

24.901/931, 2026

Introduction to Phonology

Lecture 3

Various announcements

- Read: continue chapters 2-3, begin chapter 4 in Hayes 2009
(Canvas Module: Features, Contrast, Processes)
- Office hours:
 AL: Monday 4-5 and by appointment
 DS: Thursday 1-2 and by appointment
- Recitation:
 Thursdays 4-5

Next 2-3 lectures

4 connected topics

- **FEATURES:** articulatory or acoustic/auditory properties in mental representation of speech sounds.
- **PROCESSES:** modifications of speech sounds that the grammar records; arguably operating on features.
- **CONTRAST:** pairs of sounds perceived as categorically distinct in a phonological system; able to convey meaning differences
- **INVENTORY:** the set of contrasting features/phonemes in a phonological system; constraints generating possible inventories.

Part 1: IPA categories as features

IPA table of pulmonic Cs

manner categories (degree of constriction) intersecting place categories (site of constriction)

CONSONANTS (PULMONIC)

	Bilabial	Labiodental	Dental	Alveolar	Postalveolar	Retroflex	Palatal	Velar	Uvular	Pharyngeal	Glottal
Plosive	p b		t d			ʈ ɖ	c ɟ	k ɡ	q ɢ		ʔ
Nasal	m	ɱ	n			ɳ	ɲ	ŋ	ɴ		
Trill	ʙ		r						ʀ		
Tap or Flap		ⱱ	ɾ			ɽ					
Fricative	ɸ β	f v	θ ð	s z	ʃ ʒ	ʂ ʐ	ç ʝ	x ɣ	χ ʁ	ħ ʕ	h ɦ
Lateral fricative			ɬ ɮ								
Approximant		ʋ	ɹ			ɻ	j	ɰ			
Lateral approximant			l			ɭ	ʎ	ʟ			

Symbols to the right in a cell are voiced, to the left are voiceless. Shaded areas denote articulations judged impossible.

More dimensions in the IPA C-table

Place Where the vocal tract narrows	lips	teeth	alv. ridge	hard palate	velum	uvula	pharynx	larynx
	<i>labial</i>	<i>dental</i>	<i>alveolar</i>	<i>post-alveolar</i>	<i>velar</i>	<i>uvular</i>	<i>pharyngeal</i>	<i>laryngeal</i>
	p, m, β	t̪ θ, ð	t, s, z	ʃ, ʒ	k, g, x	q, ɢ	ħ, ʕ	ʔ
Stricture How narrow the constriction in the vocal tract is	no air escapes			air escapes with turbulence		air escapes without turbulence		
	<i>plosive</i>			<i>fricative</i>		<i>approximant, glide</i>		
	p, t, g, q...			(f), s, ʃ...		r, ɹ, l, w, ...		
(Vent) Which cavity and how the air escape from	nose only			mouth (and possibly nose)				
	<i>nasal</i>			central airflow		lateral airflow		
	m, n, ...			β, a, w, s, ...		l, ʎ, ...		

