

A contrastive hierarchical account of positional neutralization¹

1 Introduction

Positional neutralization can be defined as the systematic and categorical inability to realize a particular contrast in some phonologically definable environment.

A textbook example:

(1) Word-final voicing neutralization in Dutch (Gussenhoven and Jacobs 2011:67, adapted)

- a. /pɑd/ → [pɑt]
- b. /pɑd-ən/ → [pɑd-ən]

- c. /kɑt/ → [kɑt]
- d. /kɑt-ən/ → [kɑt-ən]

How is neutralization handled phonologically?

In this talk, I propose that patterns of neutralization are determined by the organization of features in language-specific Contrastive Hierarchies (Dresher 2009).

I will argue for a model in which non-terminal nodes of the contrastive tree are available in phonological representations as segments in neutralized positions. Essentially, the tree *is* the inventory.

This means that neutralization of e.g., voicing as in (1) involves not a change from underlying [+voice] to surface [-voice], but rather a lack of the feature [\pm voice] in word-final position.

This approach has several advantages:

- Conceptually, it does not imply a contrast in neutralized positions by specifying contrastive values for neutralized features there.
- The phonetic realization of non-terminal nodes follows from their contrastive specifications when interpreted according to the model of phonetic implementation outlined by Hall (2011).
- Non-alternating neutralized segments which never surface in a contrastive environment can be represented as “underlyingly neutralized”, without adding additional complication to the inventory.

¹I owe thanks to at least Elan Dresher, Daniel Currie Hall, Keren Rice, and audiences at the 2012 CRC-sponsored Phonetics/Phonology workshop, MOT2013, and the Phonetics/Phonology discussion group at the University of Toronto for comments, suggestions, and references. Any and all mistakes and wrong turns are entirely my own.

In this model, all nodes of the contrastive hierarchy are available as “phonemes”.

As phonemes, non-terminal nodes can have positional allophony, and can be used in underlying representations, not just as the outputs of processes.

Roadmap of the rest of this talk:

1. Overview the Contrastive Hierarchy (Dresher 2009)
2. How my approach works for vowel reduction
3. How my approach works for consonant neutralization
4. Discuss the use of non-terminal nodes underlyingly
5. Summarize and conclude

1.1 Hierarchical organization of the inventory

A great many theories of phonology assume that individual segments are composed of features.

Many theories incorporate the notion of hierarchy into the organization of features, including:

- Feature geometry (Clements 1985, and many others)
- Optimality Theoretic ranking of faithfulness constraints (Prince and Smolensky 2004)

Many theories of features further assume, either implicitly or explicitly, that only *contrastive* features are represented in the phonology.

I will be building on the **Contrastive Hierarchy** (Dresher 2009), a model of hierarchical organization of contrastive features within the inventory.

Consider a three-vowel inventory:

(2)

	FRONT	BACK/ROUND
HIGH	/i/	/u/
LOW	/a/	

There are many conceivable features which could be present on these vowels, including:

- (3)
- /i/ [+high, -low, -back, -round, +tense, -nasal, ...]
 - /u/ [+high, -low, +back, +round, +tense, -nasal, ...]
 - /a/ [-high, +low, +back, -round, +tense, -nasal, ...]

Dresher (2009) proposes that inventories be divided in a series of binary cuts according to the “Successive Division Algorithm”, using ordered features.

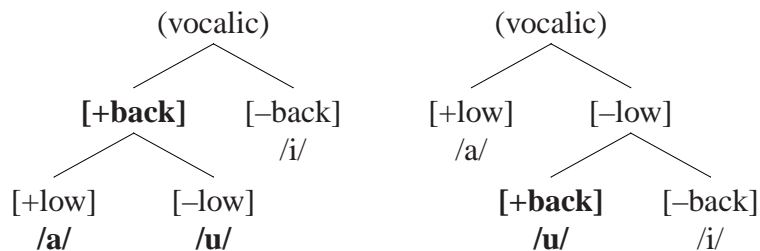
The order of the dividing features is language-specific rather than universal.

Thus two languages with an identical vowel inventory on the surface may have different contrastive hierarchies, which can be represented with tree diagrams.

