

-	-	-	-	-	-	-	-	+	-	-	-	0	0	0	-	-	0	0
-	-	-	-	-	-	+	-	-	+	-	-	0	0	0	-	-	0	0
+	-	-	-	-	-	-	-	+	-	-	-	0	0	0	-	-	0	0
+	-	-	-	-	-	+	-	-	+	-	-	0	0	0	-	-	0	0
0	-	-	-	+	+	-	-	+	-	-	-	0	0	0	-	-	0	0



UCI Teaching Demo

Phonology and Phonological Features

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LSCI 3: Introduction to Linguistics
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After this lesson, you should be able to:

- ❖ Recall the important dimensions of phonological contrast between speech sounds
- ❖ Describe the relationship between phonemes in terms of their phonological features
- ❖ Formulate phonological rules for systematic sound changes using your knowledge of phonological features

- ❖ **Phonetics:** The study of how humans produce and understand speech
 - ❖ **Descriptive:** phonetics describes real-world language usage
 - ❖ Subdisciplines: acoustic, articulatory, auditory phonetics
- ❖ **Phonology:** The study of sound systems
 - ❖ **Theoretical:** phonology theorizes how phonemes are fundamentally organized
 - ❖ Subdisciplines: phonotactics, phonological alternation
- ❖ Not completely separate – phonological theories are built on phonetic data



- ❖ A **phoneme** is the minimal unit of distinction between words
 - ❖ Test: minimal pairs
- ❖ Not to be confused with **grapheme** (minimal unit for a writing system)
 - ❖ Sometimes, phonemes and graphemes are the same.
Less often in English 😬 (queue → /kju/)
- ❖ **Phonotactics:** Different languages "carve up" the acoustic space into phonemes differently
- ❖ The **International Phonetic Alphabet (IPA)** is a language-independent way to transcribe phonemes

	<i>Orthography</i>	<i>IPA</i>	<i>Meaning</i>
Հարթ	սապ	/takʰ/	hot
Հանդիպություն	սակ	/tak/	under

minimal pairs

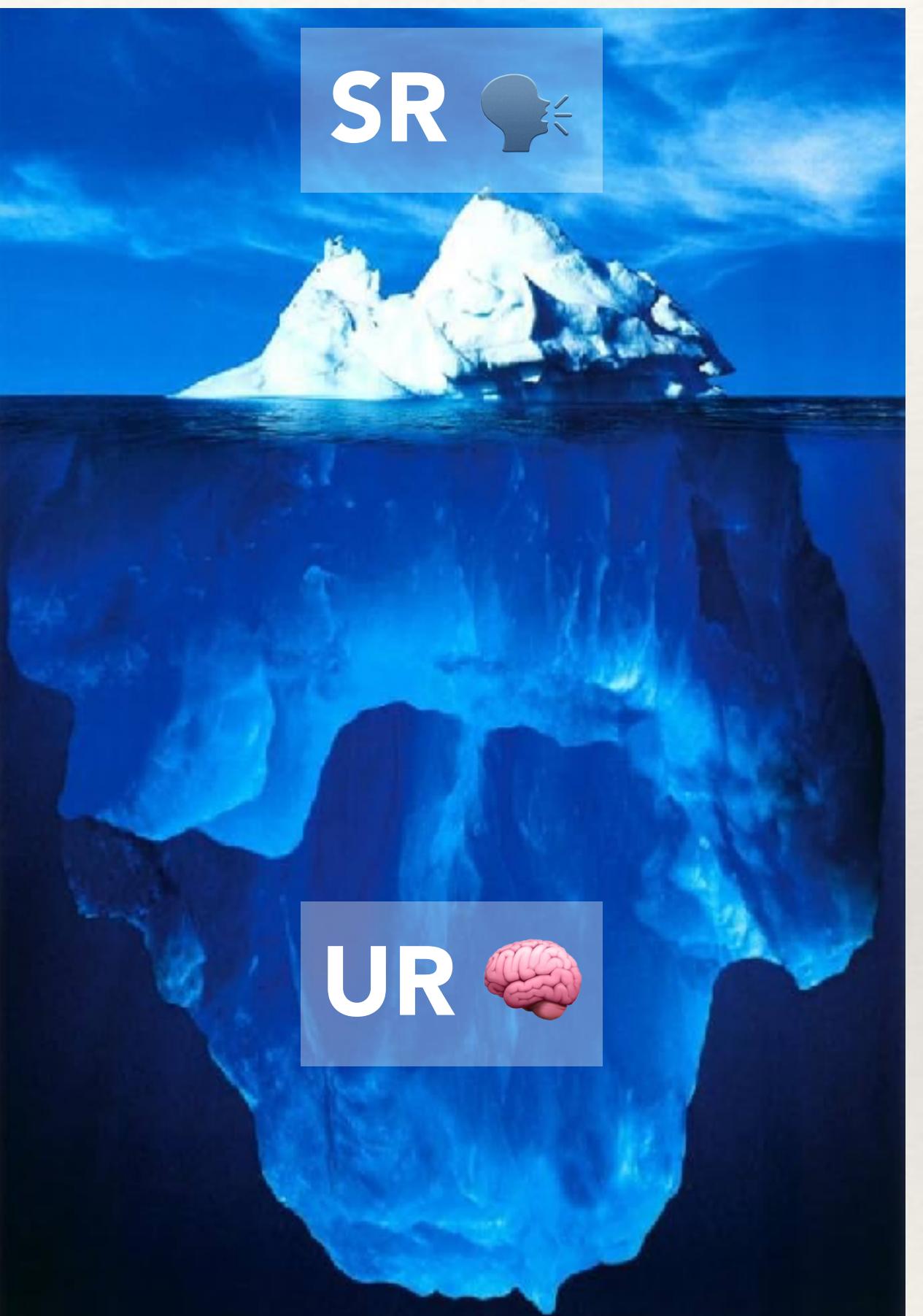
	<i>Orthography</i>	<i>IPA</i>	<i>Meaning</i>
Talk	talk	/tak/	talk
Talk	talk	/takʰ/	...still talk