Feature categories in English place assimilation

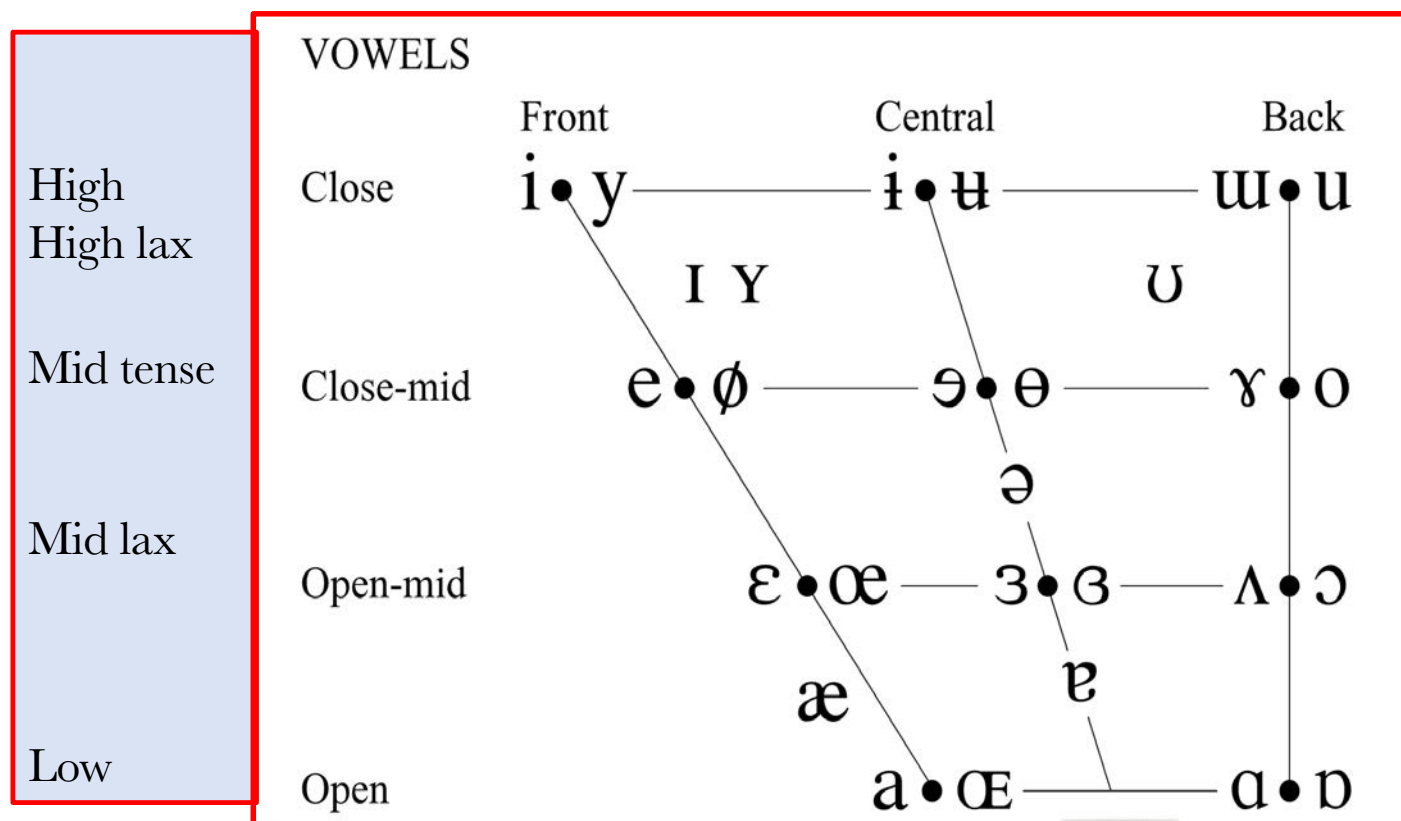
- The target of the rule: an alveolar nasal
- Its trigger: stops, fricatives and perhaps nasals cause place assimilation; approximants and glides don't (*inward*, **imward*; *unwell*, **umwell*)
[nasal, alveolar] → [α place] / _[*plosive or fricative or nasal*, α place]

IPA dimensions relevant to Cs in tabular form

	State of Larynx	Place	Manner		
			Stricture	Lateral	Nasal
[g]	voiced	velar	stop	central	oral
[θ]	voiceless	dental	fricative	central	oral
[l]	voiceless	alveolar	resonant	lateral	oral
[m]	voiced	bilabial	stop	central	nasal
[j]	voiced	palatal	approximant	central	oral

