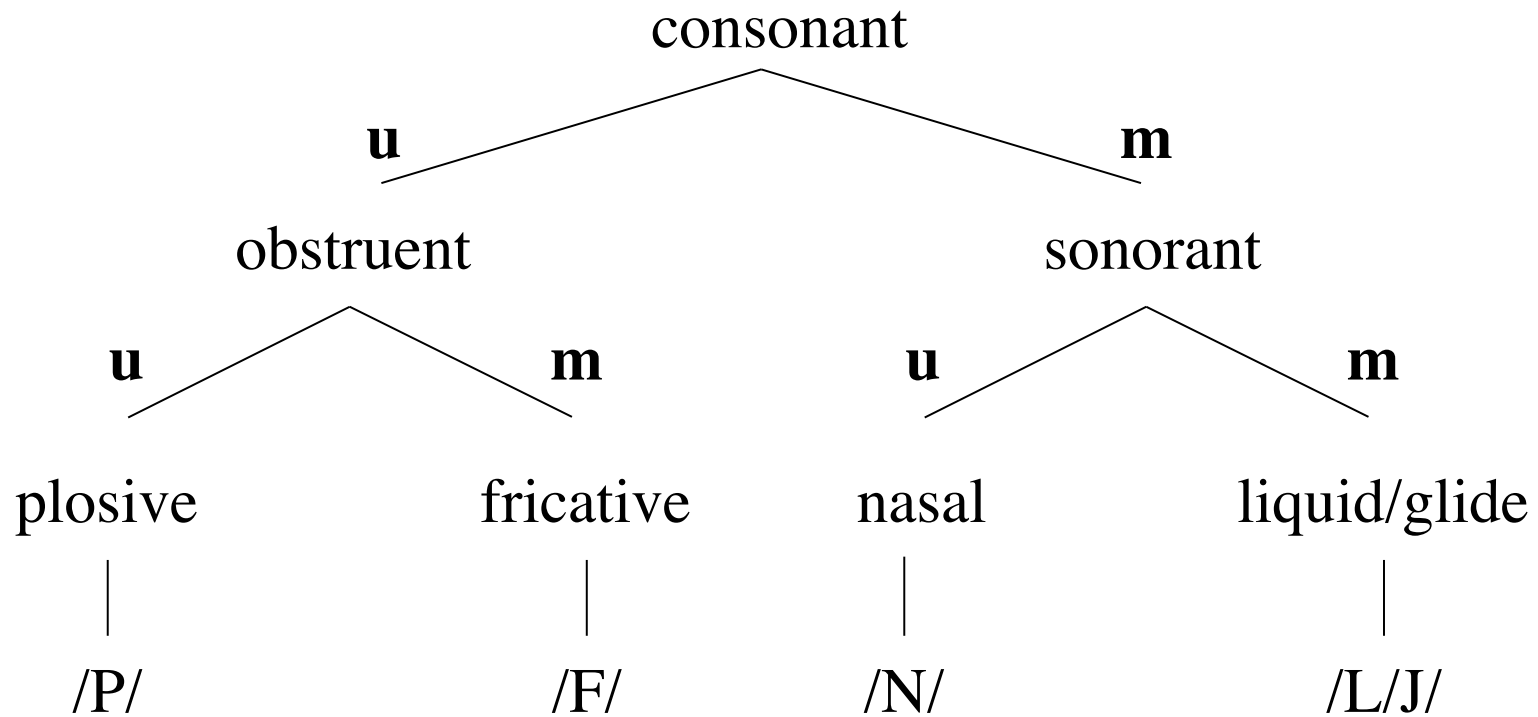
And so on from there.

Return of the branching trees

As a general theory of phonological representations, branching trees were revived, under other names, by Clements (2001; 2003; 2009), and independently at the University of Toronto, where they are called contrastive feature hierarchies (Dresher, Piggott & Rice 1994; Dyck 1995; Zhang 1996; Dresher 1998b; Dresher & Rice 2007; Hall 2007; Dresher 2009; etc.).

It is the latter approach I will be presenting here. It has gone under various names: Modified Contrastive Specification (MCS), or 'Toronto School' phonology, or Contrast and Enhancement Theory, or just Contrastive Hierarchy Theory.

I don't claim there is any 'standard version' of this theory; in what follows, I will present the theory as I understand it.

3.

A theory of phonological contrast

Contrast and hierarchy

The first major building block of our theory is that contrasts are computed hierarchically by ordered features that can be expressed as a branching tree.

Branching trees are generated by what I call the Successive Division Algorithm (Dresher 1998b, 2003, 2009):

The Successive Division Algorithm

Assign contrastive features by successively dividing the inventory until every phoneme has been distinguished.

Criteria for ordering features

What are the criteria for selecting and ordering the features?

Phonetics is clearly important, in that the selected features must be consistent with the phonetic properties of the phonemes.

For example, a contrast between /i/ and /a/ would most likely involve a height feature like [low] or [high], though other choices are possible, e.g. [front] or [advanced/retracted tongue root].

/i/

[low]   /a/

/i/

[front]

/a/

Criteria for ordering features

Of course, the contrastive specification of a phoneme could sometimes deviate from the surface phonetics.

In some dialects of Inuktitut, for example, an underlying contrast between /i/ and /ɨ/ is neutralized at the surface, with both /i/ and /ɨ/ being realized as phonetic [i] (Compton & Dresher 2011).

In this case, /i/ and /ɨ/ would be distinguished by a contrastive feature, even though their surface phonetics are identical.

/i/ ← /ɨ/

[front]

[low]   /a/

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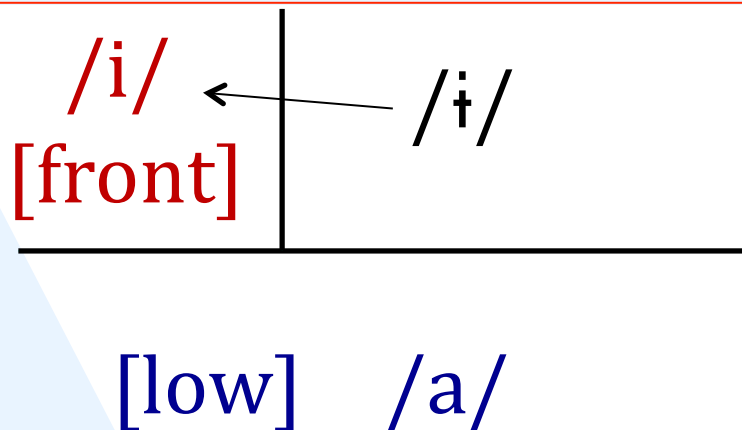
Contrast and phonological activity

As the above example shows, the way a sound patterns can over-ride its phonetics (Sapir 1925).

Thus, we consider as most fundamental that features should be selected and ordered so as to reflect the phonological activity in a language, where activity is defined as follows (adapted from Clements (2001: 77):

Phonological Activity

A feature can be said to be active if it plays a role in the phonological computation; that is, if it is required for the expression of phonological regularities in a language, including both static phonotactic patterns and patterns of alternation.

A theory of contrastive specification

The second major tenet has been formulated by Hall (2007) as the Contrastivist Hypothesis:

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.

That is, only contrastive features can be phonologically active. If this hypothesis is correct, it follows as a corollary that

Corollary to the Contrastivist Hypothesis

If a feature is phonologically active, then it must be contrastive.

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Markedness

One final assumption is that features are binary, and that every feature has a marked and unmarked value.

I assume that markedness is language particular (Rice 2003; 2007) and accounts for asymmetries between the two values of a feature, where these exist.

I will designate the marked value of a feature F as [F], and the unmarked value as (*non-F*). I will refer to the two values together as [±F].
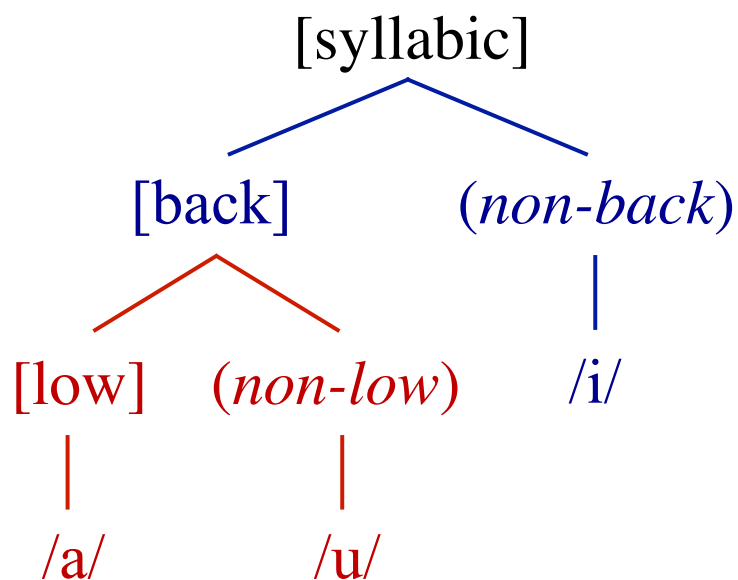
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How the contrastive hierarchy works

For example, if a language has three vowel phonemes /i, a, u/, and if the vowels are split off from the rest of the inventory so that they form a sub-inventory, then they must be assigned a contrastive hierarchy with two vowel features.

Though the features and their ordering vary, the limit of two features constrains what the hierarchies can be.
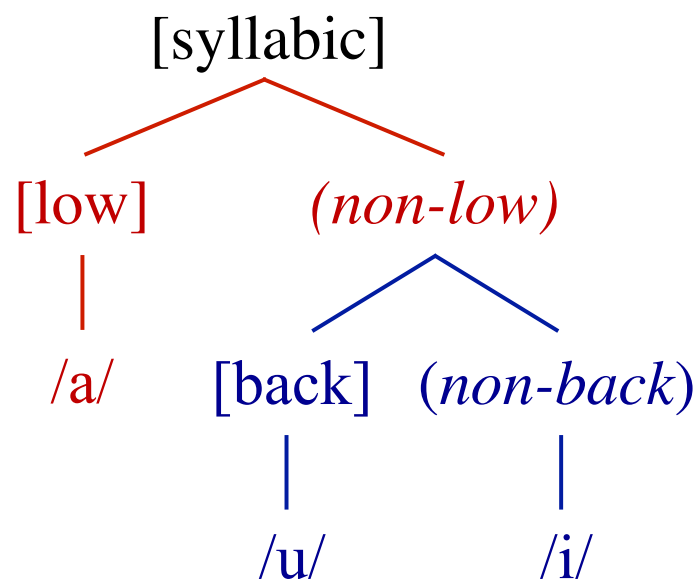
How the contrastive hierarchy works

Here are two possible contrastive hierarchies using the features **[back]** and **[low]**.

[back] > [low]	**[low] > [back]**
[syllabic]	[syllabic]
[back]　　(*non-back*)	[low]　　(*non-low*)
[low]　(*non-low*)　/i/	/a/　[back]　(*non-back*)
/a/　　/u/	/u/　　/i/

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How the contrastive hierarchy works

Here are two more hierarchies, using **[high]** and **[round]**.

[high] > [round]
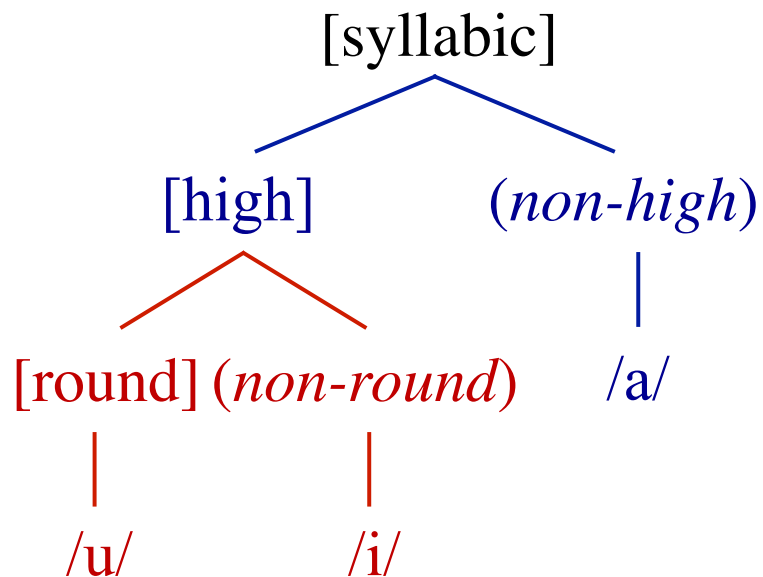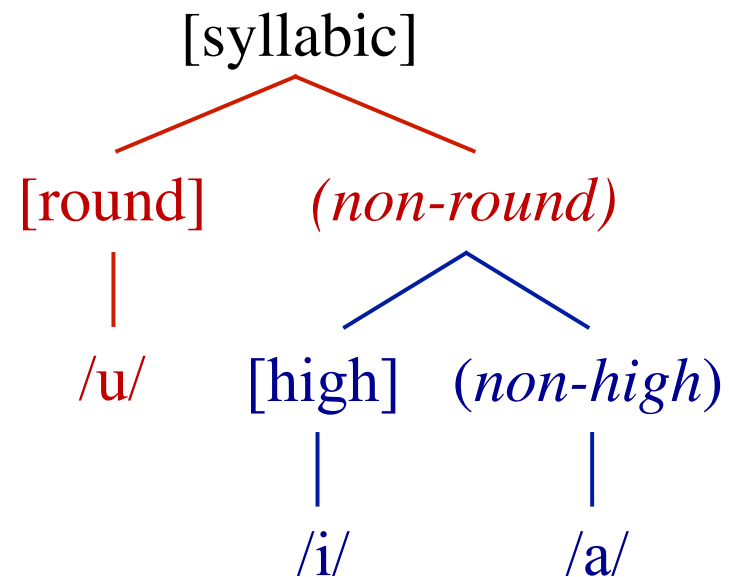
```
                [syllabic]
               /          \
          [high]        (non-high)
          /    \             |
   [round] (non-round)      /a/
      |         |
     /u/       /i/
```

[round] > [high]

```
                [syllabic]
               /          \
          [round]      (non-round)
             |            /      \
            /u/       [high]   (non-high)
                         |          |
                        /i/        /a/
```

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What does the hierarchy do? Synchrony

1. The hierarchy constrains phonological activity:
Only contrastive features can be phonologically active.

Which phonemes can trigger backing?
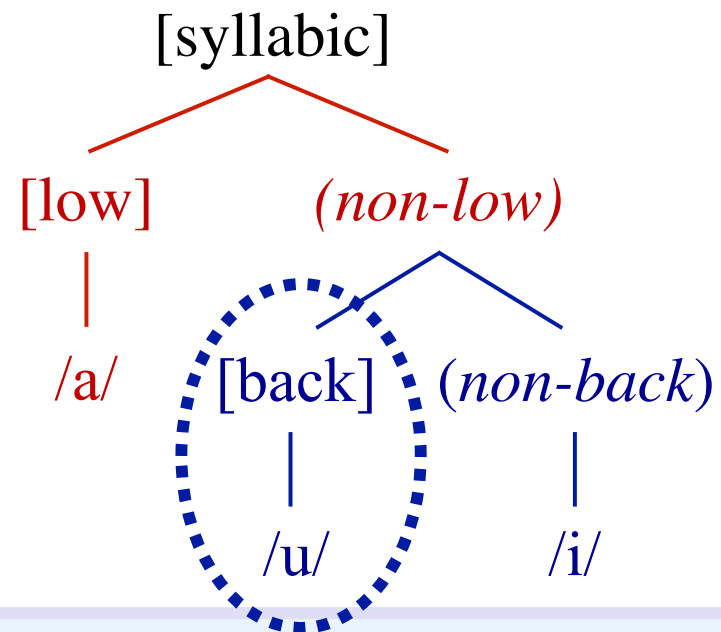
What does the hierarchy do? Synchrony

1. The hierarchy constrains phonological activity:
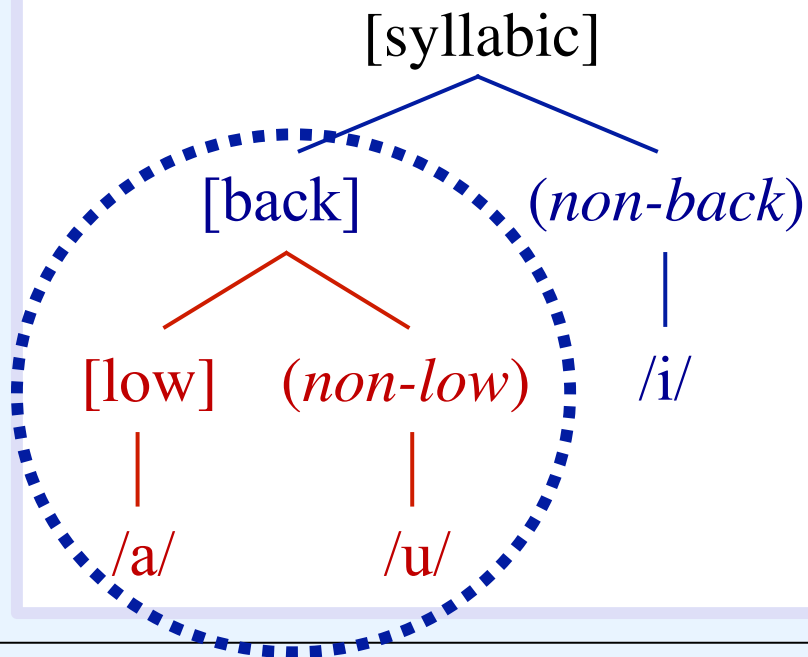Only contrastive features can be phonologically active.

Which phonemes can trigger raising?