allophones

Aspiration is phonemic in Armenian
but not in English



- ❖ Speech sounds are **surface representations** of deep-seated **underlying (phonemic) representations**
 - ❖ Surface reps. are the spoken sounds
 - ❖ Underlying reps. are the mental organization of the sounds spoken
- ❖ For IPA, surface reps. are transcribed [in brackets] and underlying reps. are transcribed /in forward slashes/
 - ❖  - /kæt/ vs. [kʰæt̪]
 - ❖  - /kərtɛf/ vs. ['kəːrəf]





- ❖ **Phonological alternation:** The specific surface representation of an underlying representation is usually predictable given the context of the sound
 - ❖ Alternations can also be morphological or syntactic, but that's a topic for another day!
- ❖ A phonologist writes **phonological rules** to capture that sound change
 - ❖ Phonological rules tell us the context in which we can expect specific allophones
 - ❖ Context can be the start of a word (#_), the end of a word (_#), after a vowel (V_), between consonants (C_C), the list goes on...

/UR/ → [SR] / context

The typical form for a phonological rule



- ❖ **Assimilation** – One phoneme "spreads" one or more of its features to another
 - ❖ English: Voicing assimilation of plural /s/
 - ❖ **Vowel Harmony** – a form of assimilation where all vowels in a word adopt similar features (Hungarian dative suffix takes form -nak before back vowels and -nek before front vowels) (there's also **nasal harmony**)
- ❖ **Dissimilation** – A phoneme "drops" features its shares with its neighbor(s)
 - ❖ Kikuyu: Infinitive prefix /ko-/ dissimilates when root word begins with a stop to /yo-/ (velar fricative)

- ❖ **Epenthesis/Addition** – Addition of a phoneme
 - ❖ Spanish: /e/ added to word-initial consonant clusters beginning with /s/ (escuela)
- ❖ **Deletion/Haploglossy** – Removal of a phoneme
 - ❖ French: Word-final consonants are deleted and the vowel is nasalized: *poisson* [pwɑ̃sõ]
- ❖ **Metathesis** – Phonemes switch places
 - ❖ ask /æsk/ to [æks] in some dialects of English (e.g., AAVE)



- ❖ Phonological rules are non-symmetrical. Order of operations matters!
 - ❖ PEMDAS, but for linguists
- ❖ Example English plural /-s/ (right)
 - ❖ Asterisk * used to denote an incorrect form

Rule A: Voicing assimilation of /-s/ to the preceding phoneme		Rule B: Add a schwa before /-s/ when the root word ends with a strident (/s, z, ʃ, ʒ, tʃ, dʒ/)	
<i>Ordering #1</i>		<i>Ordering #2</i>	
Root	bʌs	Root	bʌs
Assimilation (A)	bʌs + s	Epenthesis (B)	bʌs + ə + s
Epenthesis (B)	bʌs + ə + s	Assimilation (A)	bʌs + ə + z
Surface rep.	*bʌsəs	Surface rep.	bʌsəz

Rule ordering to pluralize "bus"