IPA basic V chart uses different dimensions

<https://www.internationalphoneticassociation.org/>

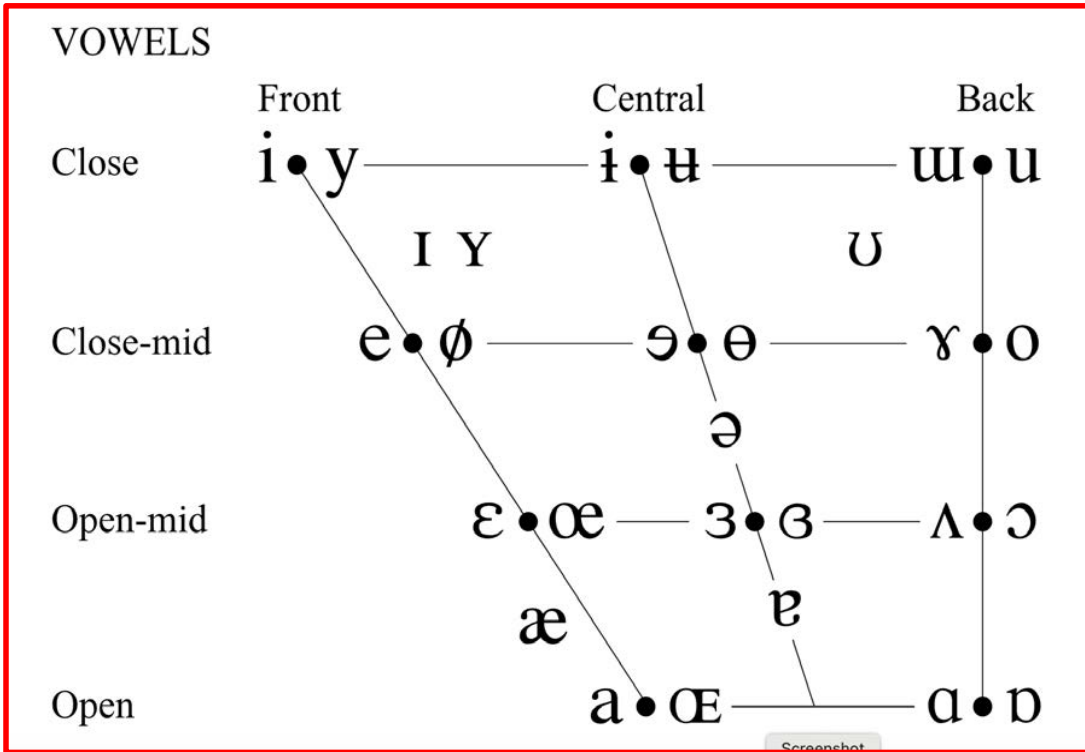


Note rounded-unrounded differences within each region of the V space

heed, hid, hayed, head, had, hawed, hod, hood, who'd

i I e ε æ α, ɔ ɒ ʊ u

High
High lax
Mid tense
Mid lax
Low



Front-back dimension corresponds to horizontal position of the tongue.

The acoustic dimension: values of 2nd Formant (F2) and 3rd Formant (F3)

High-low (~~close-open~~) dimension corresponds to vertical position of jaw & tongue.

The acoustic dimension: values of 1st Formant (F1)

IPA dimensions for Vs and glides in tabular form

	Tongue Height	Tongue Backness	Lip Rounding
[a]	low	front	unrounded
[e]	mid tense	front	unrounded
[ʊ]	high lax	back	rounded
[i]	high tense	front	unrounded
[œ]	mid lax	front	rounded
[j]	high	front	unrounded
[w]	high	back	rounded