These trees represent all and only contrastive features:

(4) Three-vowel hierarchies with $[\pm\text{back}]$ and $[\pm\text{low}]$.

a. $[\pm\text{back}] > [\pm\text{low}]$ b. $[\pm\text{low}] > [\pm\text{back}]$



The order of features is determined with the Contrastivist Hypothesis (Hall 2007) in mind, which states that only the contrastive features of an inventory can be referenced by phonological processes.

Evidence for a hierarchy can thus be determined by the features that form classes:²

(5) Triggers of a backing processes

Language (4a) /a/ /u/ (both phonemes contrastively [+back])

Language (4b) /u/ (only one phoneme contrastively [+back])

Only segments contrastively specified as **[+back]** can participate as back in phonological processes.

Given that there are some grounds to posit hierarchical organization of features, I build on this here by proposing that the contrastive hierarchy serves an additional function:

(6) **Contrastive hierarchical neutralization**

Positions subject to phonological neutralization (i.e., an inability to show a contrast) are represented with non-terminal nodes of the contrastive hierarchy.

All nodes of the hierarchy, not only terminal nodes, are licit phonological representations (“phonemes”). In some ways this is an explicit and principled use of **archiphonemes** as members of the full inventory.³

²For some examples of work on diachronic and typological implications of different contrastive hierarchies, see Compton and Dresher 2011, Harvey 2012, Oxford 2012, and Dresher, Harvey, and Oxford (this conference).

³See Davidsen-Nielsen (1978) for much discussion of the Prague School concept of the archiphoneme.

We will see that building this into the hierarchy has a number conceptual, theoretical, and empirical advantages.

2 Vowel reduction

First I will apply my model to some cases of phonological vowel reduction, the loss of vowel contrasts in unstressed position.

Phonetic vowel reduction (centralization) in unstressed position will be seen to follow as an epiphenomenon of the feature specifications used in phonologically reduced positions.

2.1 Bulgarian

Stressed syllables in Bulgarian show a six-way vowel contrast:

(7) Bulgarian stressed vowel inventory (based on e.g. Scatton 1984)

	front	central	back
		non-round	round
high	i		u
mid	e	â	o
low		a	

In unstressed positions, these neutralize in three pairs, according to a “rigid hierarchy” (Scatton 1984:57):

(8) Implicational hierarchy of Bulgarian vowel pair neutralizations

/i/-/e/	>	/u/-/o/	>	/â/-/a/
(eastern dialects)		(informal registers)		(all dialects/registers)

This means that depending on dialect and register, Bulgarian can show one of three unstressed inventories:

(9) Possible unstressed inventories in Bulgarian

a.	<table border="1" style="display: inline-table; vertical-align: middle;"> <tr><td>i</td><td>u</td></tr> <tr><td>e</td><td>ə</td></tr> <tr><td></td><td>o</td></tr> </table>	i	u	e	ə		o	b.	<table border="1" style="display: inline-table; vertical-align: middle;"> <tr><td>i</td><td></td></tr> <tr><td>e</td><td>ə</td></tr> <tr><td></td><td>ʊ</td></tr> </table>	i		e	ə		ʊ	c.	<table border="1" style="display: inline-table; vertical-align: middle;"> <tr><td>ɪ</td><td>ʊ</td></tr> <tr><td></td><td>ə</td></tr> </table>	ɪ	ʊ		ə
i	u																				
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One possible analysis (taken by Scatton) is to say that when a pair neutralizes, its members are changed by rule to the featural representation of the one whose phonetic realization is closest to the neutralized segment:

(10)	Stressed	→	Unstressed
	/â/, /a/	→	/a/ [ə]
	/o/, /u/	→	/u/ [ʊ]
	/e/, /i/	→	/i/ [ɪ]

But such representations don't capture the fact that neutralization has taken place. Using members of a fully contrastive inventory implies they are still in contrast.

Rather than assuming that the smaller numbers of contrasts in neutralized positions are literal subsets of the full inventory, or "subinventories", I argue for the archiphonemic representation of neutralized segments.