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

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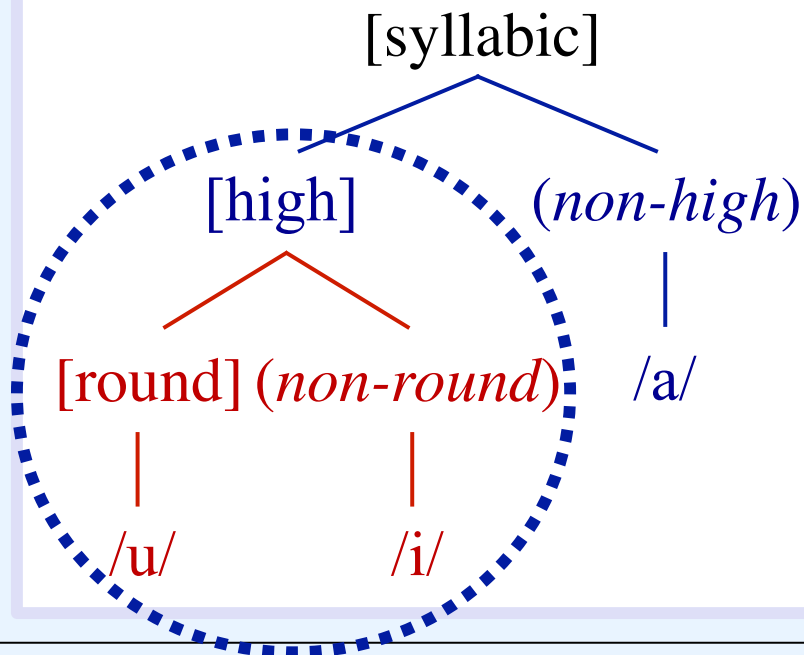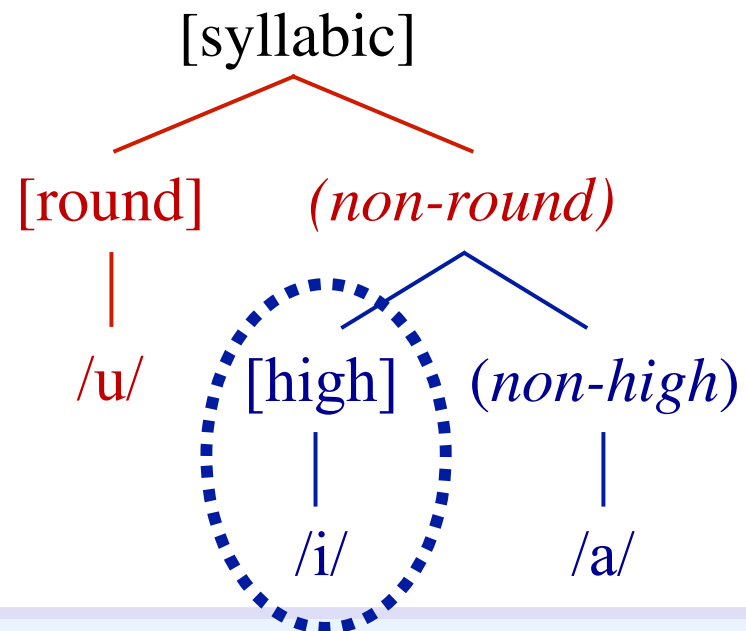
What does the hierarchy do? Diachrony

2. The hierarchy constrains neutralization and merger:
Mergers affect phonemes that are contrastive sisters.

Which phoneme can /ʊ/ merge with?
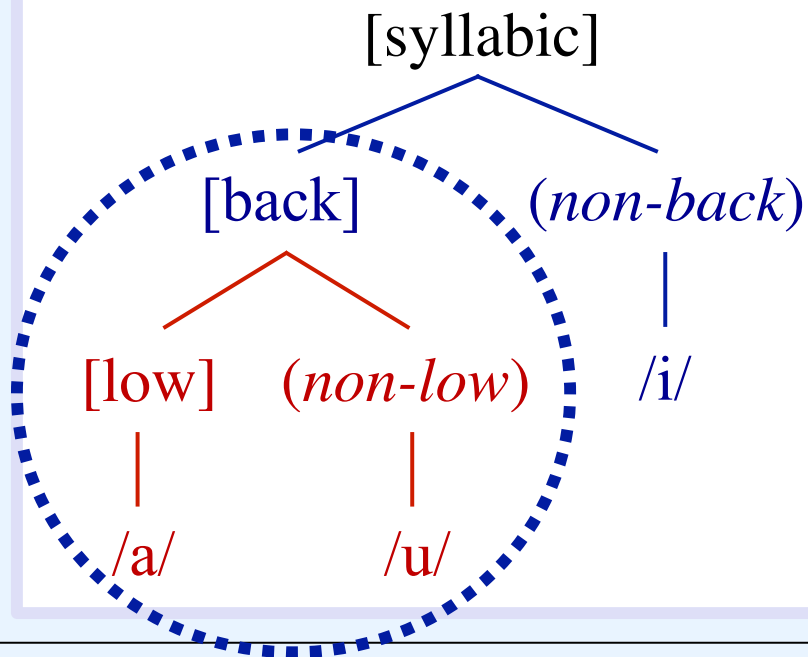
[back] > [low]	[low] > [back]
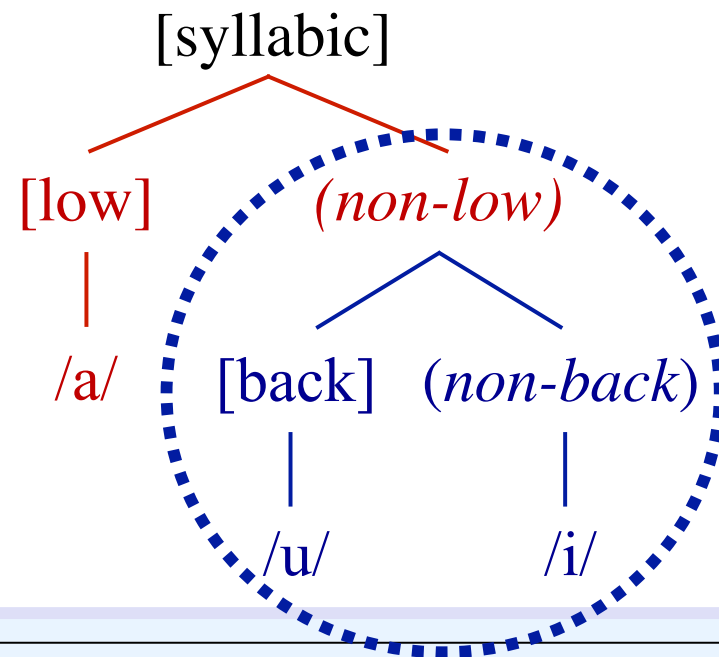
Where can we find typological generalizations?

Typological generalizations can thus not be found by looking at inventories alone (say, /i, a, u/), or at individual phonemes (/a/), or phones ([a]), without also considering the relevant contrastive feature hierarchy.

[back] > **[low]**

[syllabic]

[back] (*non-back*)

[low] (*non-low*) /i/

/a/ /u/
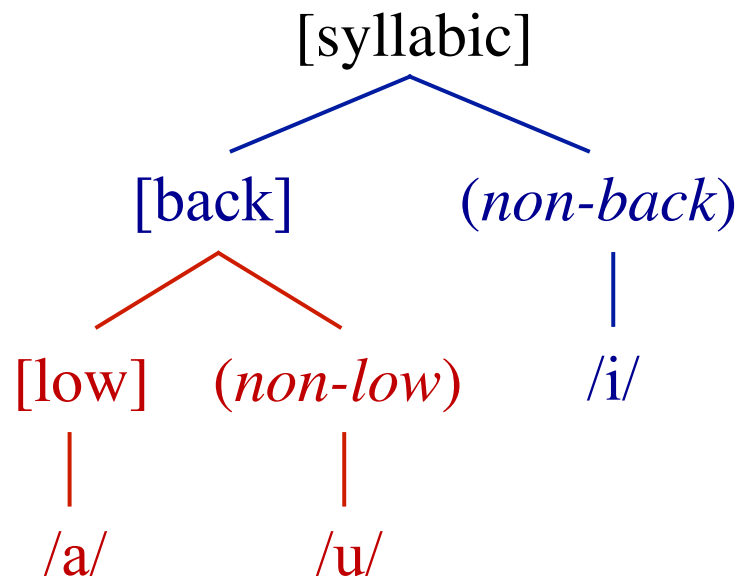
Enhancement of underspecified features

Unless a vowel is further specified by other contrastive features (originating in another vowel or in the consonants), it is made more specific only in a post-phonological component.

Stevens, Keyser & Kawasaki (1986) propose that feature contrasts can be enhanced by other features with similar acoustic effects (see also Stevens & Keyser 1989; Keyser & Stevens 2001, 2006).

Hall (2011) shows how the enhancement of contrastive features can result in configurations predicted by Dispersion Theory (Liljencrants & Lindblom 1972; Lindblom 1986; Flemming 2002)

Enhancement of underspecified features

Thus, a vowel that is [back] and *(non-low)* can enhance these features by adding {round} and {high}, becoming [u].

I designate enhancement features with curly brackets { }.

These enhancements are not necessary, however, and other realizations are possible (Dyck 1995; Hall 2011).

4.

Phonological features: innate or emergent?

Emergent features

There is a growing consensus that phonological features are not innate, but rather 'emerge' in the course of acquisition.

In a volume titled *Where do phonological features come from?* (Clements & Ridouane 2011), most of the papers take an emergentist position; none argue for innate features.

Mielke (2008) and Samuels (2011) summarize the arguments against innate features:

Against innate features

➢ from a biolinguistic perspective, phonological features are too specific, and exclude sign languages (van der Hulst 1993; Sandler 1993);

➢ empirically, no one set of features have been discovered that 'do all tricks' (Hyman 2011 with respect to tone features, but the remark applies more generally);

➢ since at least some features have to be acquired from phonological activity, a prespecified list of features becomes less useful in learning.

Why do features emerge at all?

But if features are not innate, what compels them to emerge at all? It is not enough to assert that features may emerge, or that they are a useful way to capture phonological generalizations.

We need to explain why features inevitably emerge, and why they have the properties that they do. In particular:

> ➢ Why don't learners, or some learners, simply posit segment-level representations?

> ➢ What controls the number of features—how broad or narrow are they? How many features should learners posit for 3 vowels, for example? Are there limits?

The contrastive feature hierarchy provides an answer to these questions: learners must arrive at a set of hierarchically ordered contrastive features.

How many features are there?

An inventory of 3 phonemes allows exactly 2 contrastive features. Two variants are shown, differing in how marked features are distributed.

3 phonemes: F1 > F2

```
              /\
             /  \
        [F1]      (non-F1)
         /\          |
        /  \         |
   [F2]   (non-F2)  /3/
    |       |
    |       |
   /1/     /2/
```

3 phonemes: F1 > F2

```
              /\
             /  \
        [F1]      (non-F1)
         |           /\
         |          /  \
        /1/    [F2]   (non-F2)
                |       |
                |       |
               /2/     /3/
```
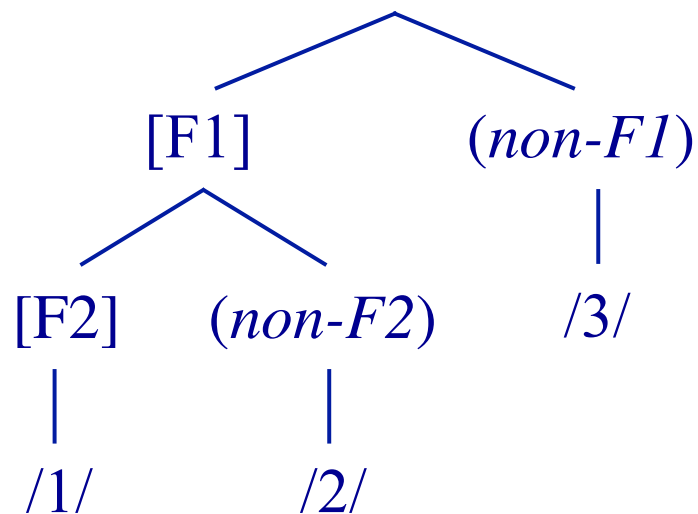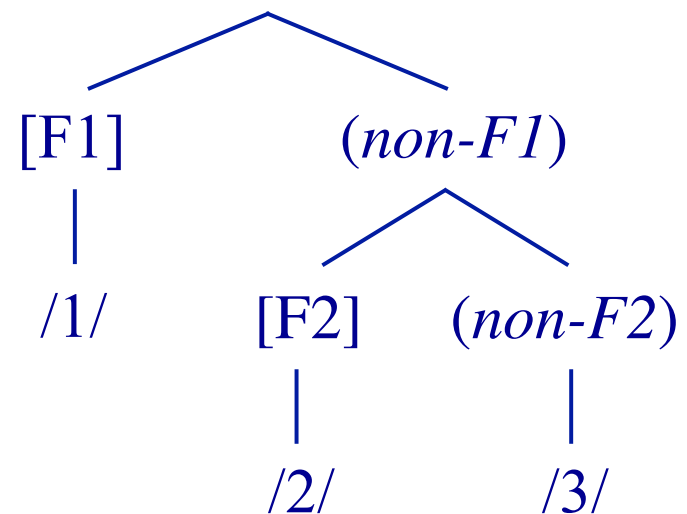
How many features are there?

A 4-phoneme inventory can have a minimum of 2 features and a maximum of 3.

4 phonemes: minimum

```
              [F1]              (non-F1)
            /      \          /        \
        [F2]   (non-F2)   [F2]    (non-F2)
         |        |        |         |
        /1/      /2/      /3/       /4/
```

4 phonemes: maximum

```
    [F1]        (non-F1)
     |        /        \
    /1/    [F2]     (non-F2)
            |      /        \
           /2/  [F3]    (non-F3)
                 |          |
                /3/        /4/
```
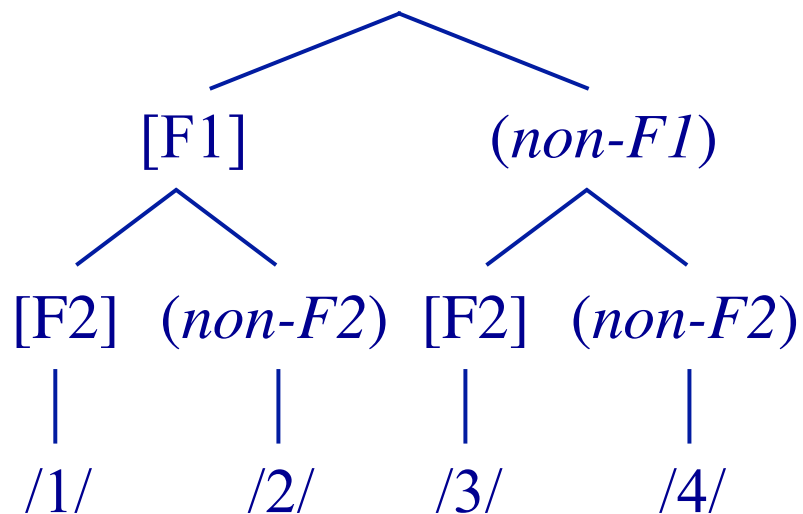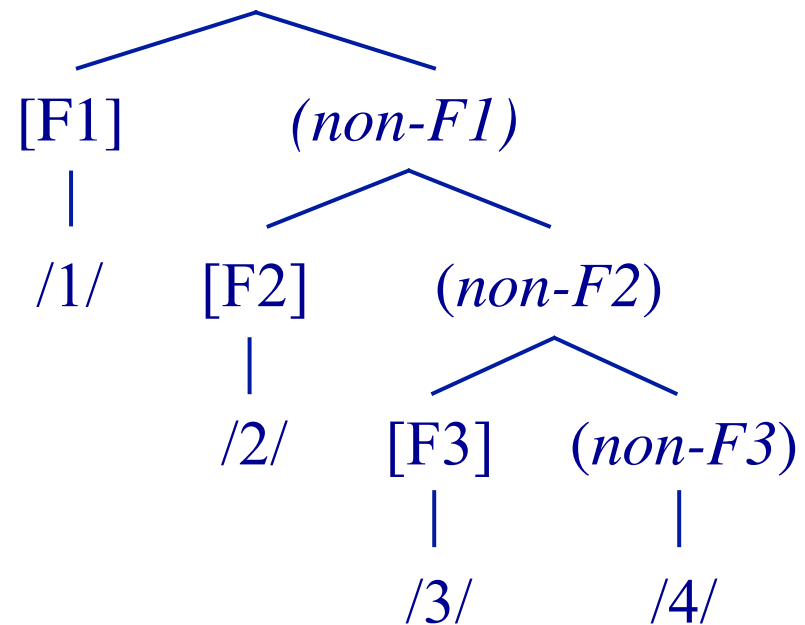
How many features are there?

In general, the number of features required by an inventory of n elements will fall in the following ranges:

the minimum number of features = the smallest integer $\geq \log_2 n$

the maximum number of features = $n-1$

Phonemes	$\log_2 n$	min	max
3	1.58	2	2
4	2	2	3
5	2.32	3	4
6	2.58	3	5

How many features are there?

The minimum number of features goes up very slowly as phonemes are added.

The upper limit rises with n.

Phonemes	$\log_2 n$	min	max
7	2.81	3	6
8	3	3	7
10	3.32	4	9
12	3.58	4	11

How many features are there?

However, inventories that approach the upper limit are extremely uneconomical.

At the max limit, each new segment uses a unique contrastive feature unshared by any other phoneme.

Phonemes	$\log_2 n$	min	max
16	4	4	15
20	4.32	5	19
25	4.64	5	24
32	5	5	31

Emergent features and UG

Thus, the contrastive hierarchy and Contrastivist Hypothesis account for why phonological systems resemble each other in terms of representations, without requiring individual features to be innate.

For the content of features, learners make use of the available materials relevant to the modality:

Emergent features and UG

➢ for spoken language, acoustic and articulatory properties of speech sounds;

➢ for sign language, hand shapes and facial expressions.

On this view, the concept of a contrastive hierarchy is an innate part of Universal Grammar (UG), and is the glue that binds phonological representations and makes them appear similar from language to language.

Phonological features are cognitive entities

It is important to emphasize that, though phonological features may make use of innate auditory dispositions, they are not the same as those, but are cognitive entities created by learners.

[back] > **[low]**

[syllabic]

[back]   (*non-back*)

[low]   (*non-low*)   /i/

/a/   /u/
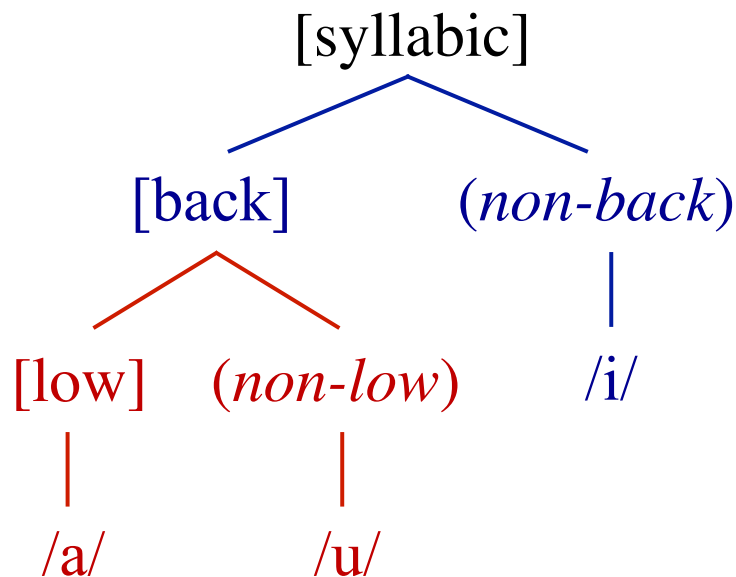
Thus, the contrasts indicated by [back] and [low] may be cross-linguistically common because we have neurons sensitive to formant transitions.

Phonological features are cognitive entities

It is important to emphasize that, though phonological features may make use of innate auditory dispositions, they are not the same as those, but are cognitive entities created by learners.

[back] > [low] ?

Thus, the contrasts indicated by [back] and [low] may be cross-linguistically common because we have neurons sensitive to formant transitions.

So, it appears, do ferrets (Mesgarani et al. 2008). But ferrets do not necessarily have our kind of phonological representations.

5.

Contrastive feature hierarchies: synchronic phonology

Xunke Oroqen vowel system (Zhang 1996)

The Xunke dialect of Oroqen has 9 vowel phonemes
(length contrasts are omitted; they are not relevant here):

/i/   /u/

                                       /ʊ/

/e/   /ə/   /o/

/ɛ/   /ɔ/

            /a/

Xunke Oroqen vowel system (Zhang 1996)

Even if there were innate universal features, there would be considerable ambiguity as to how they apply to this system.