Same properties can classify Cs and Vs

◦ Voiceless	n̥ d̥	⋯ Breathy voiced	b̤ a̤	┘ Dental	t̪ d̪
✓ Voiced	s̹ t̹	˜ Creaky voiced	b̰ a̰	┘ Apical	t̟ d̟
h Aspirated	tʰ dʰ	˘ Linguolabial	t̝ d̝	┘ Laminal	t̠ d̠
◌ More rounded	ɔ̹	˘w Labialized	tʷ dʷ	˘ Nasalized	ẽ
◌ Less rounded	ɔ̹̹	j Palatalized	tʲ dʲ	n Nasal release	dⁿ
+ Advanced	u₊	ʏ Velarized	tʷ dʷ	ˡ Lateral release	dˡ
- Retracted	e₋	ʕ Pharyngealized	tˤ dˤ	˘ No audible release	d˘
¨ Centralized	ë	˘ Velarized or pharyngealized	ɫ		
× Mid-centralized	ẽ	⊥ Raised	e⊥ (ɹ̥ = voiced alveolar fricative)		
Syllabic	n̩	⊥ Lowered	e⊥ (β̥ = voiced bilabial approximant)		
◌ Non-syllabic	e̥	┘ Advanced Tongue Root	e̟		
˘ Rhoticity	ɹ̥ ɹ̥	┘ Retracted Tongue Root	e̠		

Distinctions found across all place/manner classes

Oral – nasal	b, d, g – m, n, ŋ	a, e, u – ã, ã̃, ã̄	w, j, r – Ẃ, Ẅ, Ẇ	f, s, ʃ – ɸ, ɸ̃, ɸ̄
Voiced – voiceless	b, d, g – p, t, k	a, e, u – ̤, ̥, ̦	Ẃ, Ẅ, Ẇ – w, j, r	v, z, ʒ – f, s, ʃ
Aspirated – unaspirated	p, t, k – p ^h , t ^h , k ^h			f ^h , s ^h , ʃ ^h – f, s, ʃ
Glottalized – non-glottalized*	ᵇ, ᵈ, ᵍ – b, d, g p', t', k' – p, t, k	̤, ̥, ̦ – a, e, u	Ẃ, Ẅ, Ẇ – w, j, r	
Palatalized – non-palatalized	pʲ, tʲ, kʲ – p, t, k	(≈ front-back)	rʲ	ɸʲ, sʲ, ʃʲ – f, s, ʃ
Labialized – non-labialized	pʷ, tʷ, kʷ – p, t, k	(≈ round-unround)	rʷ	fʷ, sʷ, ʃʷ – f, s, ʃ
Short-long	p, t, k – p:, t:, k:	a, e, u – a:, e:, u:	w, j, r – w:, j:, r:	f, s, ʃ – f:, s:, ʃ:
Syllabic – non-syllabic**	ᵐ, ᵑ, ᶯ – m, n, ŋ	i, e, u – ̩, ̪, ̫	Ẃ, Ẅ, Ẇ – w, j, r	ɸ, ɸ̃, ɸ̄ – f, s, ʃ

* Glottalized is not an IPA term: it refers to a partial or complete airflow obstruction at the larynx.

- Glottalized voiced stops ≈ implosives
- Glottalized voiceless stops ≈ ejectives
- Glottalized vowels and approximants ≈ creaky voiced

** • the IPA diacritics for *non-syllabic* Vs does not appear in the IPA tables but it exists: ̩ is a non-syllabic vowel

Expanded tables for Vs and glides

	State of larynx	Tongue Height	Tongue Backness	Lip Rounding	Nasality
[a]	voiced	low	front	unrounded	oral
[ẽ]	voiced	mid tense	front	unrounded	nasal
[ʊ]	voiced	high lax	back	rounded	oral
[i̥]	voiceless	high tense	front	unrounded	oral
[œ̃]	voiced	mid lax	front	rounded	nasal
[j]	voiced	high	front	unrounded	oral
[w̥]	voiceless	high	back	rounded	oral

Consonants vs. vowels $\neq$ non-syllabics vs. syllabics

- Consonants (C) vs. vowels (V)
Is the flow of air substantially impeded (blocked completely or partly) in the vocal tract? If yes, it's a C. If no, it's a V. (With complications)
- Syllabic vs. non-syllabic
Vs are sounds with maximally unimpeded oral airflow.
Also typically *centers of syllables*, aka *nuclei*. They are *syllabic* sounds.
Cs *can* be syllabic (e.g. *rhythm* [ɹɪð**m**], *cable* [keɪb**l**]). Typically are not.
- Glides
V-like sounds with slightly narrower constrict., typically non-syllabic.
As in *yellow* [**j**elə**w**], *beauty* [b**j**uri], *boy* [bɔ**j**], *twin*. Can be syllabic.