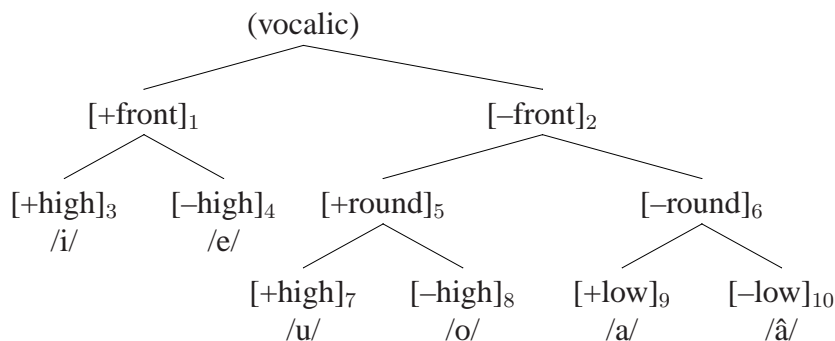
Since they follow from a hierarchically structured inventory, this is in the spirit of Trubetzkoy (1969:228), who said of neutralizations that:

"They are just as characteristic of the phonemic system of the individual languages and dialects as are the differences in the phonemic inventory."

This can be formalized in a principled manner by building on contrastive hierarchies (Dresher 2009) such that the non-terminal nodes above neutralized contrasts are interpretable as (archi)phonemes of neutralized positions.

Consider the hierarchy in (11):

(11) Contrastive hierarchy for Bulgarian



Rather than allowing only one of nodes 9 /a/ and 10 /â/ in unstressed position, both are changed instead to the corresponding non-terminal node 6.

Similarly, nodes 7 and 8 are both changed to 5, and nodes 3 and 4 are changed to node 1:

(12)	Stressed		Unstressed
	9, 10	→	6
	7, 8	→	5
	3, 4	→	1

This is preferable conceptually because it does not represent a contrastive feature, and thus imply a contrast, in positions where a given contrast is neutralized.

The centralization observed in unstressed positions (phonetic vowel reduction) is also predicted when Hall's (2011) model of contrastive feature-driven dispersion is applied.

They are free to move within their specified phonetic space because there are no competing phonemes with contrastive height specifications:

(13) Feature specifications of all Bulgarian vowel phoneme nodes

Phoneme	Node	Feature Specifications	Phonetic Realization
/a/	9	[-front, -round, +low]	[a]
/â/	10	[-front, -round, -low]	[ʌ]
/a/-/â/	6	[-front, -round]	[ə]
/u/	7	[-front, +round, +high]	[u]
/o/	8	[-front, +round, -high]	[o]
/u/-/o/	5	[-front, +round]	[ʊ]
/i/	3	[+front, +high]	[i]
/e/	4	[+front, -high]	[e]
/i/-/e/	1	[+front]	[ɪ]

2.2 Russian

Stressed syllables in Russian contrast five different vowels:⁴

(14) Russian stressed vowel inventory

i	u
e	o
a	

Traditional analyses of Russian vowel reduction distinguish two degrees of neutralization: “moderate” and “radical”.

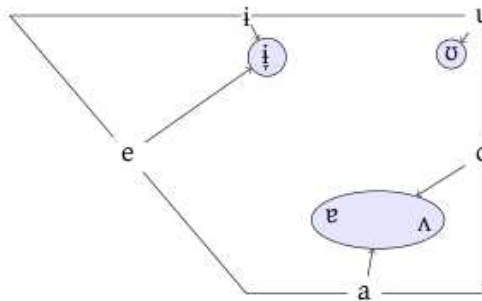
Moderate environments include (Iosad 2012:524):

- (15)
- The syllable immediately preceding the stressed one (the “first pretonic”);
 - Onsetless syllables, regardless of stress (though this is somewhat contested);
 - Gradient effects in phrase-final unstressed open syllables;
 - Some claim both vowels in a hiatus will undergo moderate reduction.