Description of Rule	Example	Formalization
A vowel in between two nasal consonants becomes nasal itself	/nænsi/ → [næ̃nsi]	/æ/ → [ã] / n_n
The plural -s becomes voiced if the phoneme before it is voiced	/dags/ → [dagz]	/s/ → [z] / g_#
The plural -s becomes voiced if the phoneme before it is a vowel	/kjuʊs/ → [kjuʊz]	/s/ → [z] / ou_#
Schwa epenthesis in between stridents	/maʊs-s/ → [maʊsəz]	$\emptyset \rightarrow [\theta] / \left\{ \begin{array}{l} s \\ z \\ \text{ʃ} \\ ʒ \\ t\text{ʃ} \\ dʒ \end{array} \right\} - \left\{ \begin{array}{l} s \\ z \\ \text{ʃ} \\ ʒ \\ t\text{ʃ} \\ dʒ \end{array} \right\}$



There's got to be a better way!





- ❖ We don't have to write out a phonological rule for every single instance of a sound change if there's some observable pattern
- ❖ Multiple phonemes can be grouped into **natural classes**
 - ❖ Phonological rules can apply to all members of a natural class
 - ❖ Consonants: **place**, **manner**, **voicing**
 - ❖ Vowels: height, backness, roundness

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CONSONANTS (PULMONIC)												
	Bilabial	Labiodental	Dental	Alveolar	Postalveolar	Retroflex	Palatal	Velar	Uvular	Pharyngeal	Glottal	
Plosive	p b			t d		t̪ d̪	c ɟ	k ɣ	q ɣ̪		?	
Nasal	m	m̪		n		n̪	ɲ	ŋ	N			
Trill	B			r						R		
Tap or Flap		v		f		t̪		x	v̪	χ	h̪	
Fricative	ɸ β	f v	θ ð	s z	ʃ ʒ	ʂ ʐ	ç ɟ	x ɣ	v̪ ɣ̪	χ ɣ̪̪	h̪ ɦ̪	
Lateral fricative				ɬ ɭ								
Approximant		v		ɹ		ɻ	j	w				
Lateral approximant				l		ɿ	ɻ̪	ɿ̪				