Non-IPA categories: $[\pm\text{continuant}]$,
 $[\pm\text{sonorant}]$, $[\pm\text{consonantal}]$

CONSONANTS (PULMONIC)

	Bilabial	Labiodental	Dental	Alveolar	Postalveolar	Retroflex	Palatal	Velar	Uvular	Pharyngeal	Glottal
Plosive	p b		t d			ʈ ɖ	c ɟ	k ɡ	q ɢ		ʔ
Nasal	m	ɱ	n			ɳ	ɲ	ŋ	ɴ		

All these sounds involve complete blockage of *oral* airflow.

They're [-continuant].

In affricates (tʃ, dʒ, ts, pf), the initial phase is [-cont]. There is a second phase, involving frication (= turbulent airflow): that is [+cont].

The plosive phase is typically longer.

[±continuant]

[±continuant]

Trill	B		r							R		
Tap or Flap		ʋ	ɾ				ɽ					
Fricative	ɸ β	f v	θ ð	s z	ʃ ʒ	ʂ ʐ	ç ʝ	x ɣ	χ ʁ	ħ ʕ	h ɦ	
Lateral fricative			ɬ ɮ									
Approximant		ʊ	ɹ				ɻ	j	ɰ			
Lateral approximant			l				ɭ	ʎ	ʟ			

All these Cs (the *complement class*) plus all the vowels and glides are [+continuant]:
air escapes, whether turbulent or not, out of the oral tract

[± sonorant]

	Bilabial	Labiodental	Dental	Alveolar	Postalveolar	Retroflex	Palatal	Velar	Uvular	Pharyngeal	Glottal
Plosive	p b			t d		ʈ ɖ	c ɟ	k ɡ	q ɢ		ʔ
Fricative	ɸ β	f v	θ ð	s z	ʃ ʒ	ʂ ʐ	ç ʝ	x ɣ	χ ʁ	ħ ʕ	

All these (stops + fricatives) are *obstruents*, or *non-sonorants* or [-sonorant].
They lack acoustic energy in the lower spectral regions above F0.

Nasal	m	ɱ		n		ɳ	ɲ	ŋ	ɴ		
Trill	ʙ			ʀ					ʀ		
Lateral fricative				ɬ ɮ							
Approximant		ʋ		ɹ		ɻ	j	ɰ			
Lateral approximant				l		ɭ	ʎ	ʟ			

These are *sonorants*, or *resonants*, or [+sonorant].
They have acoustic energy in the lower spectral regions
Vowels are also [+sonorant].

Common sounds and their manner features

	Sonorant	Continuant	Nasal	Syllabic	Voiced
p, t, k	-	-	-	-	-
b, d, g	-	-	-	-	+
s, ʃ, f	-	+	-	-	-
z, ʒ, v,	-	+	-	-	+
m, n, ŋ	+	-	+	-	+
r, l, w	+	+	-	-	+
i, u, a...	+	+	-	+	+

Also
m̥, w̥, r̥...

Also
ã, ã...

Also
m̥, n̥, l̥...