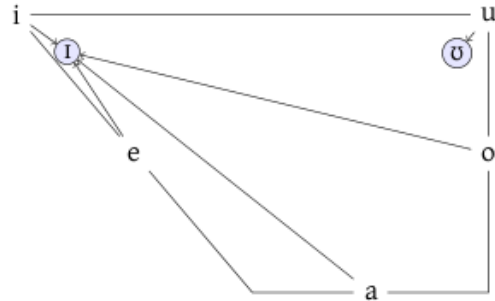
Moderate reduction neutralizes the five-vowel system to a three-vowel system following non-palatalized consonants:

⁴See Timberlake (2004) for some discussion of a five- versus six-vowel analysis of Russian.

(16) Moderate reduction in a non-palatal context (Iosad 2012:526)



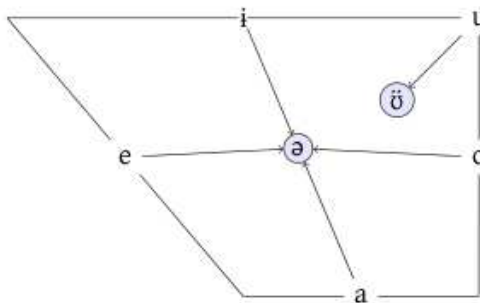
(a) Non-palatalized context



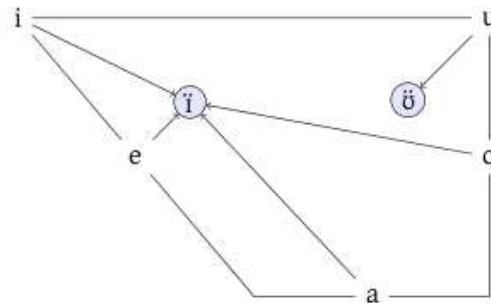
(b) Palatalized context

Radical reduction occurs in all other unstressed syllables. Radical reduction always occurs in reduction to a two-vowel system:

(17) Radical reduction (Iosad 2012:529)

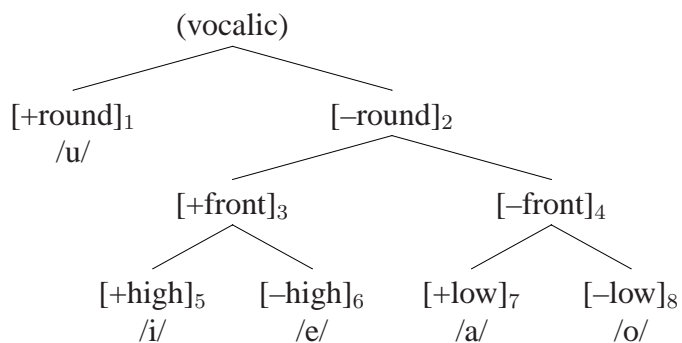


(a) Non-palatalized context



(b) Palatalized context

(18) Contrastive hierarchy for Russian



/u/ is kept separate, with its only contrastive feature being [+round]. This is because it never neutralizes with any other vowel.

In non-palatal moderate positions, 5 /i/ and 6 /e/ become node 3, and nodes 7 /a/ and 8 /o/ become node 4.

Because non-terminal nodes are considered phonemes in this model, they can receive their own allophonic rules. Thus node 4 has predictable allophonic height variation along a continuum depending on its phonetic duration:

(19) Russian feature specifications in a moderate non-palatal reduction context

Phoneme	Node	Feature Specifications	Phonetic Realization
/u/	1	[+round]	[ʊ]
/i/–/e/	3	[–round, +front]	[i̠]
/a/–/o/	4	[–round, –front]	[ɐ, ʌ]

In other contexts (moderate palatal and all radical contexts), all of nodes 5, 6, 7, and 8 are represented as node 2, reflecting a four-way neutralization.

Again, because non-terminal nodes are phonemes in this model, node 2 is entitled to predictable allophony, depending on its duration and proximity to palatalized consonants:

(20) Russian feature specifications in a moderate palatal or radical reduction context

Phoneme	Node	Feature Specifications	Phonetic Realization
/u/	1	[+round]	[ʊ]~[ö]
/i/–/e/–/a/–/o/	2	[–round]	[ɪ]~[ə]~[i̠]

The crucial distinction between moderate and radical reduction is the realization of the neutralized /a/–/o/. In moderate reduction, it is a lower [ɐ, ʌ], while in radical reduction it is the higher [ə].