natural class

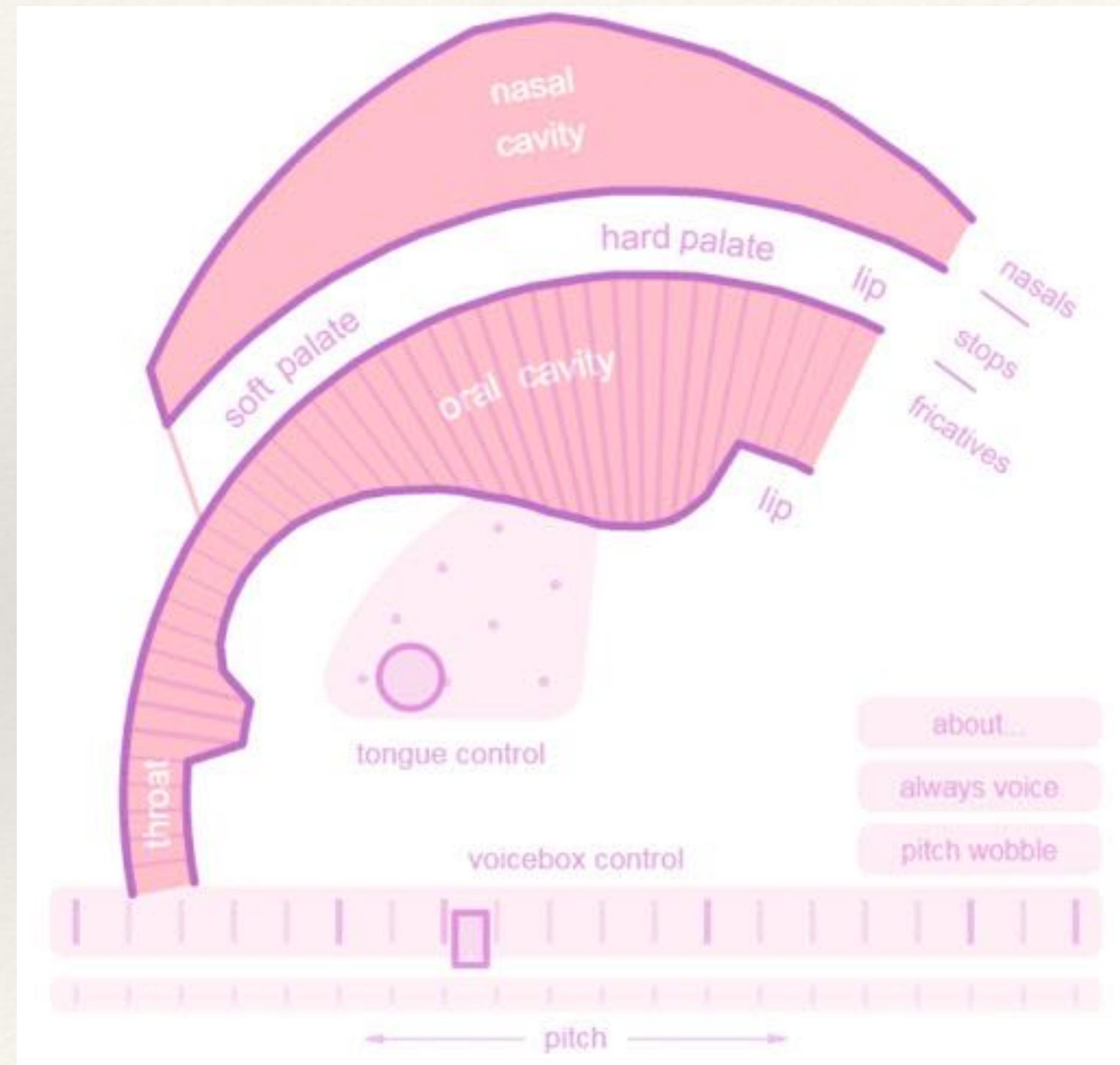
natural class

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

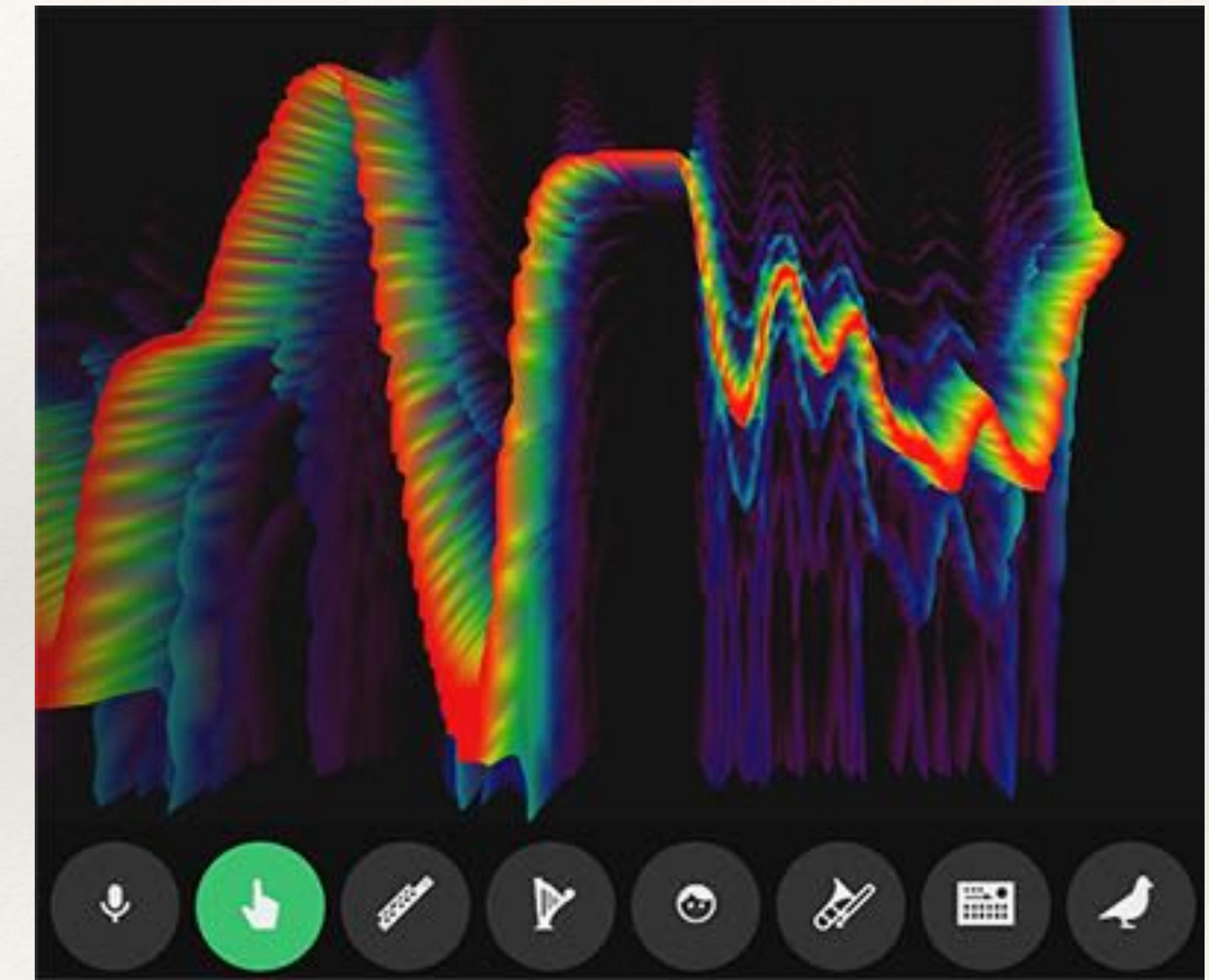
natural
class

natural class

Visualizing place and manner



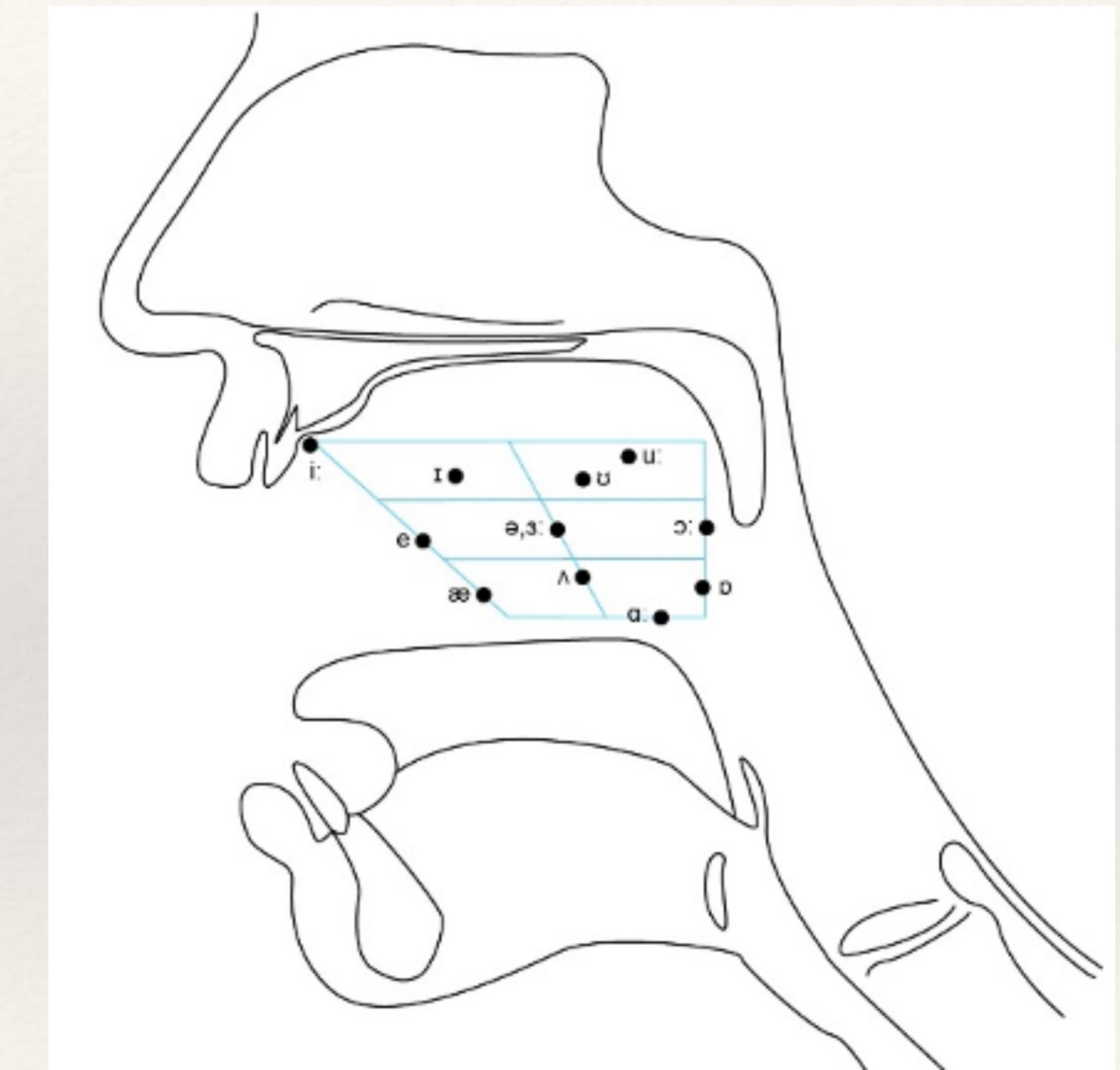