/i/   /u/

                                       /ʊ/

/e/   /ə/   /o/

/ɛ/   /ɔ/

              /a/

Xunke Oroqen vowel system (Zhang 1996)

For example, where is the boundary between the low vowel(s) and the rest? How many heights should we distinguish: 2, 3, 5?

/i/		/u/
		/ʊ/
/e/	/ə/	/o/
/ɛ/		/ɔ/
	/a/	
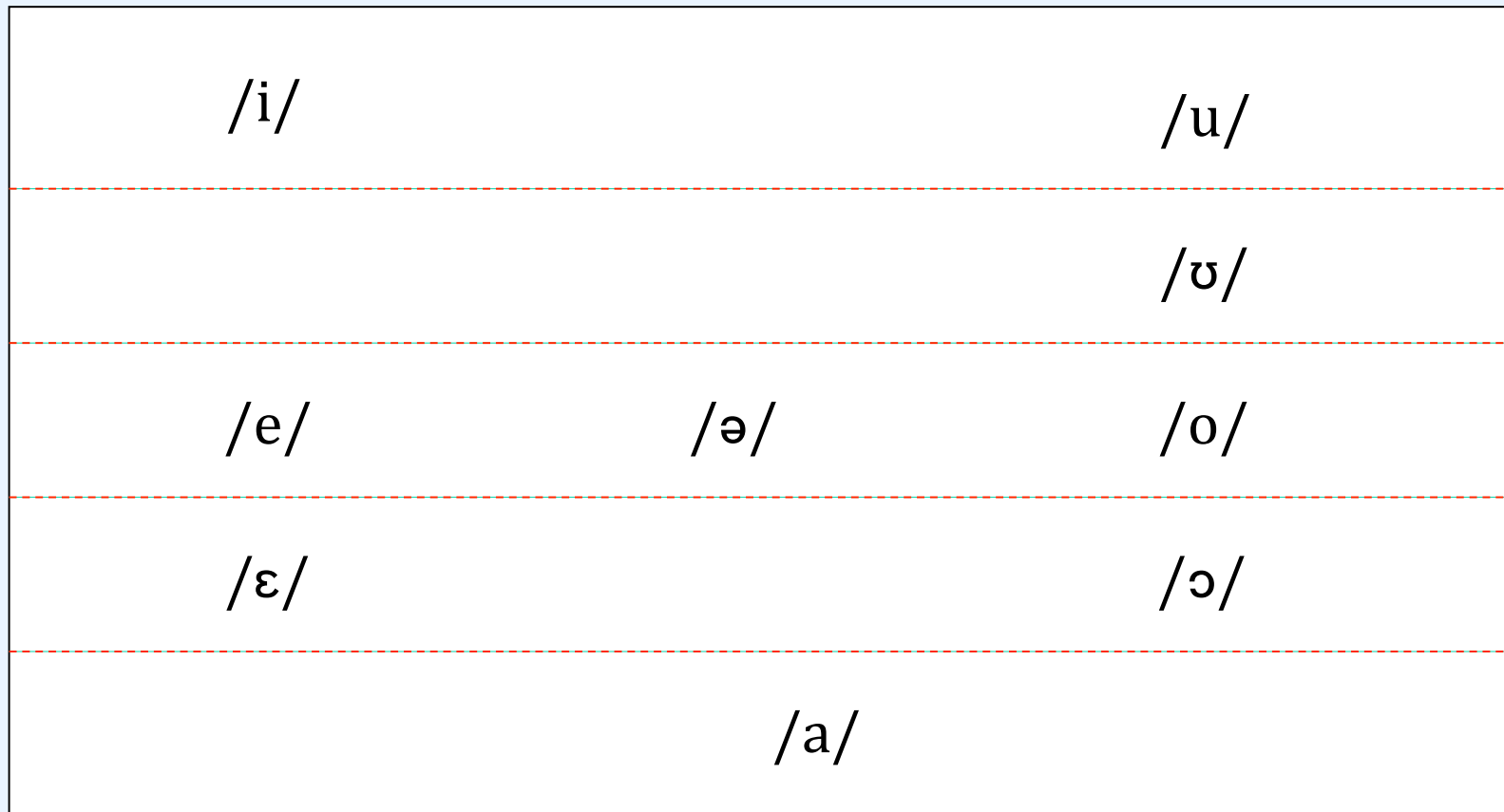
Xunke Oroqen vowel system (Zhang 1996)

For further insight, we need to look at how the vowels pattern, that is, at the types of phonological activity they exhibit.

/i/   /u/

/ʊ/

/e/   /ə/   /o/

/ɛ/   /ɔ/

/a/

Activity in Xunke Oroqen

The three most notable kinds of phonological activity involving vowels are:

➢ RTR (retracted tongue root) harmony

➢ Labial (rounding) harmony

➢ Palatalization

RTR harmony

Vowels fall into two sets:

yin, or non-RTR, vowels in red include /u, e, ə, o/

yang, or RTR, vowels in blue include /ʊ, ɛ, a, ɔ/

Only vowels from the same set may co-occur in a word:

/i/

/u/

/ʊ/

/e/ /ə/ /o/

/ɛ/ /ɔ/

/a/

non-RTR:	ulə	'meat'
RTR:	ʊla	'quill'
non-RTR:	ujəlee	'cousin'
RTR:	ɔjalɛɛ	'quill'
non-RTR:	kosuun	'pond'
RTR:	kɔɔsʊn	'empty'

RTR harmony

The vowel /i/ is neutral and may co-occur with either set:

/i/

/u/

/ʊ/

/e/   /ə/   /o/

/ɛ/   /ɔ/

/a/
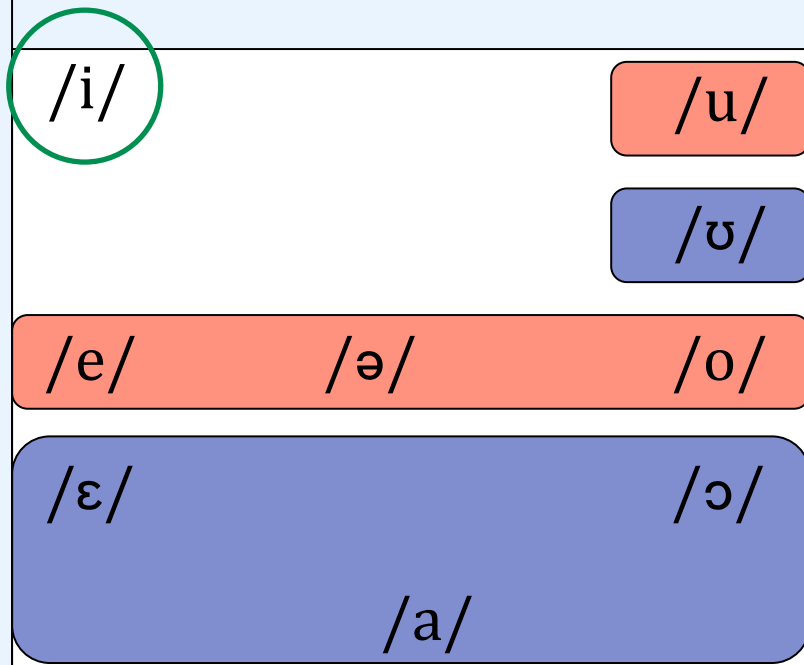
non-RTR:	nəkin-	'sweat'
RTR:	mʊrin	'horse'
non-RTR:	ulin-	'gifts'
RTR:	tari-	'that'
non-RTR:	bitə-	'letter'
RTR:	birakan-	'river'

RTR harmony

/i/

/u/
/ʊ/

/e/
/ɛ/

/ə/

/o/
/ɔ/

/a/
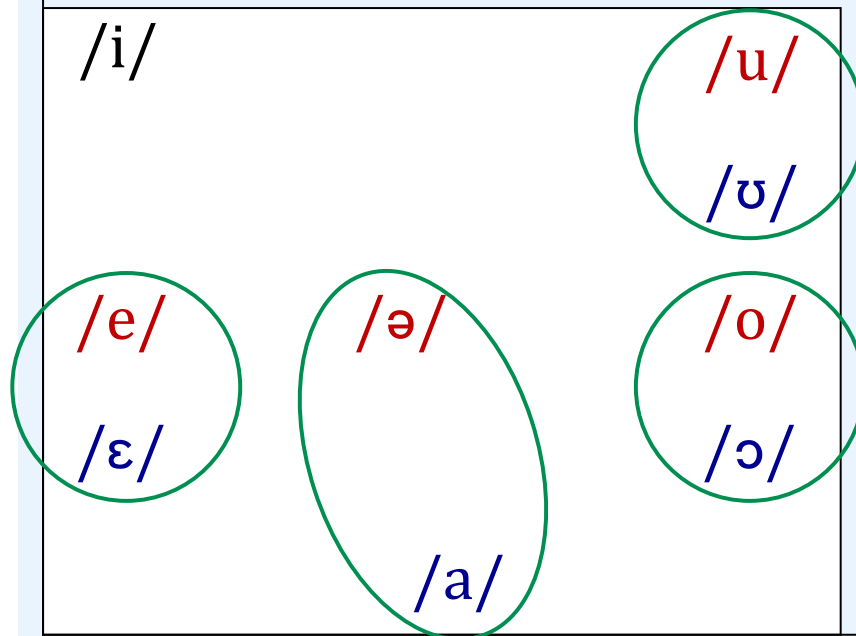
Except for /i/, every non-RTR vowel has an RTR counterpart with which it alternates.

RTR harmony

The vowels /ʊ/, /ɛ/, /a/ and /ɔ/ trigger RTR stem-to-suffix harmony within a word, creating alternations in suffix vowels.

Definite object: *-ma* alternates with *–mə*

[RTR]	kɔɔkan-ma	'child DEF.OBJ'
(*non-RTR*)	bəjun-mə	'moose DEF.OBJ'

Dative: *-dʊ* alternates with *–du*

[RTR]	bʊwa-dʊ	'place DAT'
(*non-RTR*)	utə-du	'son DAT'

RTR harmony

The vowel /i/ is neutral and transparent to harmony: it does not disrupt the redness or blueness of a word.

Plural: *-sal* alternates with *–sǝl*

[RTR]	mʊrin-sal	'horse PL'
(*non-RTR*)	dǝji-sǝl	'bird PL'

Diminutive: *-tʃara* alternates with *–tʃǝrǝ*

[RTR]	wargi-tʃara	'salty DIM'
(*non-RTR*)	toŋgorin-tʃǝrǝ	'round DIM'

/i/ in instrumental suffix *–dʒi*

[RTR]	tʊkala-dʒi	'clay INST'
(*non-RTR*)	sukǝ-dʒi	'axe INST'

RTR harmony

The evidence from activity, therefore, is that every vowel except /i/ has a + or – value of an active feature; by hypothesis, this feature must be contrastive.

/i/   /u/ *(non-F)*

/ʊ/   [F]

/e/   /ə/   /o/ *(non-F)*

/ɛ/   /ɔ/

[F]

/a/

RTR harmony

What feature could this be?
I have already given away that it is [RTR].

/i/

/u/ *(non-RTR)*

/ʊ/ [RTR]

/e/ /ə/ /o/ *(non-RTR)*

/ɛ/ /ɔ/

[RTR]

/a/

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RTR harmony

But this is not obvious, because /i/ is phonetically {non-RTR}.
(Ovals and { } represent phonetic percepts.)
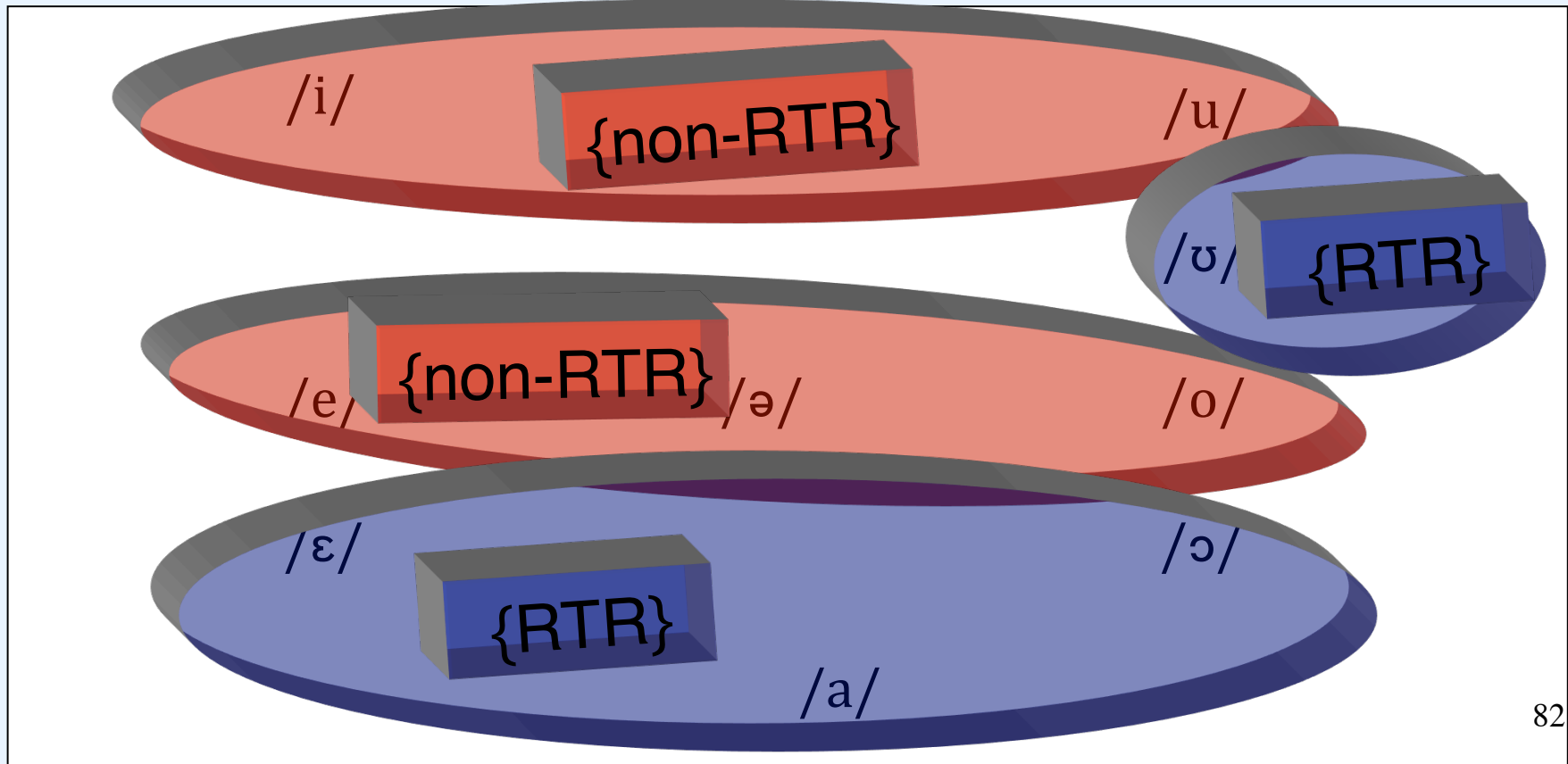
RTR harmony

Nevertheless, the Oroqen learner will have to find a feature ordering in which the feature [±RTR] does not apply to /i/.

/i/

/u/ *(non-RTR)*

/ʊ/ [RTR]

/e/ /ə/ /o/ *(non-RTR)*

/ɛ/ /ɔ/

/a/ [RTR]

Labial (rounding) harmony

Only the low vowels /o/ and /ɔ/ trigger labial harmony.

Only /ə/ and /a/ undergo rounding:

/ə/ alternates with /o/, and /a/ alternates with /ɔ/.

/i/   /u/

                 /ʊ/

/e/   /ə/   /o/

/ɛ/   /ɔ/

      /a/
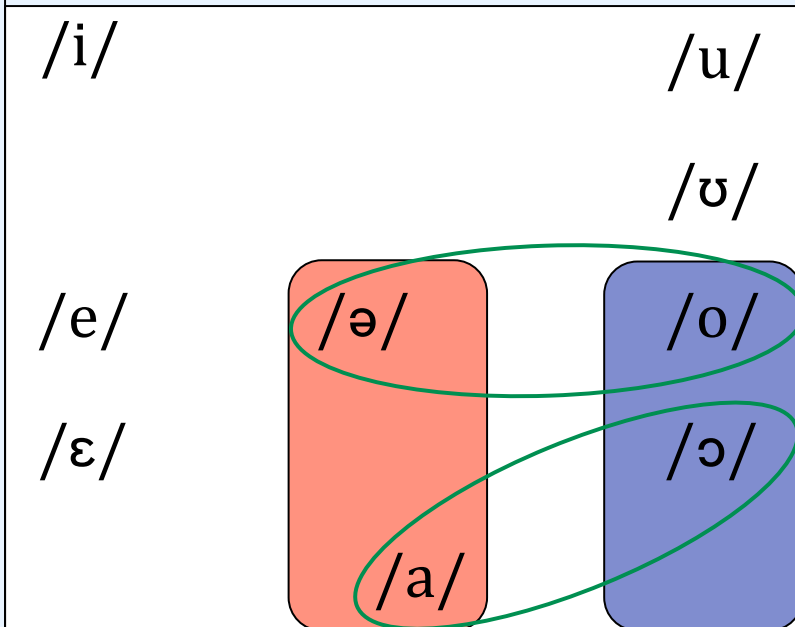
Labial (rounding) harmony

Two successive /ɔ/ or /o/ vowels cause
a suffix /a/ or /ə/ to become round:

Present tense: *-ra* alternates with *–rɔ, -rə* alternates with *-ro*

RTR stems:

baka-ra	'get PRES.TNS'
ɔlgɔɔ-rɔ	'dry PRES.TNS'

Non-RTR stems:

nəkə-rə	'weave PRES.TNS'
mooro-ro	'moan PRES.TNS'

Labial (rounding) harmony

Note that /u/ and /ʊ/ do not trigger labial harmony:

Definite object: *-wV/-mV*

RTR: *-ma* alternates with *–mɔ*

ʊrʊʊn-ma   'hoof DEF.OBJ'   *ʊrʊʊn-mɔ

non-RTR: *–wə* alternates with *–wo*

ulgulu-wə   'moose DEF.OBJ'   *ulgulu-wo

Labial (rounding) harmony

The evidence from activity here, then, is that /o/ and /ɔ/ must have an active, therefore contrastive, feature that causes rounding. [round] (or [labial]) is an obvious candidate.

/i/ /u/

/ʊ/

/e/ /ə/ /o/

[round]

/ɛ/ /ɔ/

/a/

Labial (rounding) harmony

These vowels alternate with /ə/ and /a/, the only vowels that undergo rounding, suggesting they are contrastively *(non-round)*.

/i/   /u/

                                       /ʊ/

/e/   /ə/   /o/   [round]

/ɛ/*(non-round)*   /ɔ/

                 /a/

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Labial (rounding) harmony

But /u/ and /ʊ/ are also phonetically {round}, though there is no evidence that that they have an active [round] feature.