Crosswhite (2001) analyzes the two degrees quite literally:

- Moderate reduction is caused by a desire for **peripheral vowels** in less prominent positions (contrast-enhancing reduction)
- Radical reduction is caused by a desire for **less sonorous vowels** in less prominent positions (prominence-reducing reduction)

However, this presupposes that [ɐ] and [ə] form clear categories in these contexts.

Barnes (2006) shows that they do not. The height of the vowel is a gradient function of its duration: longer duration yields a lower vowel.

At faster speech rates, moderate contexts with shorter durations can be higher, while at slower speech rates, longer non-moderate contexts can be lower. Moderate contexts just tend to receive longer duration for independent prosodic reasons (i.e., foot structure).

The height-by-duration allophony in the present analysis would be captured as an allophonic rule affecting vowels which lack a specification for [±low] (nodes 2 and 4). Crucially this height variation does not involve any phonological alteration of featural content.

Another interesting result of applying my model to the Russian data is that the feature representations we arrive at are very similar Iosad's (2012) within the Parallel Structures Model. This includes the **lack of phonological rounding on /o/**.

(21) Russian feature specifications in my analysis

Vowel	[±low]	[±high]	[±round]	[±front]
/a/	+		(-)	(-)
/o/	(-)		(-)	(-)
/e/		(-)	(-)	+
/i/		+	(-)	+
/u/			+	

(22) Russian privative feature specifications in the PSM (Iosad 2012:538)

Vowel	V-manner		V-place	
	[open]	[closed]	[labial]	[coronal]
/a/	✓			
/o/		✓		
/e/		✓		✓
/i/				✓
/u/			✓	

Why the lack of rounding on /o/?

According to Iosad (2012:537–538), /u/ and /o/ in no way pattern together, and /o/ does not behave as phonologically round.

One possibility: Phonetic implementation in Russian requires enhancement of all stressed vowels with at least some degree of one positive-valued feature. If this doesn't happen, then stressed /o/ is the only vowel with no positive values at all.

But in *all* positions except stressed, even pretonic, which has a longer duration than stressed, /o/ is realized with no phonetic rounding at all.

In other words, stressed /o/ receives rounded, but /o/ is not round.

3 Consonant neutralization

The non-terminal node model also applies to the neutralization of consonant features.

3.1 Bulgarian voicing and palatalization

Bulgarian obstruents are contrastive for voicing and palatalization, but both of these features can be neutralized positionally.

The positions in which voicing is neutralized is a subset of the positions in which palatalization is neutralized:

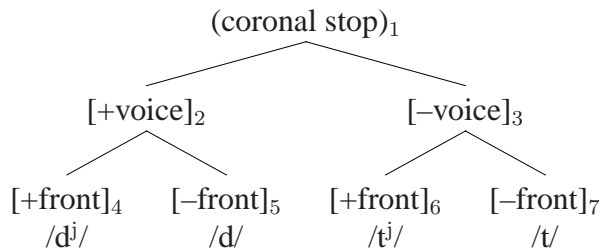
(23) Positional neutralization of palatalization and voicing in Bulgarian

Palatalization	Voicing
Word-finally	Word-finally
In all clusters	In clusters before obstruents
Before front vowels	

Thus, any context which neutralizes voicing will have necessarily also neutralized palatalization.

This subset neutralization is predicted by the non-terminal node model, such that features which are neutralized in less restricted contexts must be ordered lower in the hierarchy. This is because there are no nodes (and thus no phonemes) that are specified for $[\pm\text{front}]$ but not for $[\pm\text{voice}]$.

(24) Contrastive hierarchy for Bulgarian alveolar stops



In an environment where palatalization is neutralized, stops are contrastive only for voice.

The phonetic realization of nodes 2 and 3 is then determined allophonically.

Likewise where voicing is neutralized, stops are only contrastive for place and manner (represented as node 1), and voicing is determined by allophonic regressive spreading of phonetic voicing. Word-finally they are phonetically voiceless, while in clusters they take on the phonetic voicing quality of the following obstruent.