How the new features map to IPA stricture classes

	Sonorant	Continuant	Syllabic
Plosives: ptkbdg	-	-	typically [-syllabic]; deviations may occur depending on language and C class
Fricatives: szfvθðʒ	-	+	
Nasals: mnŋɲ	+	-	
Approximants: ɹjwɭ	+	+	
Vowels: aeɪəyɪuʌ	+	+	

More features in Hayes 2009, chap. 9

An extra stricture degree with [$\pm$ consonantal]

	Sonorant	Continuant	Consonantal	Syllabic
Oral stops: ptkbdg	-	-	+	typically [-syll.], deviations by language and C class
Fricatives: szfvθðʒ	-	+	+	
Nasals: mnŋɲ	+	-	+	
Liquids	+	+	+	
Glides	+	+	-	
Laryngeal Cs: h, ʔ	debated	+(h), -(ʔ)	debated	
Vowels: aeɪəyɪuʌ	+	+	-	+

[$\pm$ vowel] in Hayes 2009 is basically [$\pm$ consonantal]

Distinctive features are hypotheses about how humans conceive of speech sounds.
Can't observe them directly.

Linguists might agree on the need for some feature set but disagree on specifics.

We find the right features by comparing proposals for specific feature sets with the analysis of individual phonological systems and that of general sound laws.

Two IPA founders

Paul Passy

1859-1940



Daniel Jones

1881-1967



Two founders of modern phonology

Roman O. Jakobson
1896-1982



Nikolaj S. Trubetzkoy
1890-1938



Current distinctive feature sets aren't identical to those proposed by Jakobson and Trubetzkoy. But their thinking inspired current sets: they proposed the first universal sound laws and argued that a universal feature set must reflect these laws.

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IPA categories vs. distinctive features (DF)s

- Goals of current IPA system: (i) to provide notation for speech sounds, but minimize extra symbols; (ii) to help linguists record fieldwork.
- Goal of DF theory: find physical properties of speech sounds that play a role in their mental representations.
- Analysis of phonological processes (e.g. place assimilation) and sound laws guides how DF theory is developed.
- A general hypothesis: the right hypothesis about DFs can predict which processes occur across languages vs. which are systematically missing.
- Equivalently: some conceivable processes are not found in human languages because they presuppose sound representations that humans don't entertain.

The stricture categories in 2 systems

- IPA stricture categories: plosives, fricatives, nasals, approximants; vowels
- DF stricture features:
 - [$\pm$ continuant]; [$\pm$ nasal]; [$\pm$ consonantal]; [$\pm$ sonorant]; [$\pm$ syllabic]
- Both systems recognize distinctions based on airflow.
 - Airflow in the oral tract: ([$\pm$ continuant]; IPA plosives vs. fricatives)
 - Airflow in the vocal tract ([$\pm$ nasal]; to an extent [$\pm$ sonorant] too)

DFs and IPA categories for stricture (constriction degree)

[$\pm$ consonantal]: narrow *oral* constriction, so escaping air is turbulent if glottis is open

	i	j	r	l	n	z, ʒ	d, ɖ
consonantal	-	-	+	+	+	+	+
IPA	vowels	approximants			nasals	frics	plosives

DFs and IPA categories for stricture

[$\pm$ sonorant]: no significant constriction in *vocal* tract to result in oral pressure buildup

	i	j	r	l	n	z, ʒ	d, ɖ
consonantal	-	-	+	+	+	+	+
sonorant	+	+	+	+	+	-	-
IPA	vowels	approximants		nasals		frics	plosives

[$\pm$ sonorant and $\pm$ obstruent are equivalent features, the different names focus on + vs. - values

DFs and IPA categories for stricture

[$\pm$ continuant]: no significant obstacle to *oral* airflow

	i	j	r	l	n	z, ʒ	d, ɖ
consonantal	-	-	+	+	+	+	+
sonorant	+	+	+	+	+	-	-
continuant	+	+	+	(varies)	-	+	-
IPA	vowels	approximants			nasals	frics	plosives

DF system uses 3 binary features whose values can combine to generate 5 stricture classes.
IPA uses 5 unrelated categories that cannot combine.