/i/   /u/

                                     /ʊ/

/e/   /ə/   /o/ {round}

/ɛ/   /ɔ/

              /a/

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Labial (rounding) harmony

Here, the preferred analysis is one where the contrastive [round] feature is restricted to /o/ and /ɔ/, and excludes /u/ and /ʊ/.

/i/   /u/

/ʊ/

/e/   /ə/   /o/

[round]

/ɛ/   /ɔ/

/a/

Palatalization

The front vowels /i/, /e/ and /ɛ/ cause palatalization of a preceding /s/, which suggests that they have a contrastive triggering feature we will call [front] (or [coronal]).

/i/		/u/
[front]		/ʊ/
/e/	/ə/	/o/
/ɛ/		/ɔ/
	/a/	

Palatalization

/s/ palatalizes to [ʃ] before /i, e, ɛ/:

Before non-front vowels:

sukə	[suxə]	'axe'
sʊnta	[sʊnta]	'deep'
sɔkɔ-	[sɔxɔ]	'fill'
sələ	[sələ]	'iron'
sarbʊ	[sarbʊ]	'chopsticks'

Before front vowels:

asi	[aʃi]	'now'
sɛɛn	[ʃɛɛn]	'ear'

Palatalization

In this case /i, e, ɛ/ are the only vowels that fall
in the space of the phonetic percept {front}.
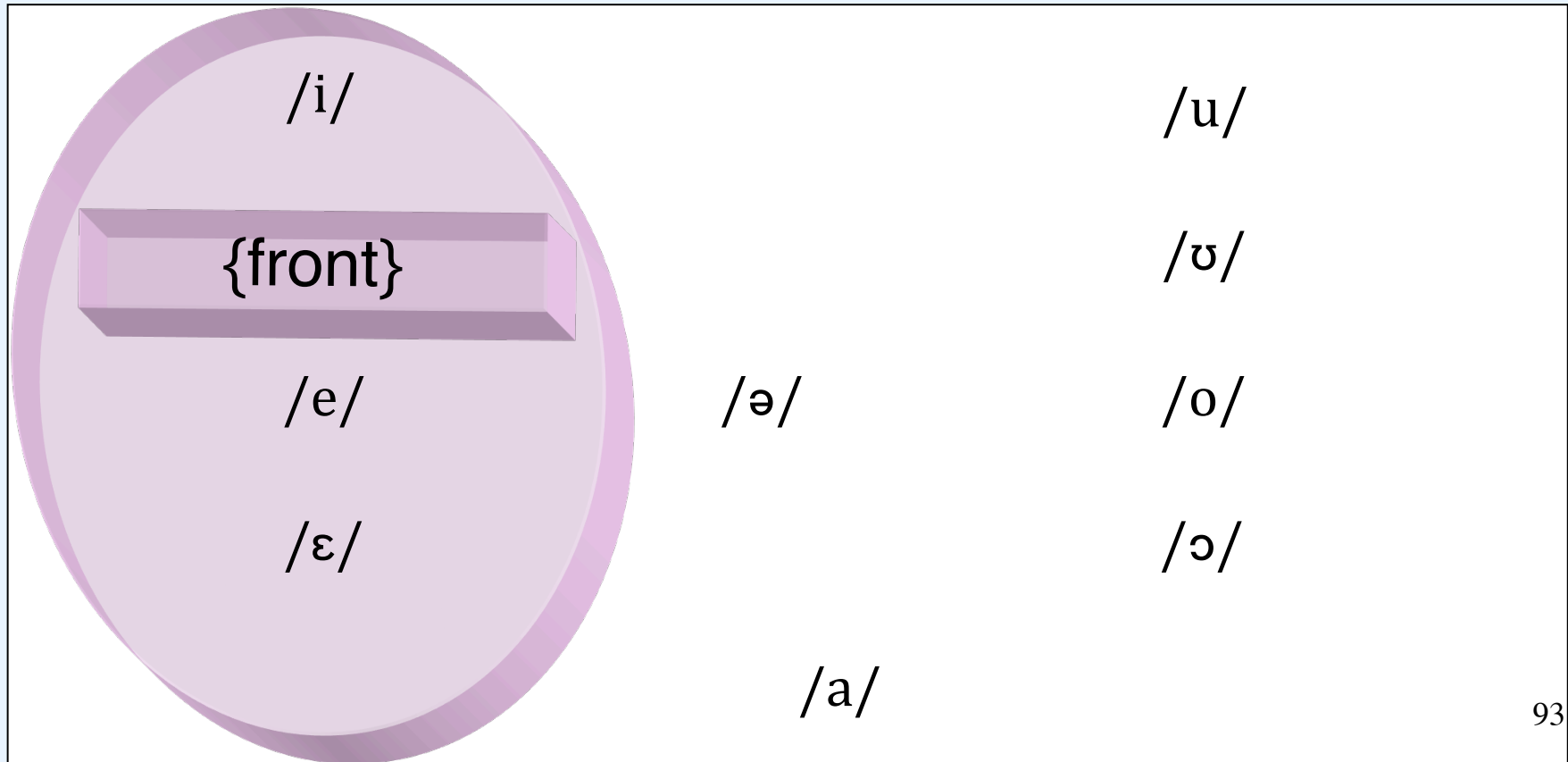
/i/   /u/

{front}   /ʊ/

/e/   /ə/   /o/

/ɛ/   /ɔ/

/a/

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One height contrast

We still need to distinguish /ə/ ~ /u/, /a/~ /ʊ/, and /e/ ~ /i/. The alternations we have seen, /ə/ ~ /a/ ~ /o/~ /ɔ/ and /u/ ~ /ʊ/, suggest that there is one height contrast.

/i/   /u/

                                                /ʊ/

/e/   /ə/ ——————— /o/
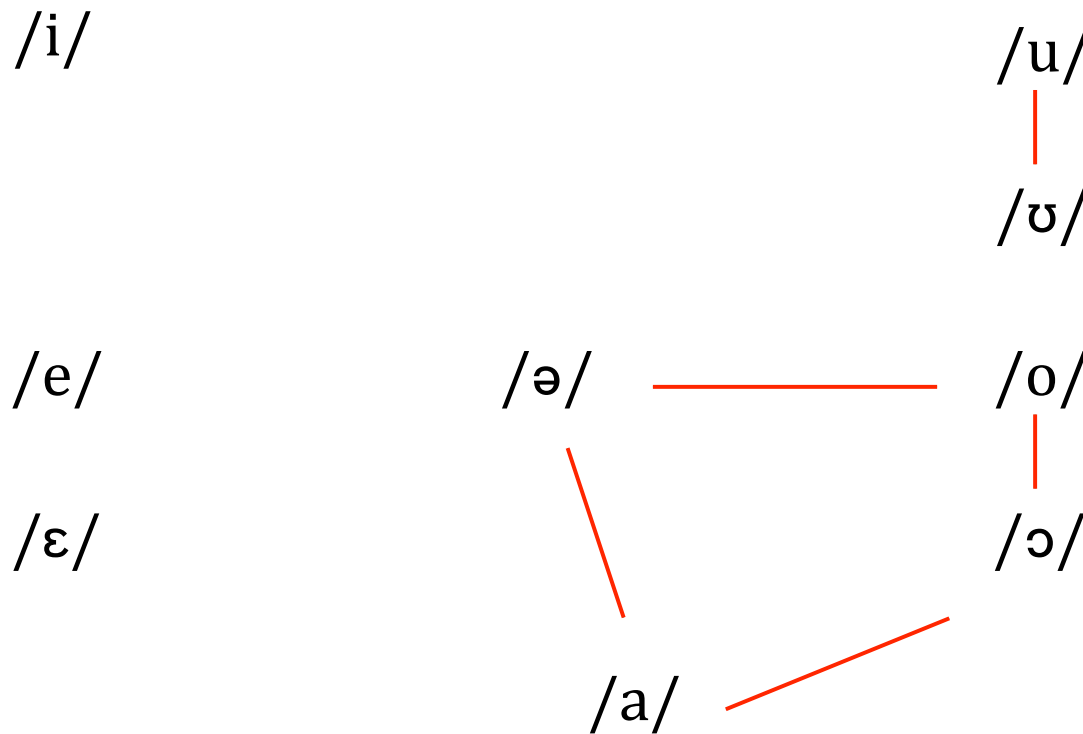
/ɛ/   /ɔ/
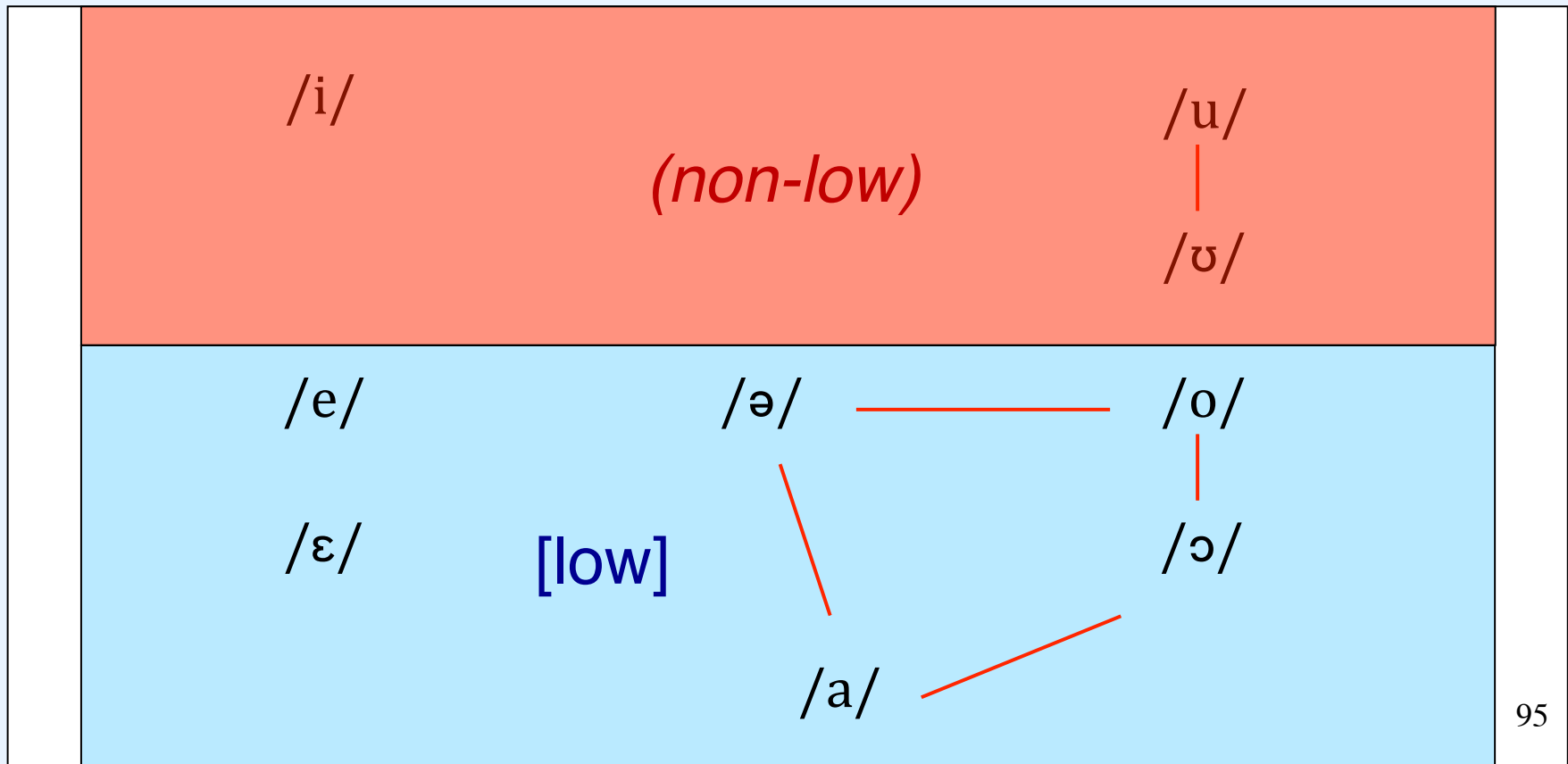
                        /a/

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# One height contrast

We still need to distinguish /ə/ ~ /u/, /a/~ /ʊ/, and /e/ ~ /i/. The alternations we have seen, /ə/ ~ /a/ ~ /o/~ /ɔ/ and /u/ ~ /ʊ/, suggest that there is one height contrast.

/i/   /u/
            (non-low) |
                        /ʊ/

/e/   /ə/ ——————— /o/

/ɛ/   [low]   /ɔ/

                /a/

One height contrast

Since height is a relative property, it is not a problem to base the contrastive feature on a perceptible phonetic difference based on relative height or sonority. [high] would also be possible here.

/i/   /u/

/ʊ/

/e/   /ə/   /o/

/ɛ/   {low}   /ɔ/

/a/
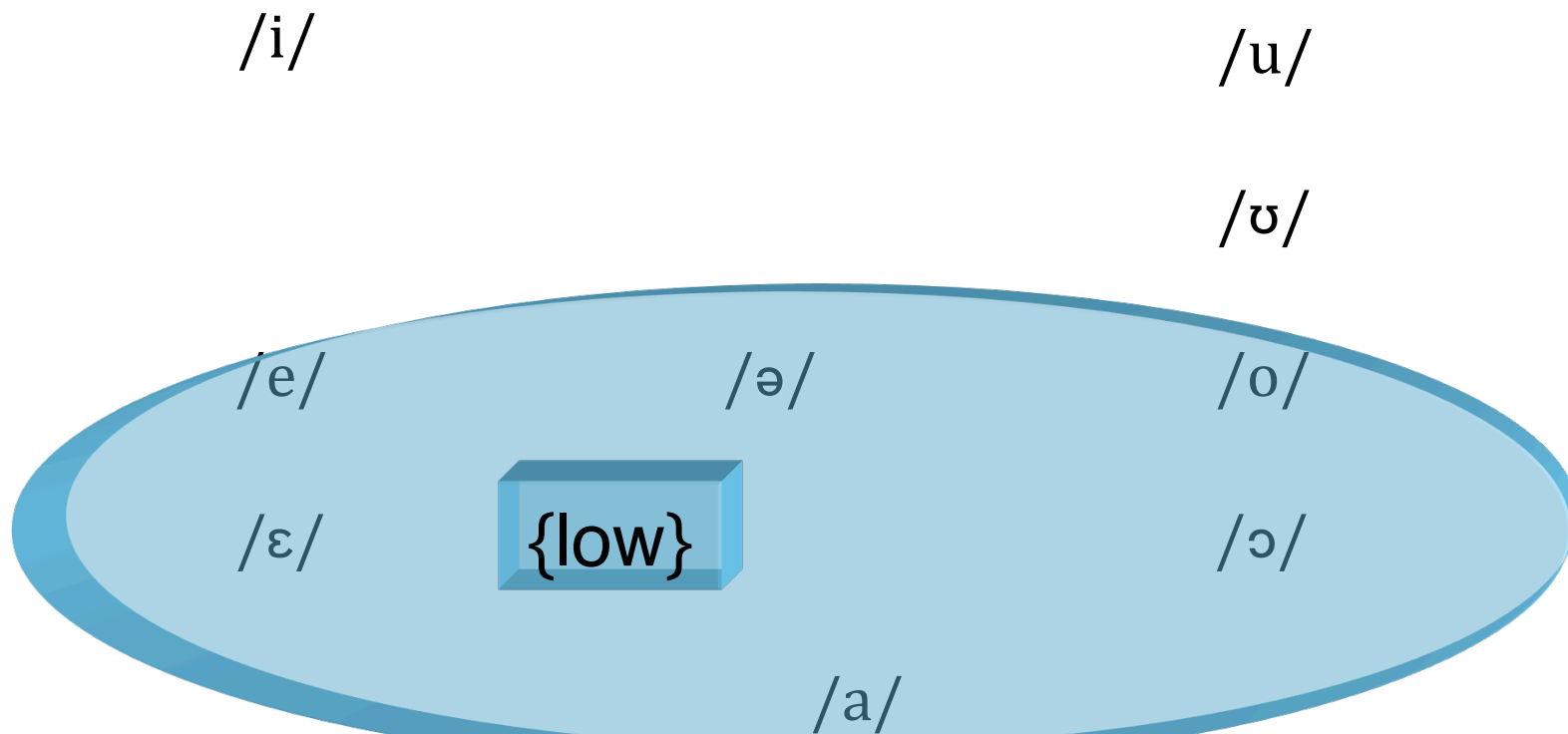
Xunke Oroqen contrastive features

Putting together the evidence of phonological activity surveyed to here, we need to arrive at a feature hierarchy that yields the required values.
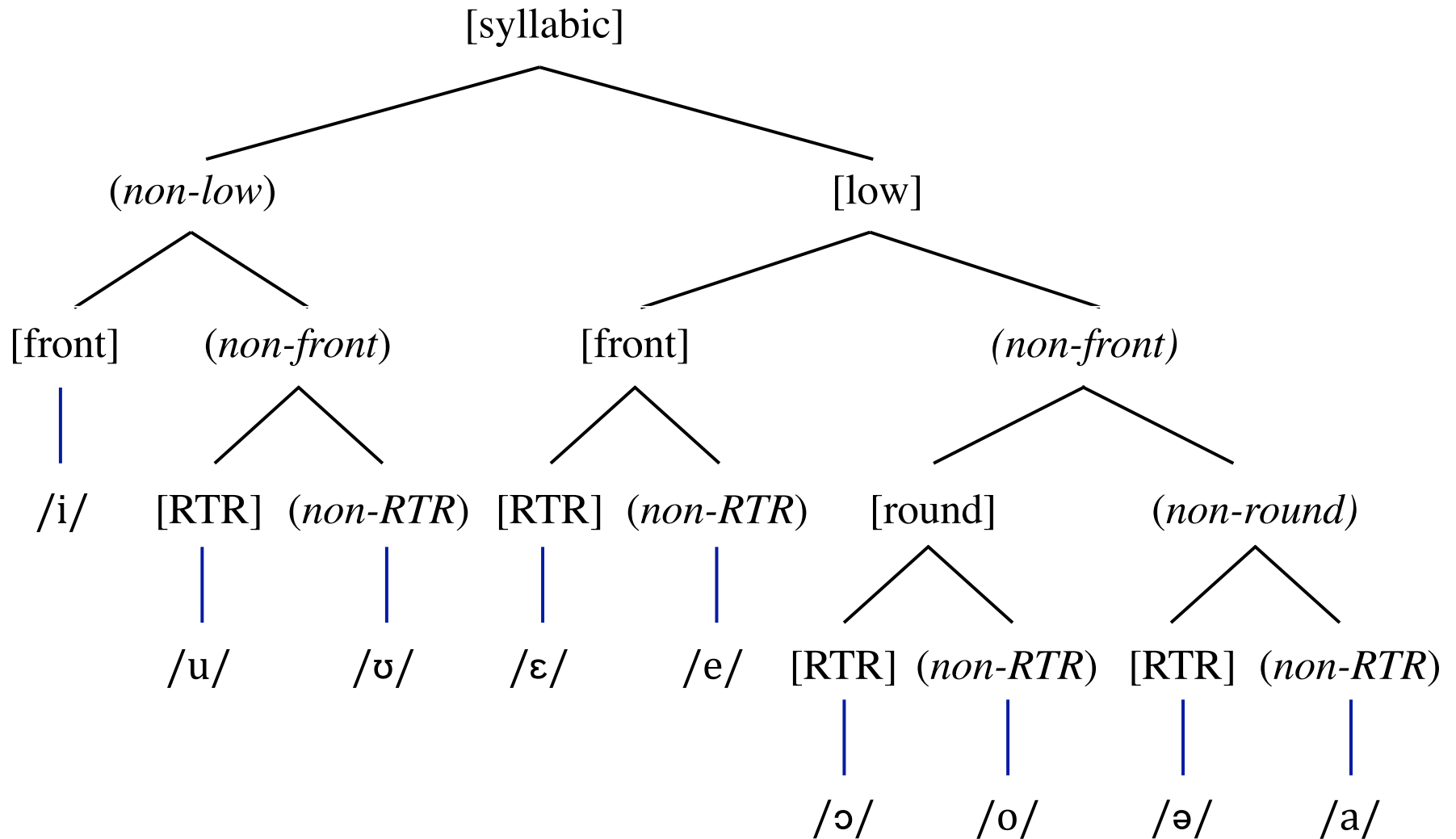
Zhang (1996) proposes the feature hierarchy:

[low] > [coronal] > [labial] > [RTR]

I adopt this analysis, substituting

[front] for [coronal]

and [round] for [labial]

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Xunke Oroqen contrastive hierarchy

[syllabic]

(*non-low*)   [low]

[front]   (*non-front*)   [front]   (*non-front*)

/i/   [RTR]   (*non-RTR*)   [RTR]   (*non-RTR*)   [round]   (*non-round*)

/u/   /ʊ/   /ɛ/   /e/   [RTR] (*non-RTR*)   [RTR] (*non-RTR*)

/ɔ/   /o/   /ə/   /a/

[low] > [front] > [round] > [RTR]

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Xunke Oroqen contrastive hierarchy

[syllabic]

(*non-low*) — [low]

(*non-low*):
- [front] — /i/
- (*non-front*):
  - [RTR] — /u/
  - (*non-RTR*) — /ʊ/

[low]:
- [front]:
  - [RTR] — /ɛ/
  - (*non-RTR*) — /e/
- (*non-front*):
  - [round]:
    - [RTR] — /ɔ/
    - (*non-RTR*) — /o/
  - (*non-round*):
    - [RTR] — /ə/
    - (*non-RTR*) — /a/
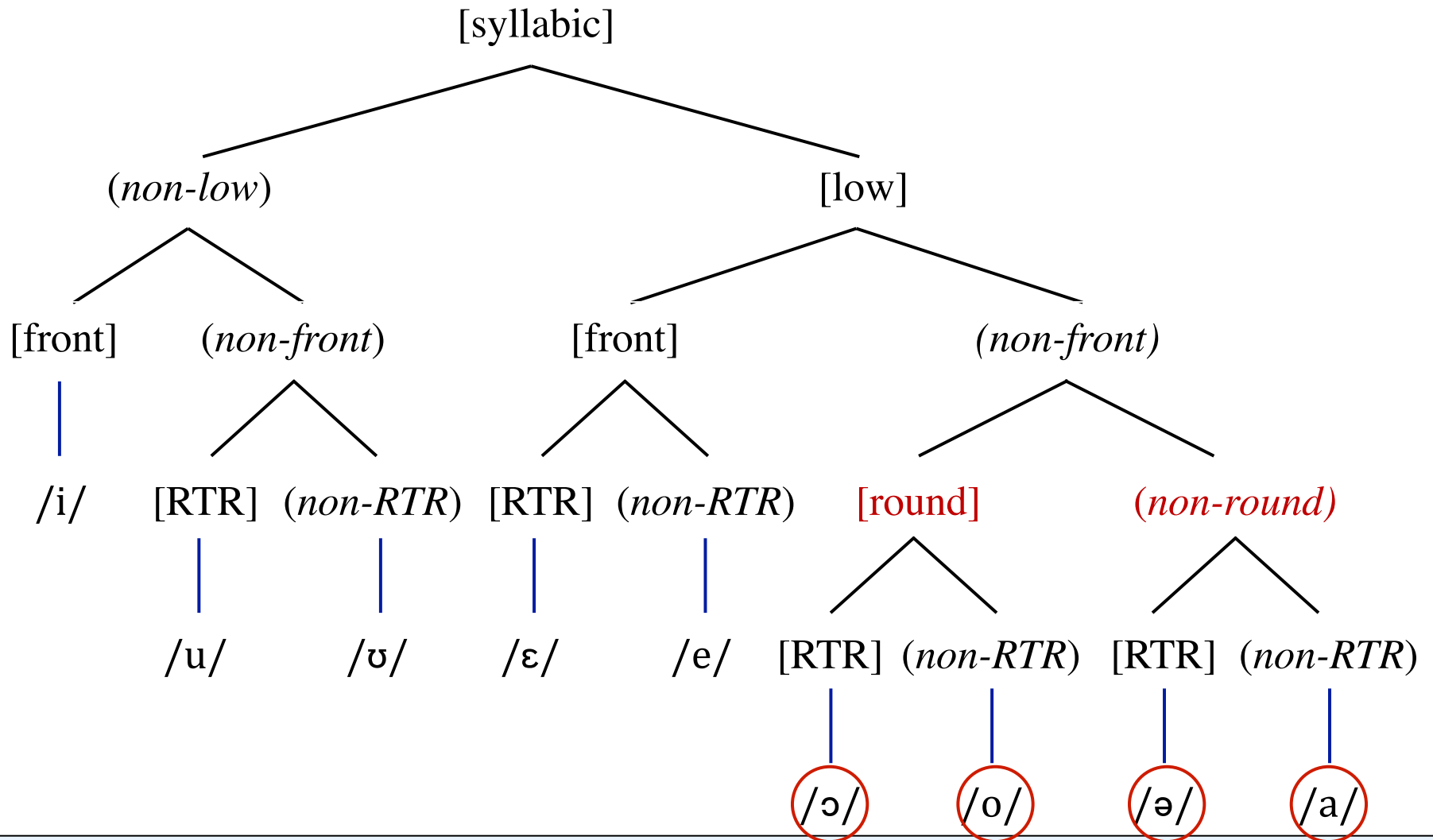
Only vowels with contrastive [round] participate in labial harmony.

Xunke Oroqen contrastive hierarchy

[syllabic]

(*non-low*)　　　　　　　　[low]

[front]　(*non-front*)　　[front]　　　(*non-front*)

/i/　[RTR]　(*non-RTR*)　[RTR]　(*non-RTR*)　[round]　　(*non-round*)

/u/　　/ʊ/　　/ɛ/　　/e/　[RTR] (*non-RTR*)　[RTR] (*non-RTR*)

/ɔ/　　/o/　　/ə/　　/a/
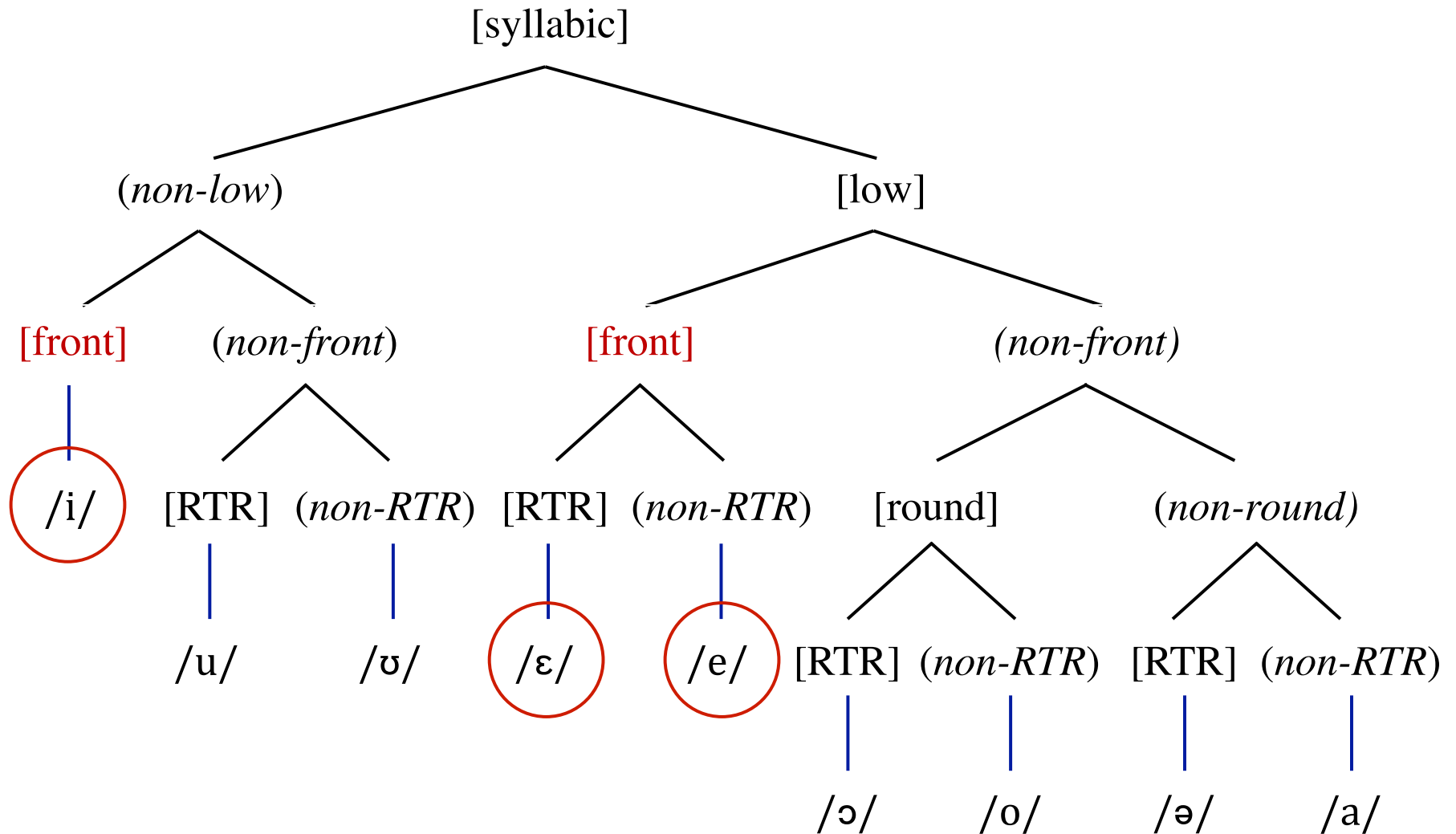
Only vowels with contrastive [front] cause palatalization.

Xunke Oroqen contrastive hierarchy

[syllabic]

(*non-low*)   [low]

[front]   (*non-front*)   [front]   (*non-front*)

/i/   [RTR] (*non-RTR*)   [RTR] (*non-RTR*)   [round]   (*non-round*)

/u/   /ʊ/   /ɛ/   /e/   [RTR] (*non-RTR*)   [RTR] (*non-RTR*)
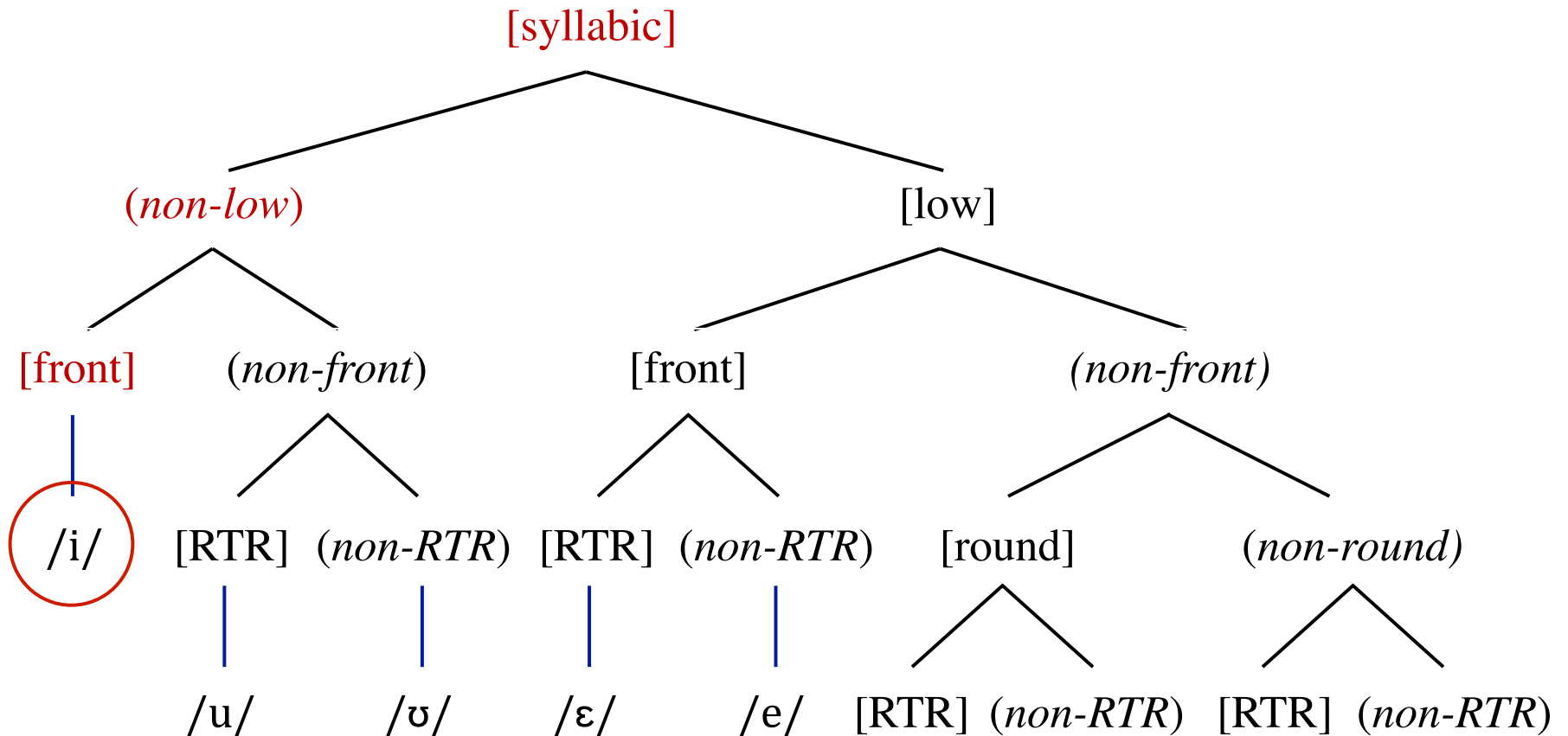
Though phonetically *{non-RTR}*, /i/ lacks the contrastive feature [±RTR], so does not participate in RTR harmony.

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Xunke Oroqen contrastive hierarchy

[syllabic]

(*non-low*)   [low]

[front]   (*non-front*)   [front]   (*non-front*)

/i/   [RTR] (*non-RTR*)   [RTR] (*non-RTR*)   [round]   (*non-round*)

/u/   /ʊ/   /ɛ/   /e/   [RTR] (*non-RTR*)   [RTR] (*non-RTR*)

Though phonetically {round}, /u/ and /ʊ/ lack a contrastive feature [round], so they do not participate in rounding harmony.

Summary: synchronic phonology

To sum up, we have been able to give an account of the vowel phonology of Oroqen that is consistent with the Contrastivist Hypothesis: all the active features are contrastive.

Moreover, this analysis explains why certain vowels participate in certain processes and others do not, in ways that that are not obvious from their phonetic description.

6.

Contrastive feature hierarchies: diachronic phonology

Contrast shift

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

Examples include: Zhang (1996) and Dresher & Zhang (2005) on Manchu; Barrie (2003) on Cantonese; Rohany Rahbar (2008) on Persian; Dresher (2009: 215–25) on East Slavic; Compton & Dresher (2011) on Inuit; Gardner (2012), Roeder & Gardner (2013), and Purnell & Raimy (2013) on North American English vowel shifts; and large-scale studies by Harvey (2012) on Ob-Ugric (Khanty and Mansi), Ko (2010, 2011, 2012) on Korean, Mongolic, and Tungusic, and Oxford (2015) on Algonquian. See further Dresher, Harvey & Oxford 2014.

The notion that contrast shift could be important in diachronic phonology is due, again, to Jakobson, in a paper published in 1931:

Contrast and phonological change

"Once a phonological change has taken place, the following questions must be asked:

...has the structure of individual oppositions [contrasts] been transformed? Or in other words, has the place of a specific opposition been changed...?"

Roman Jakobson, Principles of historical phonology, first published in German in *TCLP*, IV (Copenhagen, 1931).

i-umlaut

Contrastive hierarchy theory can shed new light on an old problem concerning the phonologization of *i*-umlaut in West Germanic.

According to many accounts (V. Kiparsky 1932; Twaddell 1938; Benediktsson 1967; Antonsen 1972; Penzl 1972), *i*-umlaut began in early Germanic as a phonetic process that created fronted allophones of the back vowels */a(ː)/, */o(ː)/, and */u(ː)/ when */i(ː)/ or */j/ followed.

Examples of the latter two are shown below:

Gloss	'evil N.S.'	'foot N.P.'
Early Germanic	*uβil	*foːt+i
i-umlaut	*yβil	*føːt+i

West Germanic vowel system

At a certain time, the West Germanic vowel system had five short and five long vowels (Antonsen 1965; Ringe & Taylor 2014: 106).

Short vowels	Long vowels
i u	iː uː
e o	eː oː
a	aː

West Germanic vowel system

At a certain time, the West Germanic vowel system had five short and five long vowels (Antonsen 1965; Ringe & Taylor 2014: 106).

I will henceforth disregard length.

i   u

e   o

a

West Germanic contrastive features

Based on the evidence from the descendant dialects, Antonsen (1972: 132–133) assumes that */a/ had allophones *[a, æ, ə, ɒ], which all have in common that they are [low].

Further, there is evidence that */i/ and */u/ had lowered allophones before */a/, again suggesting that */a/ had a feature that could affect vowel height, in this case [low].
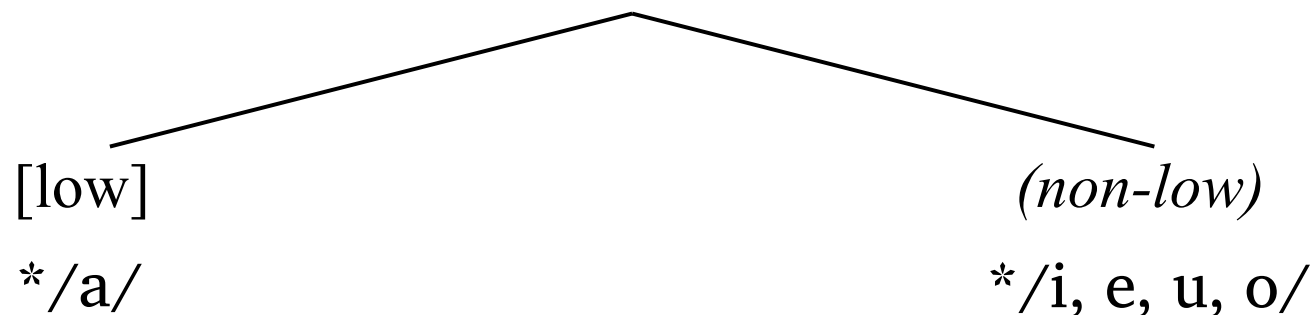
i		u
e		o
[low]	a	

There is no evidence that */a/ had any other phonologically active features.