3.2 Intermediate and variable realizations

We saw above that neutralized vowels have a realization intermediate between the phonemes from which they neutralized. That is, they undergo centralization when they are not contrastively specified for height features.

The same kind of variation is seen with neutralized consonants. For example, Bulgarian consonants neutralized for palatalization before front vowels can still have fine-grained intermediately palatalized realizations:

Scatton (1984:64–65) notes that “in these environments they moderately assimilate to the tonal qualities of the vowel: before /i/ they show weak i-tonality, before /e/ weak e-tonality.”

4 Underlying non-terminals

This model of neutralization allows the use of non-terminal nodes in underlying representations, which can be exploited in several different ways.

4.1 Underlying neutralization

4.1.1 Vowels

A vowel in Russian which never surfaces as stressed in any forms and is always heard as [ə] may be the derived reduced form of any of /a, o, i, e/.

In a model without archiphonemes, one would need to either assume a phoneme /ə/ just for such cases, or arbitrarily specify one of four possible vowels in such positions underlyingly.

With underlying non-terminal nodes, however, learners of Russian have an (archi)phoneme whose default phonetic realization is precisely [ə], which they can use underlyingly in such positions when there is no evidence to which terminal node is present.

The non-terminal node model gives us extra underlying phonemes “for free”, because they follow systematically from contrastive structure of the inventory.

4.1.2 Consonants

Non-terminal nodes can also be used underlyingly for consonants. Stem-final consonants, which may reveal their contrastive value of e.g., [\pm voice] through suffixation are not neutralized.

At the beginnings of word-internal clusters, non-terminal nodes can be used, as there is no way to the learner recover the contrastive value for voice.

The use of underlying non-terminals also makes storage of URs more economical, as fewer features are used.

4.2 Three-way contrasts

The non-terminal node model may also account for certain three-way contrasts, with theoretical implications.

Turkish seems to show three kinds of stops:⁵

⁵The transcriptions of some of the vowels, which are irrelevant here, have been changed from the original source.

(25) Types of voicing contrasts in Turkish (Inkelas 1996:3, adapted)

- a. Alternating root-final plosive:

kanat	‘wing’	kanad-ı	‘wing-acc’
kanat-lar	‘wing-pl’	kanad-ım	‘wing-1sg.poss’

- b. Non-alternating voiceless plosive:

sanat	‘art’	sanat-ı	‘art-acc’
sanat-lar	‘art-pl’	sanat-ım	‘art-1sg.poss’

- c. Non-alternating voiced plosive:

etüd	‘study’	etüd-ü	‘study-acc’
etüd-ler	‘study-pl’	etüd-üm	‘study-1sg.poss’

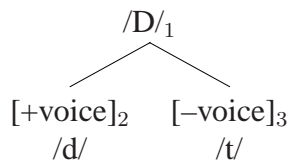
(25a,b) show neutralization of voicing in coda, but some stops (25c) do not devoice as expected.

Inkelas (1996) accounts for this with “archiphonemic underspecification”. Non-alternating voiceless stops are [-voice] and are predictably realized as voiceless, while non-alternating voiced stops are [+voice] and predictably voiced.

Alternating stops are underspecified for [\pm voice], and thus are predictably voiced in onset position, but voiceless in coda position.

Such a three-way system is exactly what we expect when we allow non-terminal nodes to be used underlyingly:

(26) Voicing hierarchy for Turkish



This gives us three stop “phonemes” per place of articulation:

(27) Specifications of Turkish alveolar stop phonemes

Phoneme	Node	Feature Specifications	Phonetic Realization
/d/-/t/ (/D/)	1	(place and manner only)	[d] ~ [t]
/d/	2	[+voice]	[d]
/t/	3	[-voice]	[t]

Fricatives never alternate:

(28) Fricatives don't devoice (Avery 1996:144, adapted)

kız	'girl'	kız-ı	'girl-3sg.poss'
kız-lar	'girl-pl'	kız-a	'girl-dat'
ev	'house'	ev-i	'house-3sg.poss'
ev-ler	'house-pl'	ev-e	'house-dat'

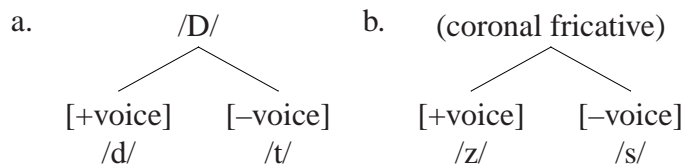
Non-alternating /t/ and /s/ clearly pattern together, in that they always surface as voiceless.