Pink Trombone



Chrome Music Labs Spectrogram



Visualizing (tasting?) vowel height and backness





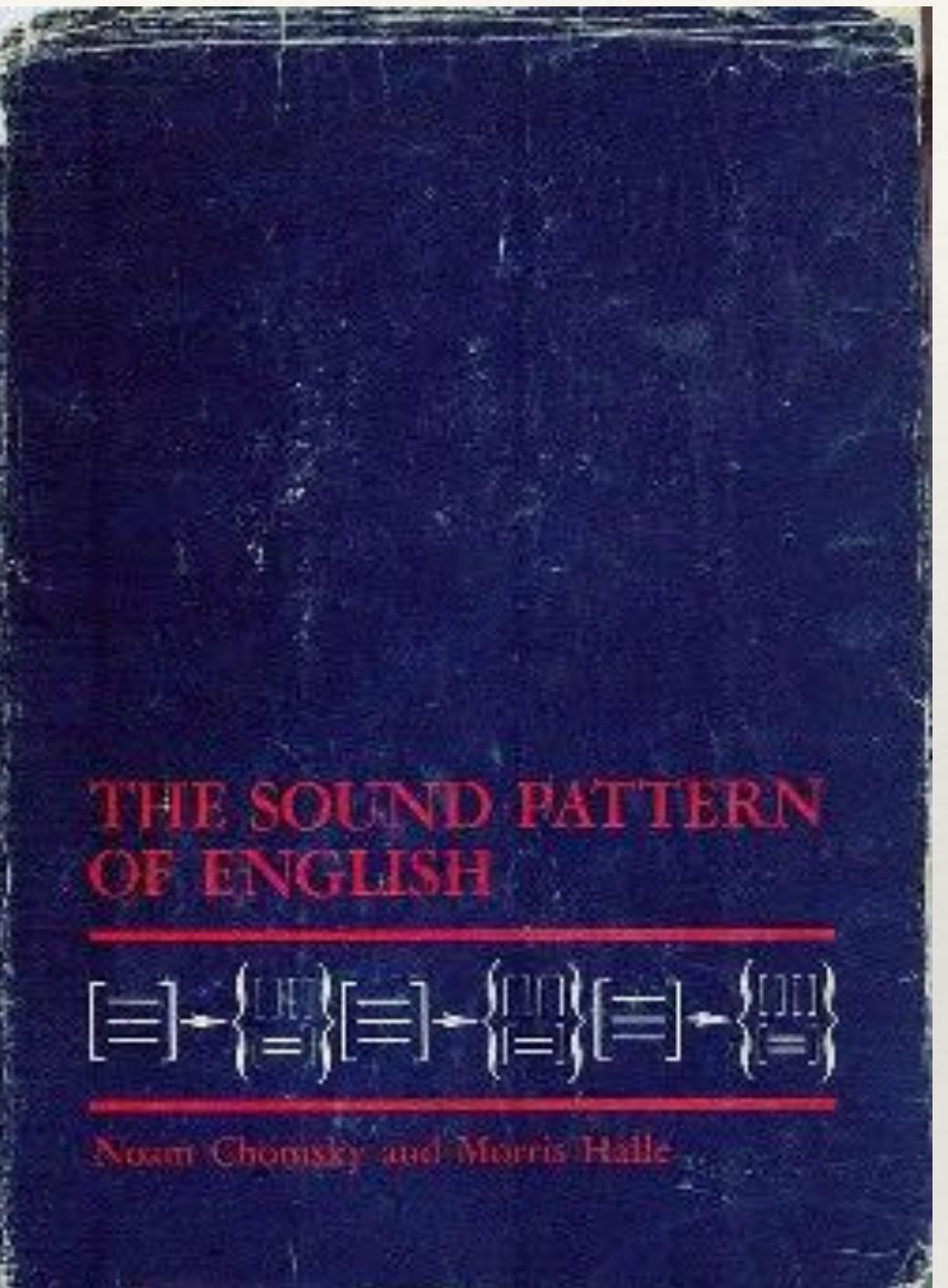
- ❖ Sometimes phonological rules apply to certain classes (place/manner/height, etc...)
- ❖ **Phonological feature theory** is a way to describe phonemes that makes generalizing rules across these **natural classes** easier
- ❖ A phoneme can be described using a **feature matrix** complementary to its IPA symbol
 - ❖ Binarized (presence/absence of features marked with +/-)