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West Germanic feature hierarchy

Therefore Antonsen, following Benediktsson 1967, puts [low] at the top of the vowel feature hierarchy, so that */a/ receives no further contrastive features.

[low]   *(non-low)*

*/a/   */i, e, u, o/*

West Germanic feature hierarchy

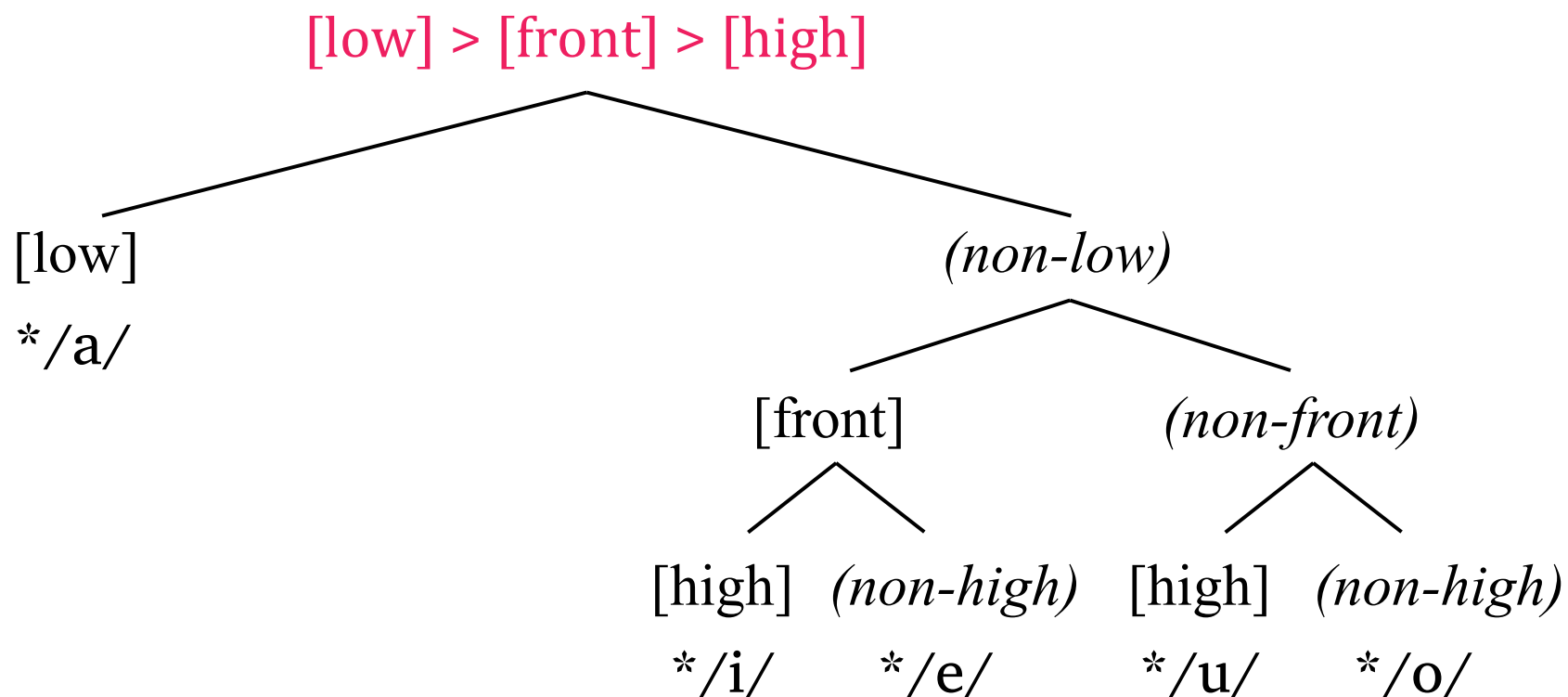I assume that [high] distinguishes between */i/~*/e/ and */u/ ~*/o/.

There is now room for only one more feature to distinguish between */i, e/ and */u, o/.
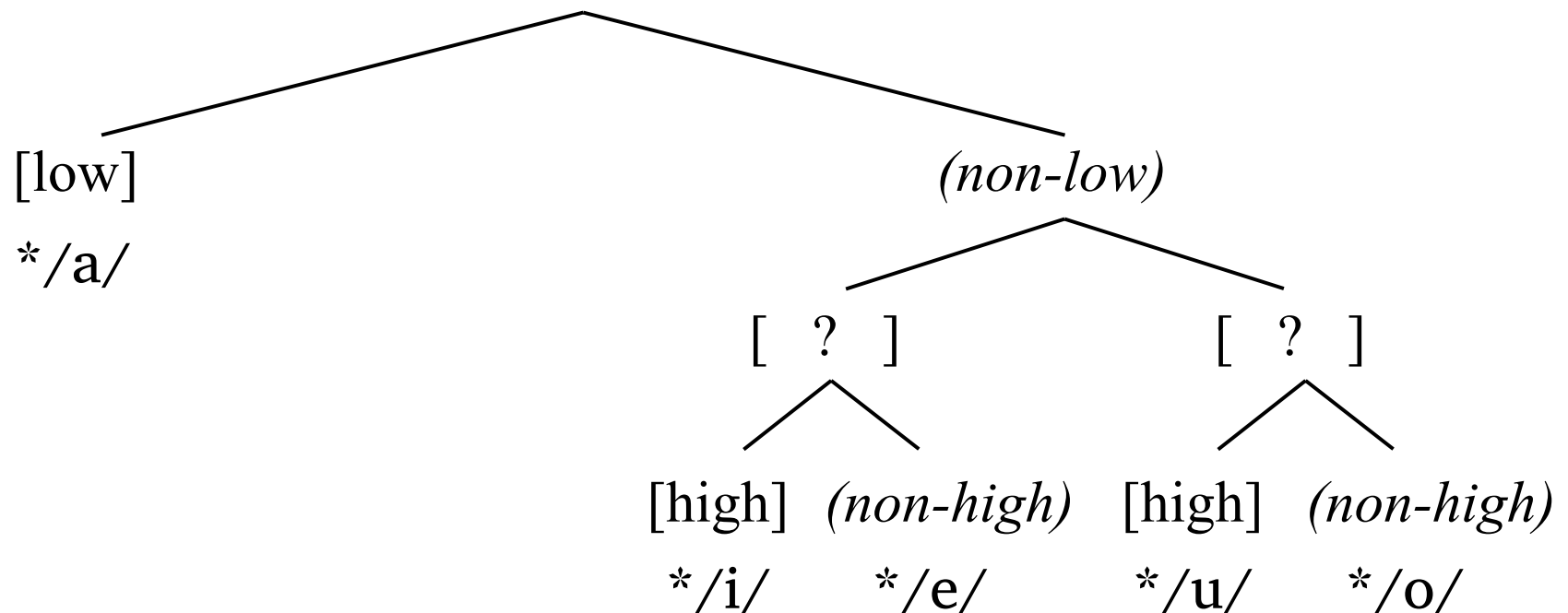
West Germanic feature hierarchy

I posit that this feature is [front] (cf. Lass 1994; Ringe 2006; Purnell & Raimy 2015).

We now have the feature hierarchy [low] > [front] > [high]. The feature [round] is not contrastive at this point.

[low] > [front] > [high]

[low]

*/a/

(non-low)

[front]

(non-front)

[high] (non-high) [high] (non-high)

*/i/   */e/   */u/   */o/

The origins of *i*-umlaut

Given our analysis of the West Germanic vowel system, the result of fronting */u, o/ in the contrastive phonology would be to simply make them identical to */i, e/.

But *i*-umlaut crucially preserves the rounded nature of the fronted vowels.
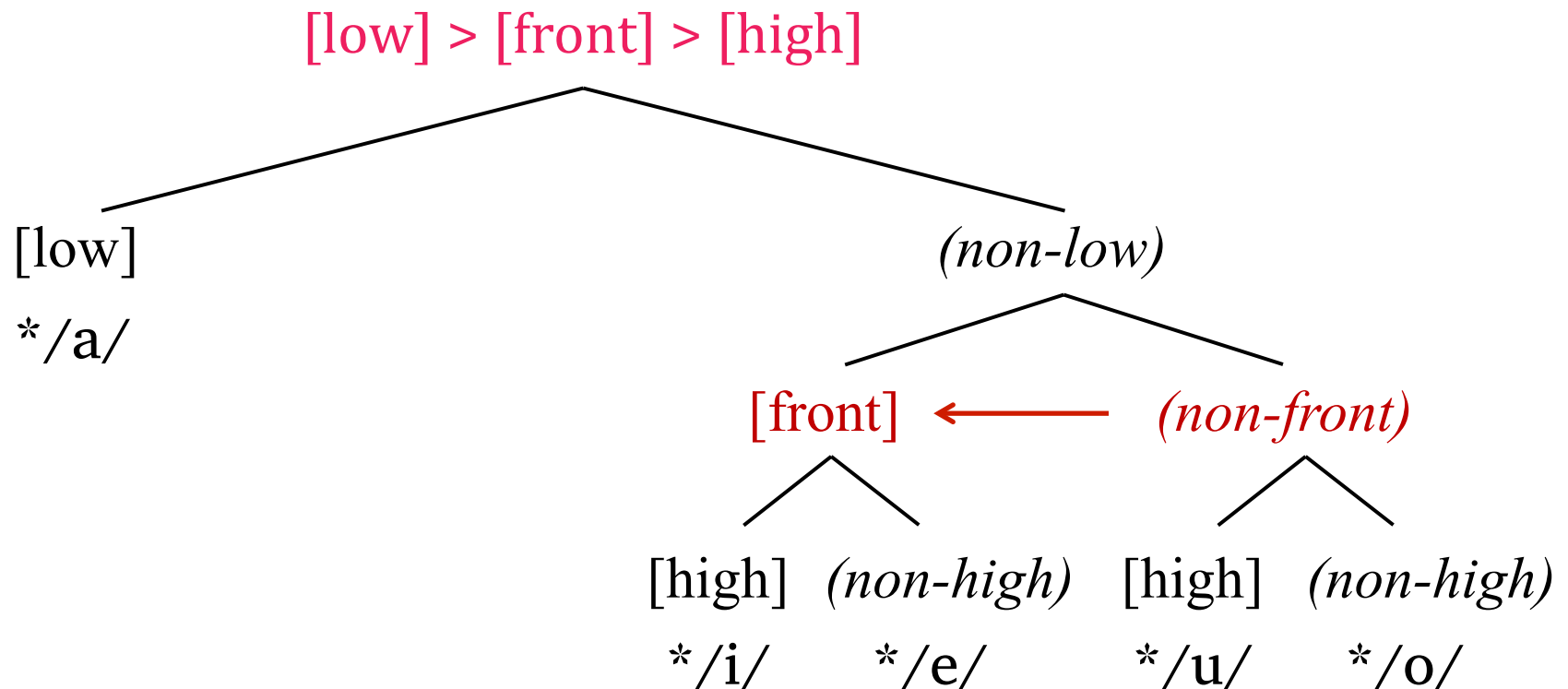
i-umlaut

Therefore, the enhancement feature {round} must be in play at the point that */u, o/ are fronted.

This conclusion is consistent with the assumption of many commentators, beginning with V. Kiparsky (1932) and Twaddell (1938), that *i*-umlaut began as a late phonetic rule, and not part of the contrastive phonology.

*u	ƀ	i	l	⟶	*y	ƀ	i	l
(non-low)		*(non-low)*			*(non-low)*		*(non-low)*	
[front]		[front]			[front]		[front]	
[high]		[high]			[high]		[high]	
{round}		{non-round}			{round}		{non-round}	

i-umlaut becomes opaque

Over time, the contexts of *i*-umlaut became weaker and more obscure.

In Old English, for example, unstressed /i/ lowered after a light syllable, as in *yfel*, and deleted after a heavy syllable, as in *føːt*.

These processes had the effect of making *i*-umlaut *opaque*.

Gloss	'evil'	'foot N.P.'
Underlying	/ufil/	/foːt+i/
i-umlaut	yfil	føːt+i
i-lowering/deletion	yfel	føːt Ø

i-umlaut becomes opaque

According to standard accounts, this led to the phonologization of [y(:)] and [ø(:)] as new phonemes; for example, the underlying form of 'evil' is restructured from /ufil/ to /yfel/.

Gloss	'evil'
Underlying	/yfel/
i-umlaut	—
i-lowering/deletion	—

Phonologization paradox

Scholars have pointed out a number of problems with this scenario (see Liberman 1991; Fertig 1996; Janda 1999, P. Kiparsky 2015).

One of these is the Phonologization Paradox: As long as *i*-umlaut remains a phonetic post-enhancement process, it is not clear how it could survive the loss of its triggering contexts.

Somehow, *i*-umlaut has to graduate into the contrastive phonology before its trigering contexts are lost—that is, while the distribution of the umlauted allophones is still predictable.

Why and how does this happen?

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Salience and contrast shift

As to why, P. Kiparsky (2015) suggests that it is because the new front rounded allophones are more perceptually salient than their triggers (Jakobson, Fant & Halle 1952), which were becoming progressively weaker as time went on.

The concept of contrast shift suggests a mechanism for how *i*-umlaut can enter the contrastive phonology.

u	f	i	l		y	f	i	l
(non-low)	*(non-low)*				*(non-low)*	*(non-low)*		
[high]	[high]				[high]	[high]		
(non-front)	[front]	⟶			[front]	[front]		
{round}	{non-round}				{round}	{non-round}		

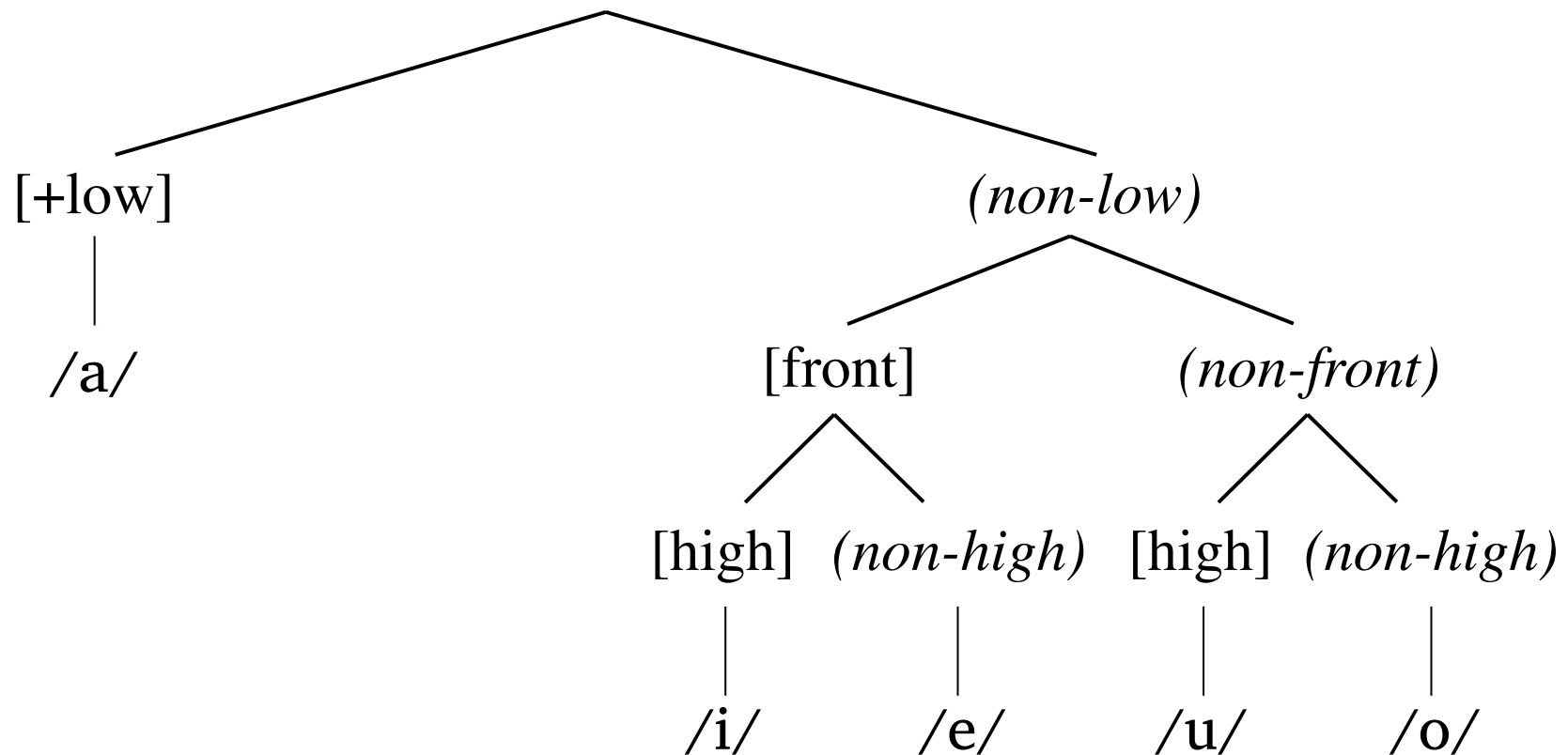# Salience and contrast shift

Let us suppose that the perceptual salience of the front rounded allophones could have led learners to hypothesize that [round] is a contrastive feature.

u   f   i   l   y   f   i   l

(non-low)   *(non-low)*   *(non-low)*   *(non-low)*

[high]   [high]   [high]   [high]

(non-front)   [front]   ⟶   [front]   [front]

[round]   *(non-round)*   [+round]   *(non-round)*
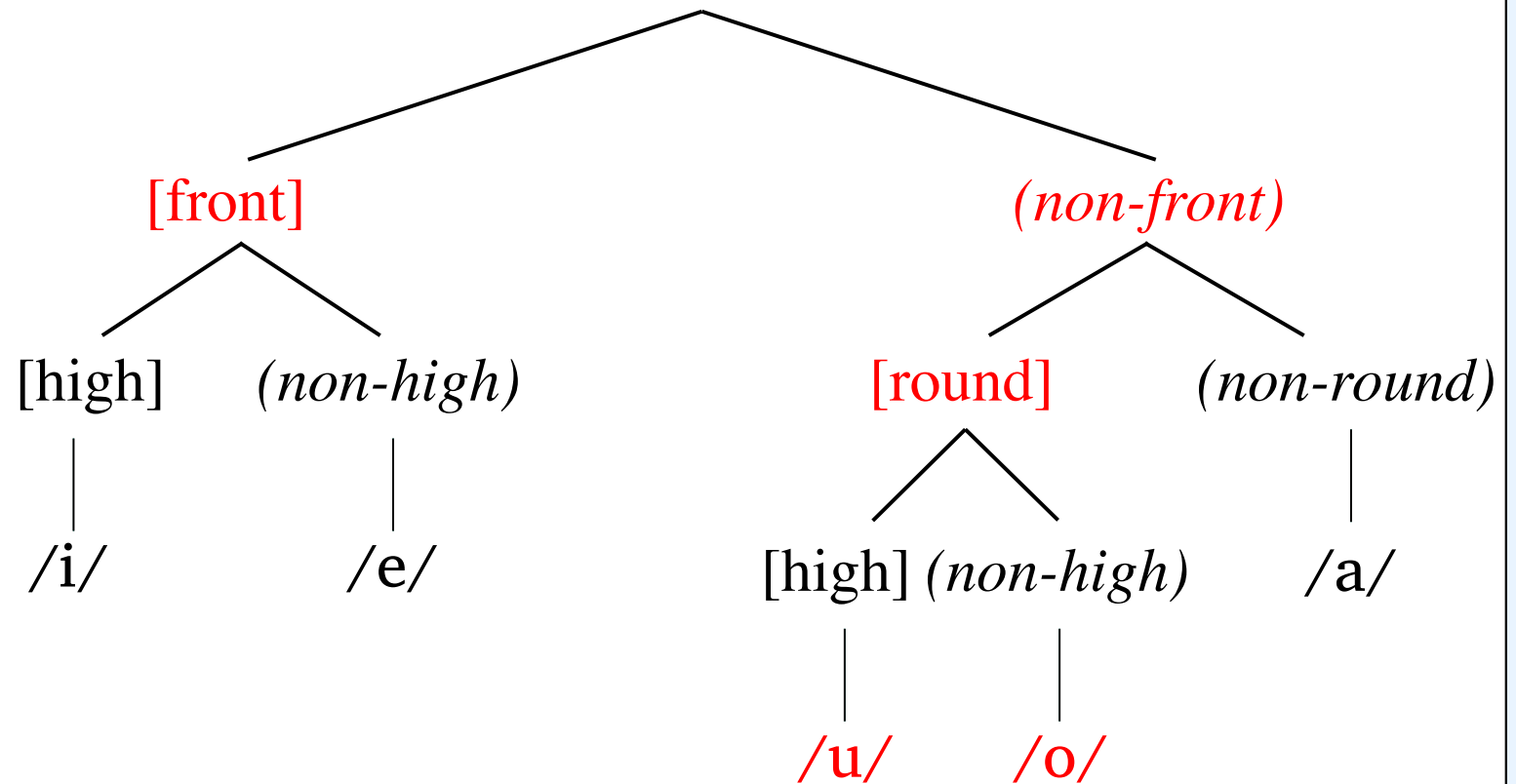
West Germanic feature hierarchy 1

Recall that this had not been the case in West Germanic until that point, for which we posited the feature hierarchy

[low] > [front] > [high]

Contrast shift in West Germanic

However, another feature hierarchy can be constructed that includes [round] as a contrastive feature.