The stricture categories in 2 systems

- IPA stricture categories: plosives, fricatives, nasals, approximants; vowels
- DF stricture features:
 - [±continuant]; [±nasal]; [±consonantal]; [±sonorant]; [±syllabic]
- Both systems recognize distinctions based on airflow.
 - Airflow in the oral tract: ([±continuant]; IPA plosives vs. fricatives)
 - Airflow in the vocal tract ([±nasal]; to an extent [±sonorant] too)
- But: DF values combine to form many sets; fewer IPA classes combine.
- The sound classes needed for phonological rules are frequently intersecting sets that IPA cannot describe: IPA categories are not general enough.

Some manner classes mentioned in rules

{plosives + nasals}:

frequently the only Cs that cause place assimilation in nasals

{plosives + fricatives}:

frequently the only segments that show voicing contrasts in a system

{affricates + fricatives}:

in English + most lgs: can't be followed by fricatives

{fricatives + approximants (glides, liquids) + h}:

nasals delete before just these Cs in many languages

{glides + vowels}: *open syllables* end in these; many lgs. have just open syll.

{nasals, approximants, vowels}: in English, only they can be *syllabic*;

in other languages, only they can be distinguished by tone, *tone bearers*

Natural classes

- Any class of sounds can be described as disjunctive set:
plosives or nasals; fricatives or approximants; vowels or nasals, uvulars or stops etc.
- Most disjunctive sets defined in this way are not used in any known rules:
vowels or nasals, uvulars or stops or glides; fricatives or vowels; nasals or affricates; ...
- Natural classes of sounds are those used by actual processes. (Hayes 2009 diff. sense)
- Hypothesis: all natural classes are defined by intersecting sets based on DFs.
- If feature theory A can't distinguish natural classes from others (= describes all with equal ease) while theory B describes only natural classes, then B is better.
- Next: we observe that a version of DF theory can describe many, maybe most, attested natural classes involving manner. And a few other classes.

IPA can define only sets where a manner class combines w. a place class e.g. nasal and labial; or plosive and velar. That leaves out most needed natural classes.

IPA classes aren't abstract enough.

Recall these natural classes of sounds

{plosives + nasals}:

frequently the only Cs to cause place assimilation onto nasals

{plosives + fricatives}:

frequently the only segments to show voicing contrasts

{affricates + fricatives}:

in English + most lgs: can't be followed by fricatives; assimilate to e.o.

{fricatives + approximants (glides, liquids) + h}:

nasals delete before just them in many languages

{glides + vowels}: *open syllables* end in these; many lgs. have just open syll.

{nasals, approximants, vowels}: in English, only they can be syllable centers;

What is their DF characterization?

DF description

{plosives + nasals}:

[-continuant]

{plosives + fricatives}:

[-sonorant]

{affricates + fricatives}:

[-sonorant, +continuant] (or [+delayed release] in Hayes 2009)

{fricatives + approximants (glides, liquids) + h}:

[+continuant]

{glides + vowels}: [-consonantal]

{nasals, approximants, vowels}: [+sonorant]

Only 2 of the sets below are natural classes

{glides + liquids}

{stops + glides + liquids}

{fricatives + vowels}

{nasals + vowels}

{nasals + fricatives}

{glides + r} (but not l)

{vowels + liquids} (but not glides)

Can our stricture DFs characterize them? If yes, how. If no, why not.

Only 2 of the sets below are natural classes

{glides + liquids} can follow stops word-initially in Spanish + other lgs

{stops + glides + liquids}

{fricatives + vowels}

{nasals + vowels}

{nasals + fricatives}

{glides + r} (but not l) can surface nasalized (Moba: Ajiboye & Pulleyblank 2000)

{vowels + liquids} (but not glides)

Can our stricture DFs characterize them? If yes, how. If no, why not.

Only 2 of the sets below are natural classes
that we know of

{glides + liquids} [-syllabic, +son, +cont]

{stops + glides + liquids}

{fricatives + vowels}

{nasals + vowels}

{nasals + fricatives}

{glides + r} (but not l) [-syllabic, +son, +cont], if l is [-cont]

or [-syllabic, +son, -lateral]

{vowels + liquids} (but not glides)

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