Orthog.	/ɹ/	/æ/	/m/
IPA	-syllabic +sonorant -stop +approx. -nasal +alveolar -labial +voice	+syllabic +sonorant +low -back +front -round +voice	-syllabic -sonorant +stop -approx. +nasal -alveolar
Ex. Feature Matrix			



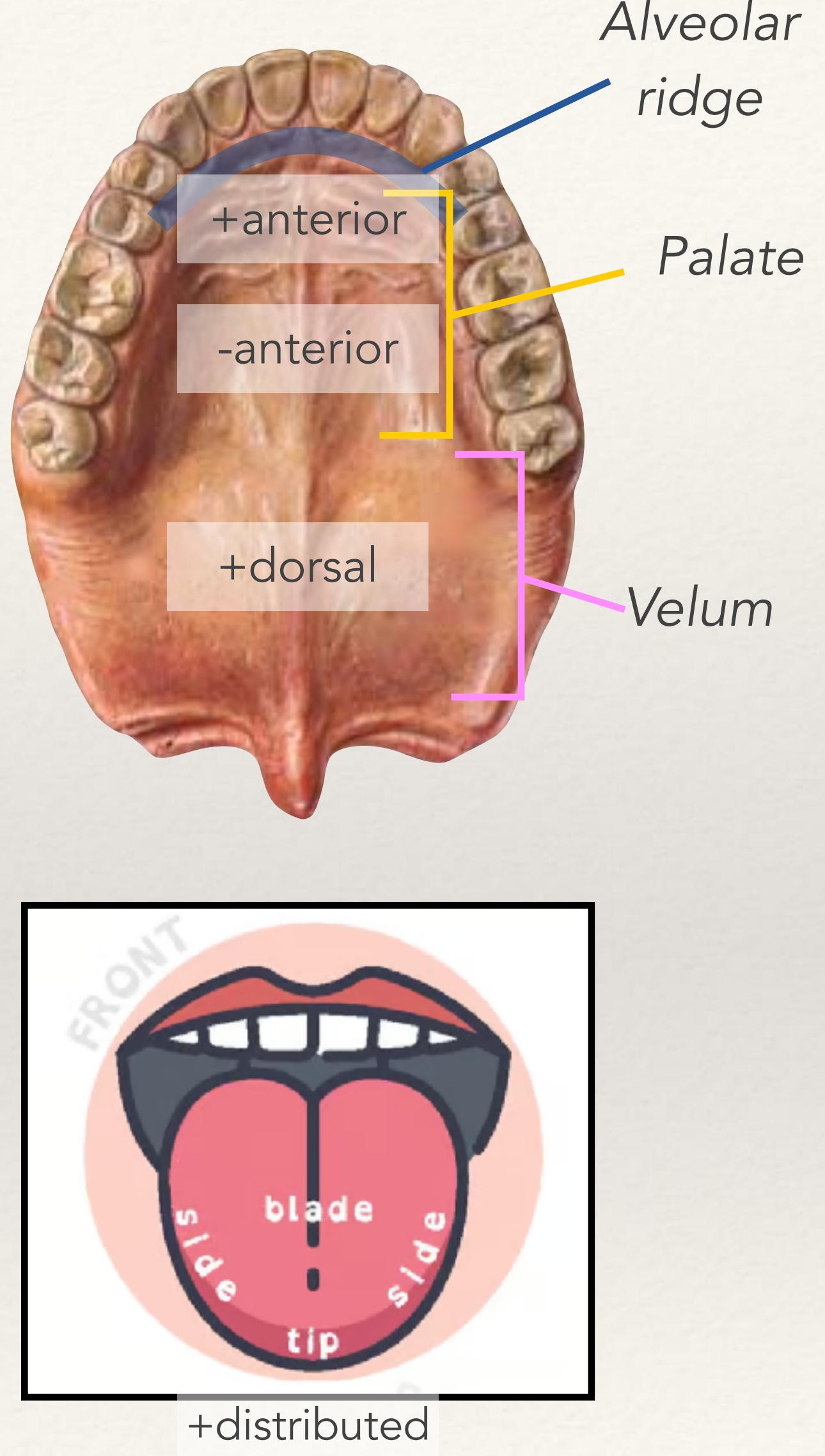
Feature	Description	Ex. Phonemes	This feature distinguishes:
(P) labial	articulated with the lips	b, p, m, f	+: labial, labiodental -: other places
(P) labiodental	articulated with lower lip & upper teeth	f, v	+: labiodentals -: other places
(P) coronal	articulated with the tongue blade/tip	t, ʒ	<i>this gets its own slide</i>
(P) lateral	articulated with the medial tongue; air proceeds around sides	l	+: laterals -: everything else
(P) dorsal	articulated with the tongue body	k, ɳ	<i>this gets its own slide</i>
(M) continuant	whether or not there is complete oral closure of the vocal tract	ʃ, a, ɹ	+: fricatives -: stops & nasals
(M) delayed release	for [-continuant] sounds, when the constriction is released	tʃ, dʒ	+: affricates & fricatives -: stops
(M) trill	a consonant produced by vibrating an	r	+: trills
(M) tap	a consonant produced by a single constriction of an articulator without a pressure buildup	r	+: taps -: other manners
(M) sonorant	loudness (sort of)	m, ɹ, l	<i>this gets its own slide</i>