This hierarchy requires demoting [low] to allow [round] to be contrastive over the non-front vowels.

In tree form this new hierarchy looks as follows:

Earlier hierarchy: [low] > [front] > [high]

Later hierarchy: [front] > [round] > [high]

West Germanic feature hierarchy 2

[front] > [round] > [high]

West Germanic feature hierarchy 2

Now changing the *(non-front)*, [round] vowels to [front] results in new front rounded vowels, which begin as allophones.
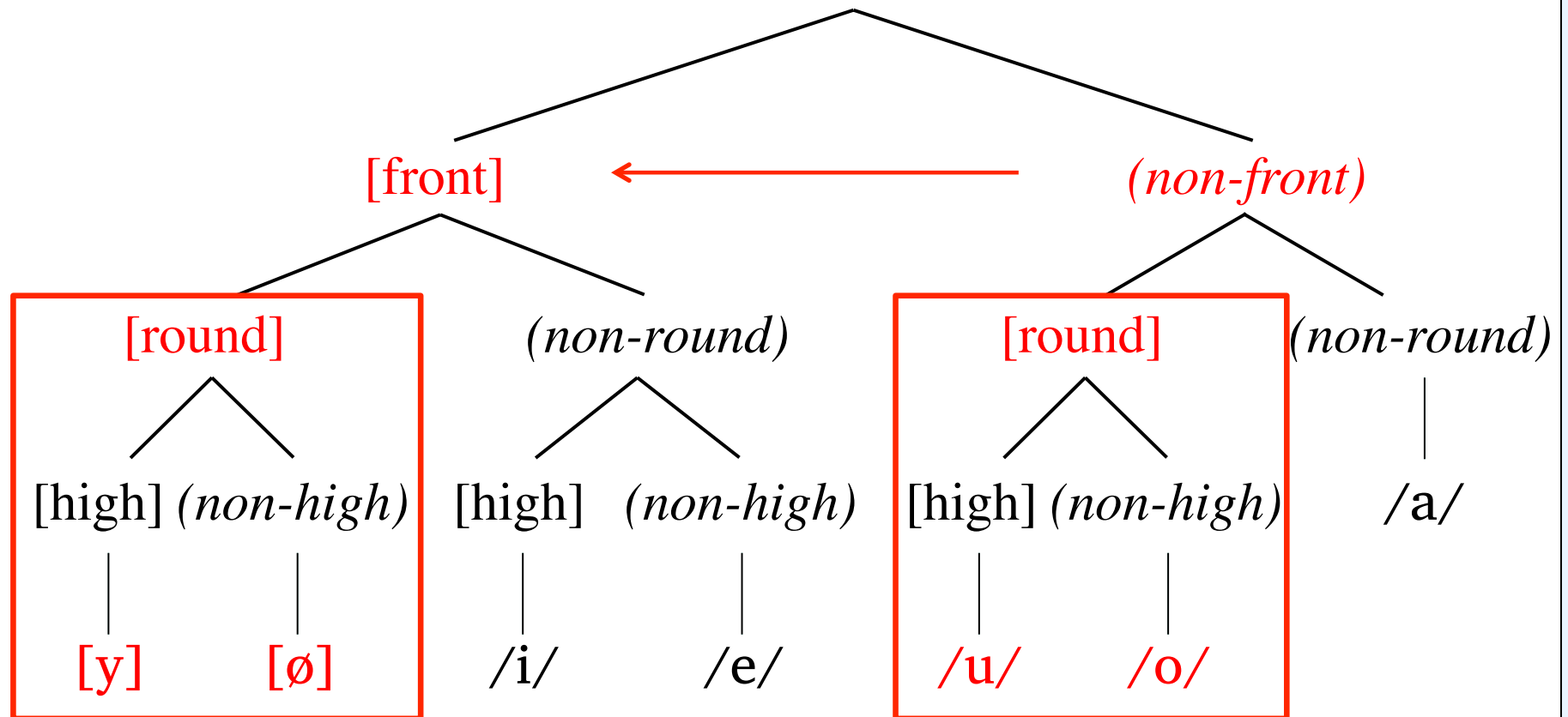
Deep allophones

Although they are allophones, they can arise in the contrastive phonology because they consist only of contrastive features.

They are thus what Moulton (2003) calls 'deep allophones', referring to the Old English voiced fricatives which also arise early in the contrastive phonology.

Deep allophones are possible because contrastive features are not all necessarily unpredictable in a hierarchical approach.

West Germanic feature hierarchy 2

In the new hierarchy, the vowel /a/ no longer has a [low] feature.
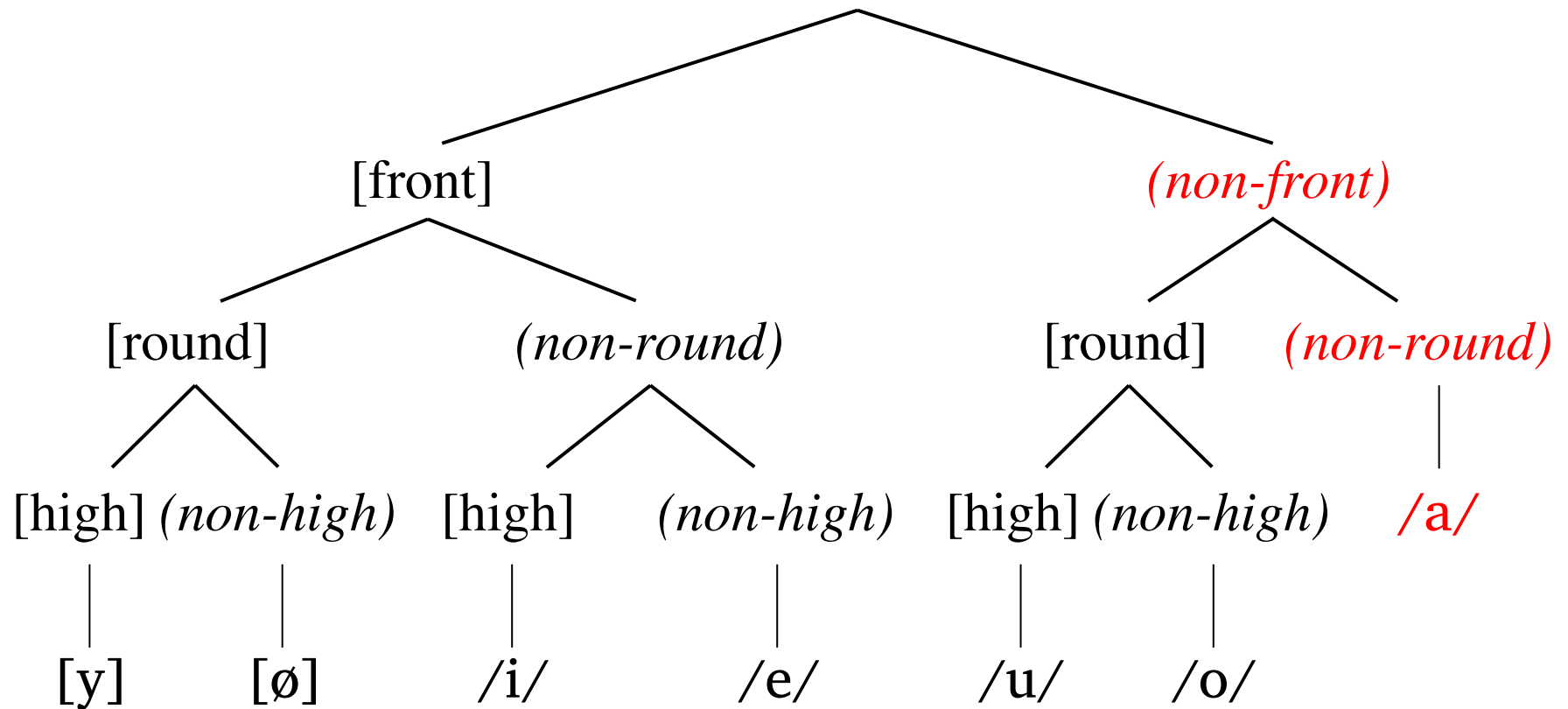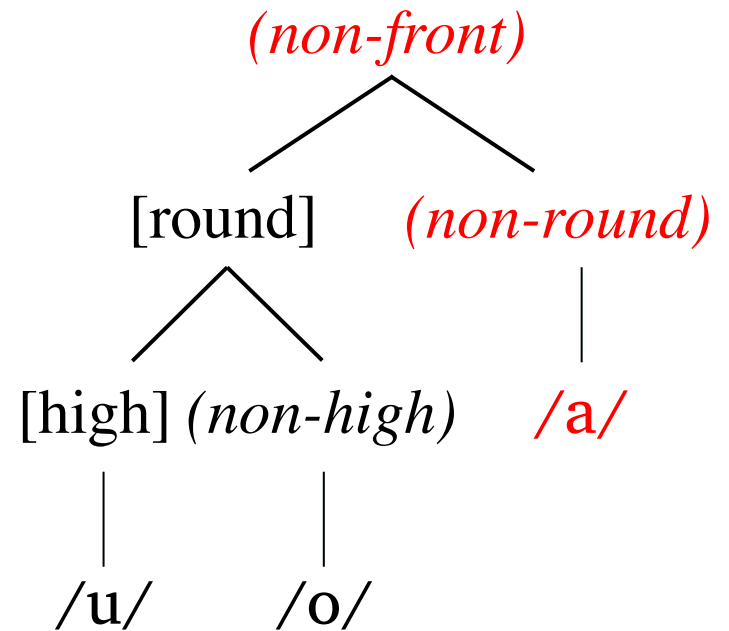
West Germanic feature hierarchy 2

In the new hierarchy, the vowel /a/ no longer has a [low] feature.

As far as I can tell, however, it does not need one.

Unlike earlier periods of the language, there is no evidence that /a/ causes lowering of other segments, for example.

```
                    (non-front)
                   /          \
            [round]          (non-round)
            /      \              |
      [high]  (non-high)         /a/
        |         |
       /ʊ/       /o/
```

7.

Contrastive feature hierarchies and language acquisition

An untenable acquisition path?

The theory set out here has built on Jakobson's fundamental insight in *Kindersprache*, that learners begin with impoverished phonological representations that become increasingly complex in the course of acquisition.

It has been suggested (Hale & Reiss 2008; Samuels 2009) that this acquisition path is inconsistent with evidence that infants begin by attending to many potential sources of contrasts, and are more able than adults to discriminate sounds not used in the ambient language (Eimas et al. 1987, Werker et al. 1981).

That is, acquisition of the native language requires that learners 'tune' their perceptual system to the contrasts used in their language, while learning to disregard contrasts that are not used (Werker & Tees 1984; Kuhl et al. 1992).
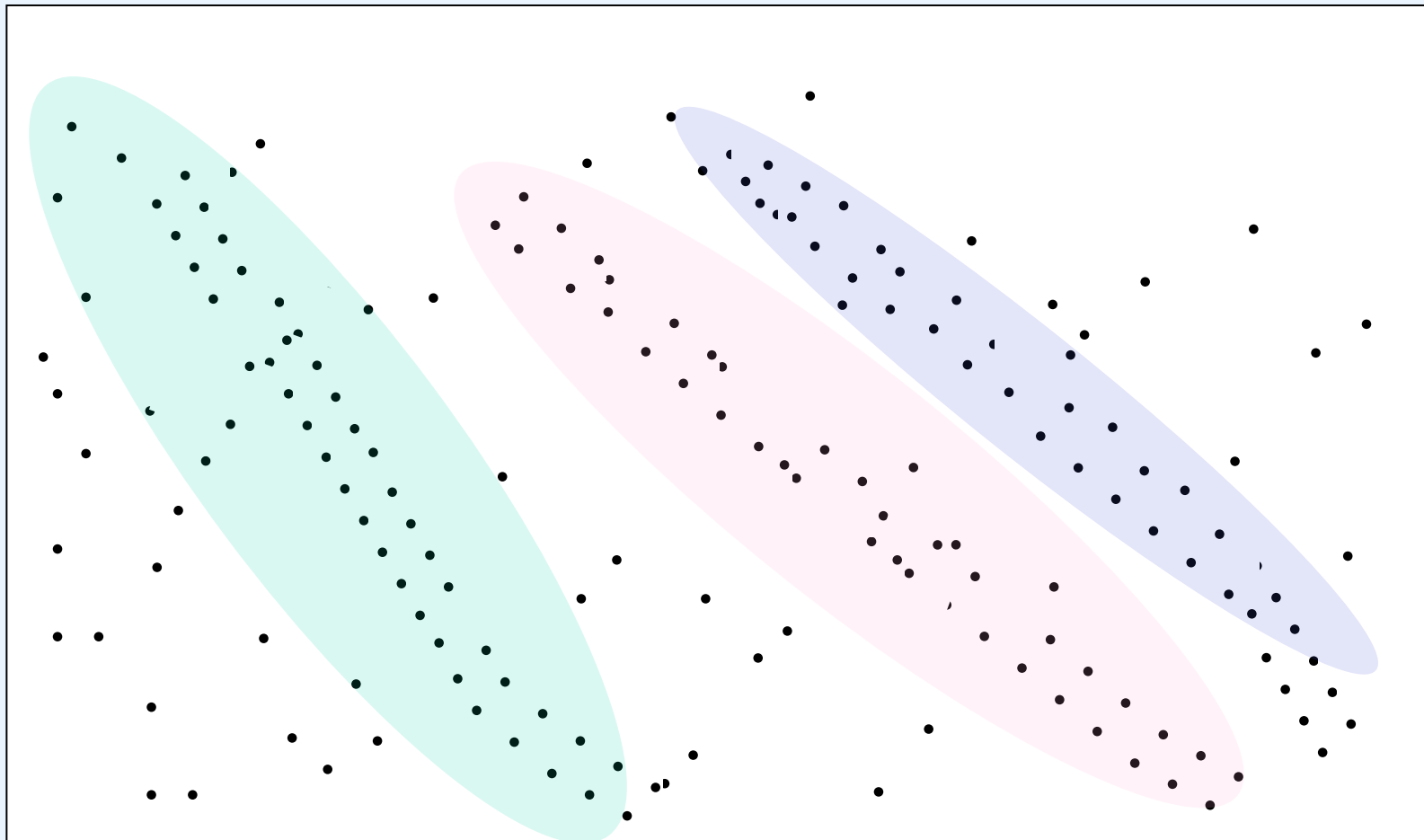
Pruning the perception of phones: Schematic depiction