Non-alternating /d/ and /z/ (which is always non-alternating) do as well.

The problem is alternating /D/. If neutralization is handled through re-writing to non-terminal nodes, then we must stipulate that this process applies only to stops, not to fricatives.

If there is no rule at all, only allphonic contextual voicing of non-terminal nodes, then there is no "neutralization" here can reside in the representations, and the (apparently different) voicing systems for stops and fricatives are completely analogous:

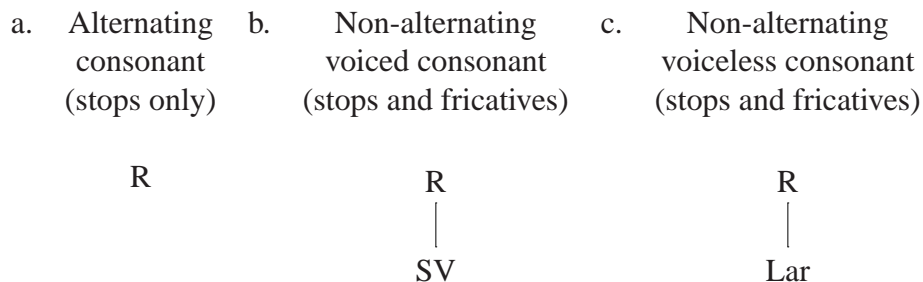
(29) Hierarchies for analogous stop and fricative voicing systems



The difference lies in whether a certain non-terminal node appears in the underlying inventory, not what rules apply. /D/ simply receives predictable phonetic allophony ([t] vs. [d]).

Avery (1996) accounts for the Turkish data by assuming that stops and fricatives can show different voicing systems in the same language. Non-alternating voiced sounds have a sonorant voice, while alternating sounds are underspecified and receive contextual voicing:

(30) Voicing specifications of Turkish obstruents (Avery 1996:150)



By using non-terminal nodes of the contrastive hierarchy, we capture Avery's insight that the differences reside in the kinds of representations use, but still allow the same features to be used,

keeping the relationships between stops and fricatives analogous.

Further evidence that /d/ and /D/ are different:

Wilson (2003) found that, for at least one speaker, /d/ and /D/ had different realizations even intervocalically: /D/'s voicing was only partial, while /d/'s was complete.

This is consistent with phonetic spreading to an underspecified non-terminal node; /d/ is fully specified, and thus must be fully voiced, while /D/ is not and only receives a certain amount of voicing in the right context.

5 Summary and conclusions

I have argued for an analysis of positional neutralization in which neutralized segments are represented with non-terminal nodes of the contrastive hierarchy. Patterns of neutralization are seen to follow from the contrastive structure of the inventory.

Conceptually preferable:

- Non-terminal nodes do not imply a contrast where one is categorically disallowed
- Neutralization is reflected in the representations allowed by the inventory of contrasts

Empirically justified:

- Phonetic realization of neutralized segments follows the more limited contrastive specifications in those positions
- Neutralized segments can have variable or intermediate realizations compared to their corresponding non-neutralized segments, as expected
- The underspecification provided by non-terminal nodes predicts exactly the kind of voicing system (phonetically and phonologically) seen in e.g., Turkish stops

Restrictive and minimal:

- Neutralizations can only be represented by non-terminal nodes above terminal contrasts
- Neutralization of a lower feature in the hierarchy must occur in a superset of positions that a higher features neutralize (as seen with Bulgarian palatalization and voicing)
- Non-terminal nodes can be used to represent “underlyingly neutralized” positions non-arbitrarily and more economically without having to posit additional phonemes

Thanks!

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