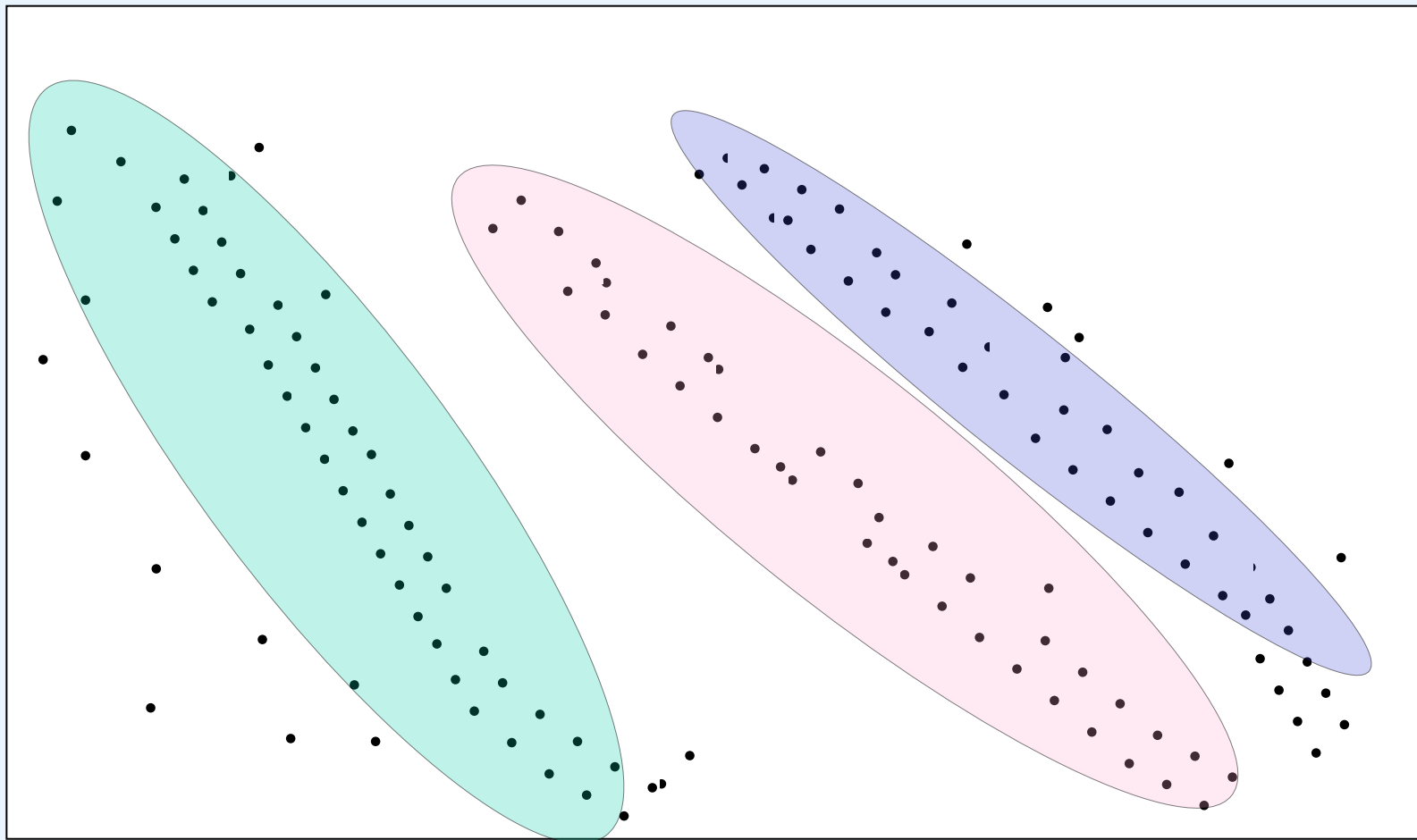This process is the opposite of what I have been assuming.
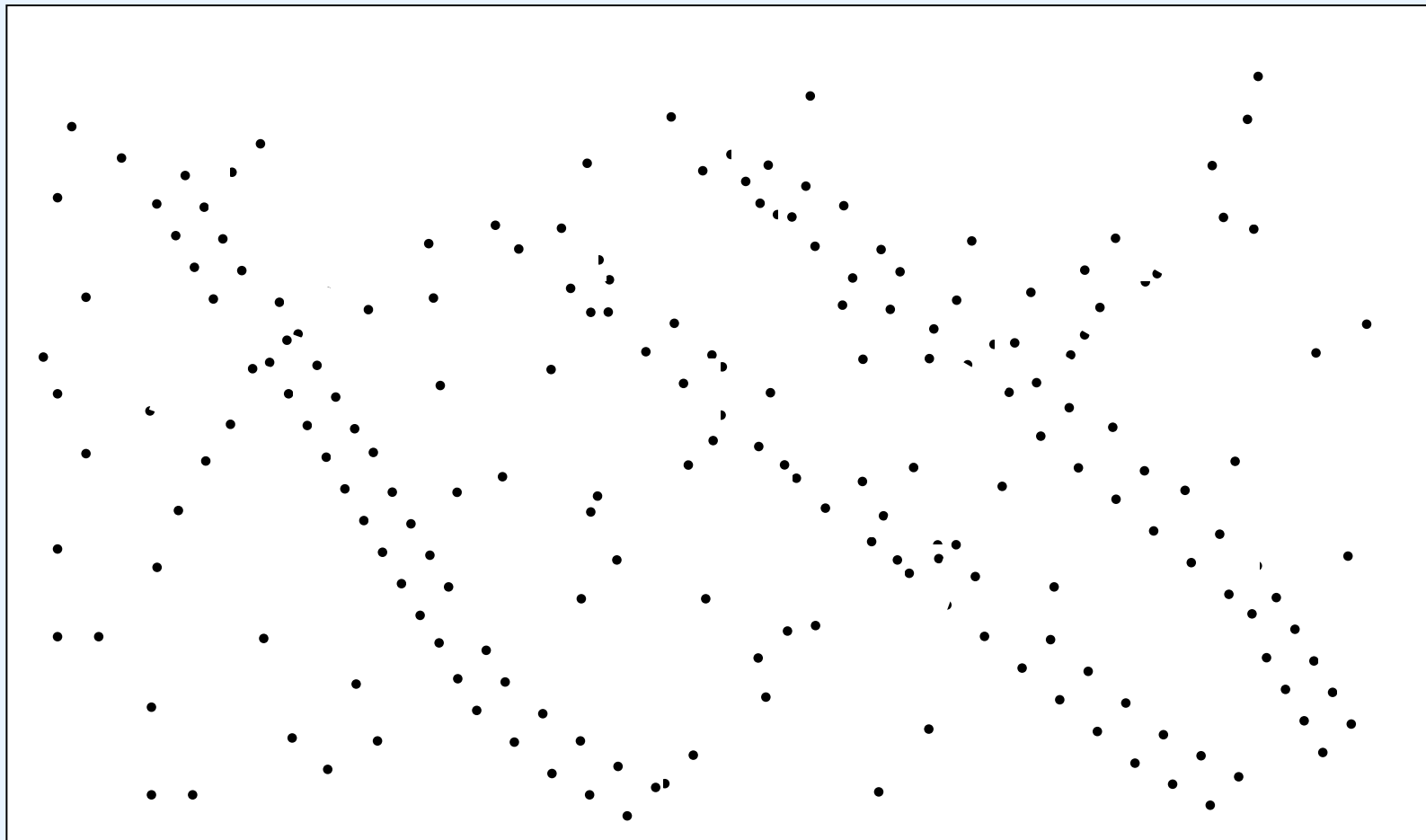
Pruning the perception of phones: Schematic depiction

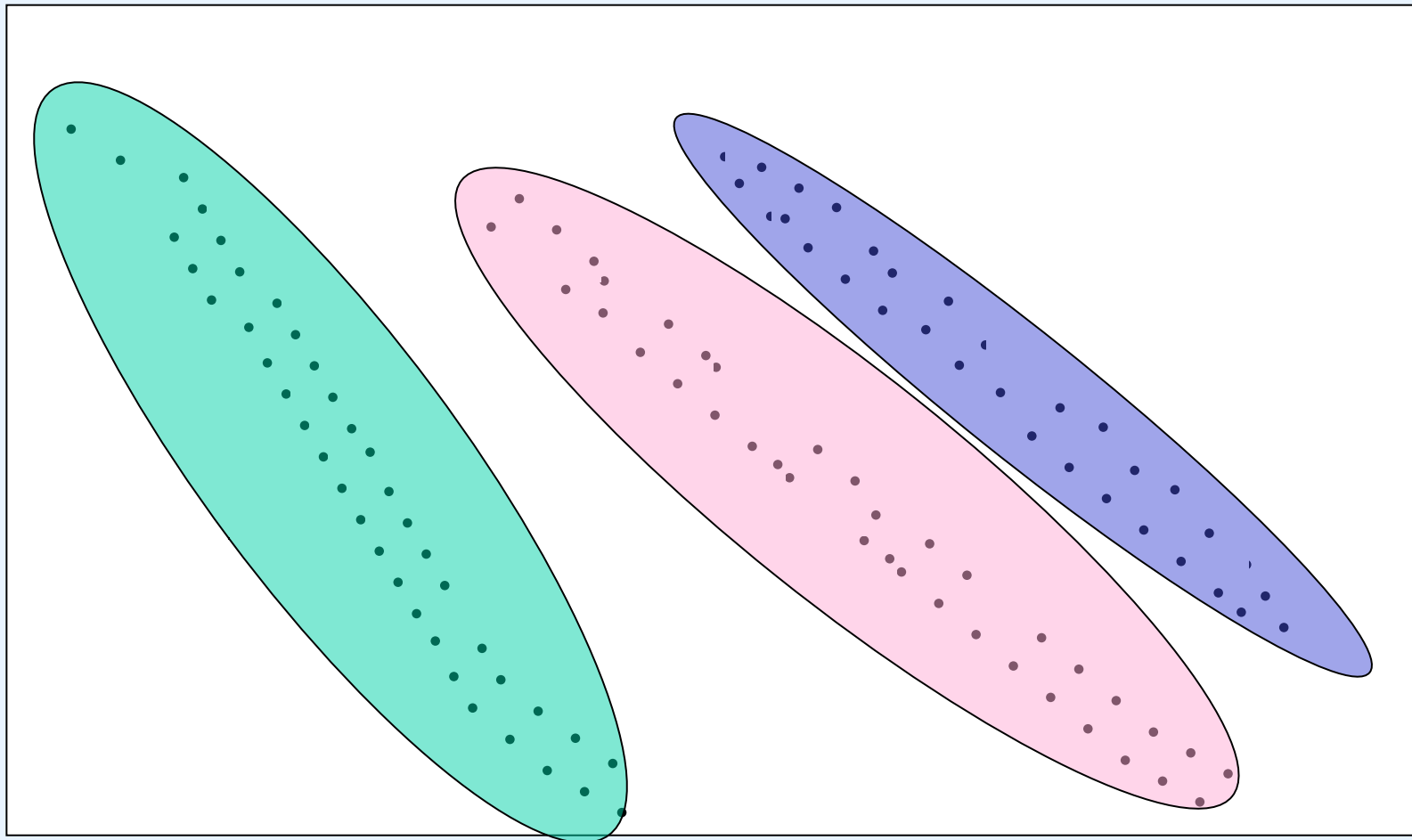Rather than building up increasingly detailed contrasts,

Pruning the perception of phones: Schematic depiction

the learner begins with overly-detailed contrasts,

Pruning the perception of phones: Schematic depiction

and prunes away the ones that are not needed.

Pruning of Perceptual Contrasts

However, there is no evidence that this 'tuning' applies to lexical phonological representations.

The observations about infants apply to phones, not to phonemes.

Learning to ignore sounds and distinctions that are not relevant to their native language is obviously helpful in eventually acquiring phonological features, but it is not the same process.

Evidence in support of this view comes from studies that show that young children are unable to utilize fine phonetic differences in word recognition tasks (Stager & Werker 1997; Werker et al. 2002; Pater, Stager & Werker 2004; Cristià, Seidl & Francis 2011).
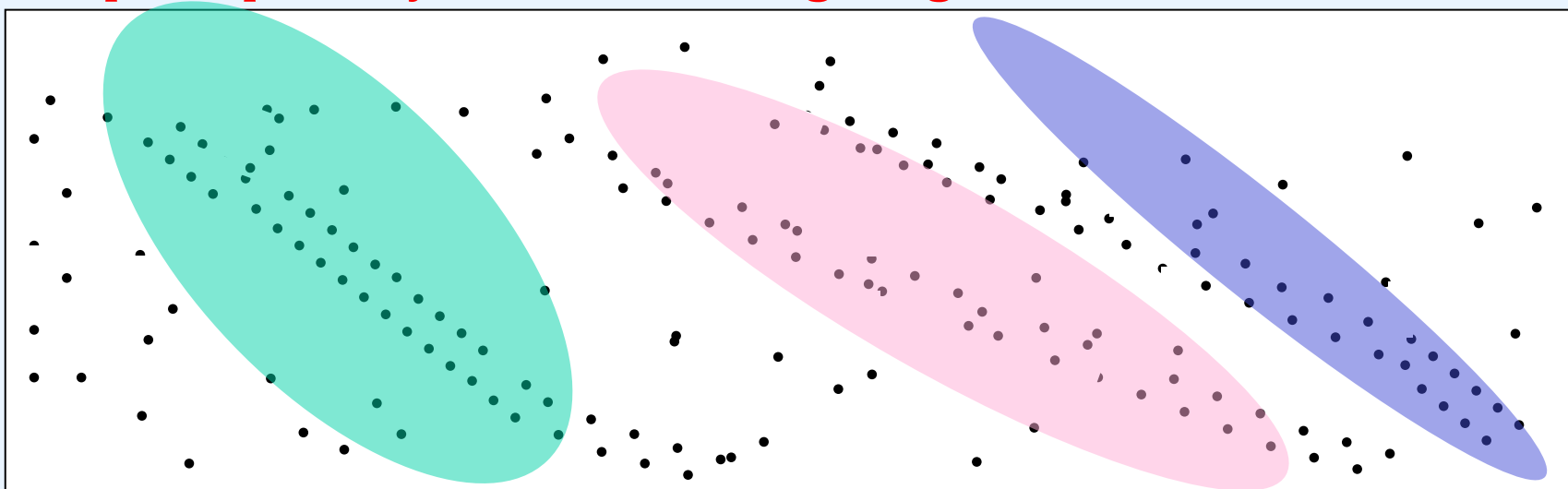
Perception versus representations

It follows that purely phonetic perception does not translate immediately into phonological representations.

The results are consistent with the view that phonological representations do not contain all the details available to phonetic perception (Werker et al. 2002; Pater, Stager & Werker 2004; Pater 2004).

Fikkert & Levelt (2008) argue that phonological representations are underspecified to begin with, in support of the 'emergentist' or 'constructionist' view of acquisition inspired by production studies.

If we combine the studies of infants tuning phonetic perceptions with phonological studies of the role of contrast in phonological inventories, we obtain a picture of a learner going in two contrary directions simultaneously:

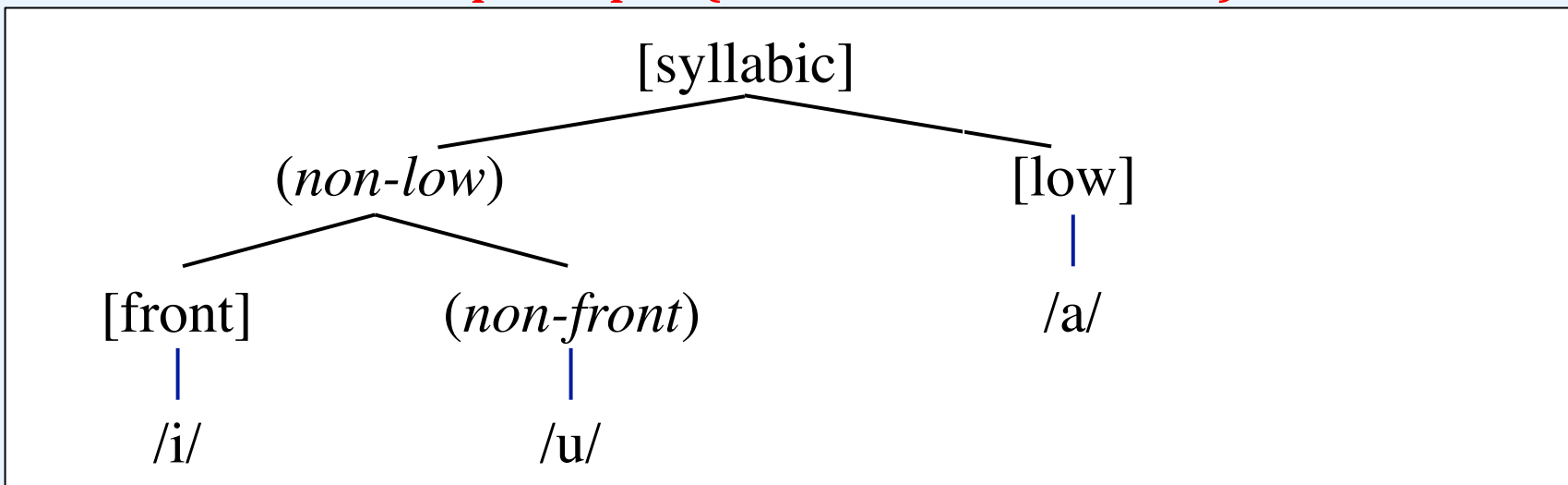# The perceptual system is learning to ignore irrelevant contrasts,

The perceptual system is learning to ignore irrelevant contrasts,
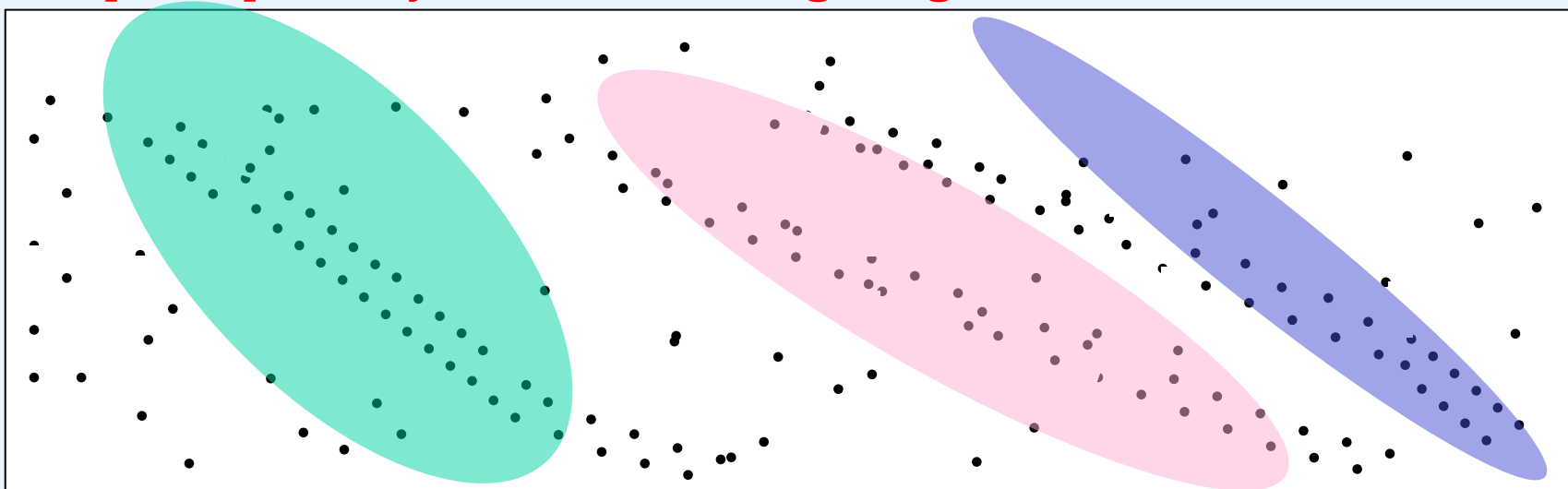
while phonological representations are becoming more complex (Rice & Avery 1995), and more removed from the initial percepts (Dresher 1996, 1999).

[syllabic]
(*non-low*)   [low]
[front]   (*non-front*)   /a/
/i/   /u/

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Conclusion

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Conclusion

To sum up, the line of research that stems from *Kindersprache* is correct in positing that the phonological systems of the world's languages use a very limited set of features.

However, this is not because there is a limited set of innate universal features; the impression that all languages use the same substantive features is to some extent an illusion.

Rather, it is because Universal Grammar requires speakers to construct contrastive feature hierarchies, and they limit the number of features available to the phonology.

Conclusion

In the words of Jakobson, Fant & Halle (1952: 9):

"The dichotomous scale [= the contrastive feature hierarchy] is the pivotal principle of the linguistic structure. The code imposes it upon the sound"

Some of the many facets of contrastive hierarchy theory are pursued further in talks at this conference.

Conclusion

Graziela Bohn shows how children may follow different paths in arriving at the contrastive hierarchy of Brazilian Portuguese vowels.

And Daniel Currie Hall and Elizabeth Cowper argue that morpho-syntactic features are also organized into contrastive hierarchies.

These talks illustrate further how contrastive feature hierarchies allow for considerable variability within a universal framework.

THANK YOU!

For discussions, ideas, and analyses I would like to thank Graziela Bohn, Elizabeth Cowper, Daniel Currie Hall, Paula Fikkert, Ross Godfrey, Christopher Harvey, Ross Krekoski, Will Oxford, Keren Rice, Christopher Spahr, and Zhang Xi.

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

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