(P) is a place of articulation feature; (M) is a manner of articulation feature





- ❖ Coronals (tongue blade/tip) can be distinguished using [anterior, distributed, strident, lateral]:
 - ❖ [anterior]: articulated at the alveolar ridge or further forward (dental)
 - ❖ [distributed]: articulated with the blade (+) or tip (-) of tongue
- ❖ Dorsals (tongue body) can be distinguished using the vowel height/backness features. This works because the tongue body is the primary articulator for vowels!
 - ❖ Velars: [+high, -low, -front, -back]
 - ❖ Uvulars: [-high, -low, -front, +back]
 - ❖ Pharyngeals: [-high, +low, -front, +back]





- ❖ Sonority is loosely based on the loudness of a sound/degree of obstruction
- ❖ Manners of articulation are hierarchically organized according to their sonority
 - ❖ Sonority governs phonotactics - often decides how sounds are sequenced within a syllable
 - ❖ Cross-linguistically, sonority decreases towards the edge of a syllable
- ❖ Sonority is represented with four (!!?) features

← greater sonority →

Vowels	Glides	Liquids	Nasals	Obstruents
[+syllabic]				[-syllabic]
	[-consonantal]			[+consonantal]
		[+approximant]		[-approximant]
			[+sonorant]	[-sonorant]

Sonority is represented by the features {syllabic, consonantal, approximant, sonorant}. These four features distinguish the primary manners of articulation in the world's languages



- ❖ Vowel systems range pretty wildly in their contrasts so the exact feature space is a little variable based on context
 - ❖ English has a 5-way height split and a 3-way backness split
- ❖ **Tense** vowels are produced with greater muscular effort than their **lax** counterparts
 - ❖ Tense: less centralized, longer, narrower mouth
 - ❖ Lax: more central, shorter, wider mouth
- ❖ **Round** feature for lip rounding (No way!!!)

	[+front, -back]		[-front, -back]		[-front, +back]	
	-round	+round	-round	+round	-round	+round
[+high, -low, +tense]	i	y	ɪ	ʊ	w	u
[+high, -low, -tense]	ɪ	ʏ	-	-	-	ʊ
[-high, -low, +tense]	e	ø	ə	θ	ɤ	ɔ
[-high, -low, -tense]	ɛ	œ	ə	ɔ	ʌ	ɔ̄
[-high, +low]	æ	œ	a	-	ɑ	ɒ

Some phonologists use a [central] feature, but it's possible to just use [front] and [back] to convey centrality as in this chart (Hayes 2011).



"Translate" IPA to phonological features

Place (IPA chart columns)		Manner (IPA chart rows)	
IPA	Phn. Feat	IPA	Phn. Feat
Bilabial	[+labial -labiodental]	Plosive	[-continuant, -nasal, +delayed release]
Labiodental	[+labiodental]	Nasal	[-continuant, +nasal]
Dental	[+coronal, +anterior, +distributed]	Trill	[+trill]
Alveolar	[+coronal, +anterior, -distributed]	Tap/Flap	[+tap]
Postalveolar	[+coronal, -anterior, +distributed, -dorsal]	Fricative	[+continuant, -approximant, -lateral]
Retroflex	[+coronal, -anterior, -distributed]	Lateral fricative	[+continuant, -approximant, +lateral]
Palatal*	[+coronal, -anterior, +distributed, +dorsal]	Affricate	[-continuant, -nasal, +delayed release]
Velar	[+dorsal, +high, -low, -front, -back]	Approximant	[+approximant, -lateral, -trill]
Uvular	[+dorsal, -high, -low, -front, +back]	Lateral approximant	[+approximant, +lateral, -trill]
Pharyngeal	[+dorsal, +low, -front, +back]	* Hayes' feature chart does not distinguish palatal and post-alveolar for some reason, but other phonologists use [+dorsal] for this.	
Glottal	/ʔ/: [+constr gl]; /h, ɦ/: [+spread gl]		

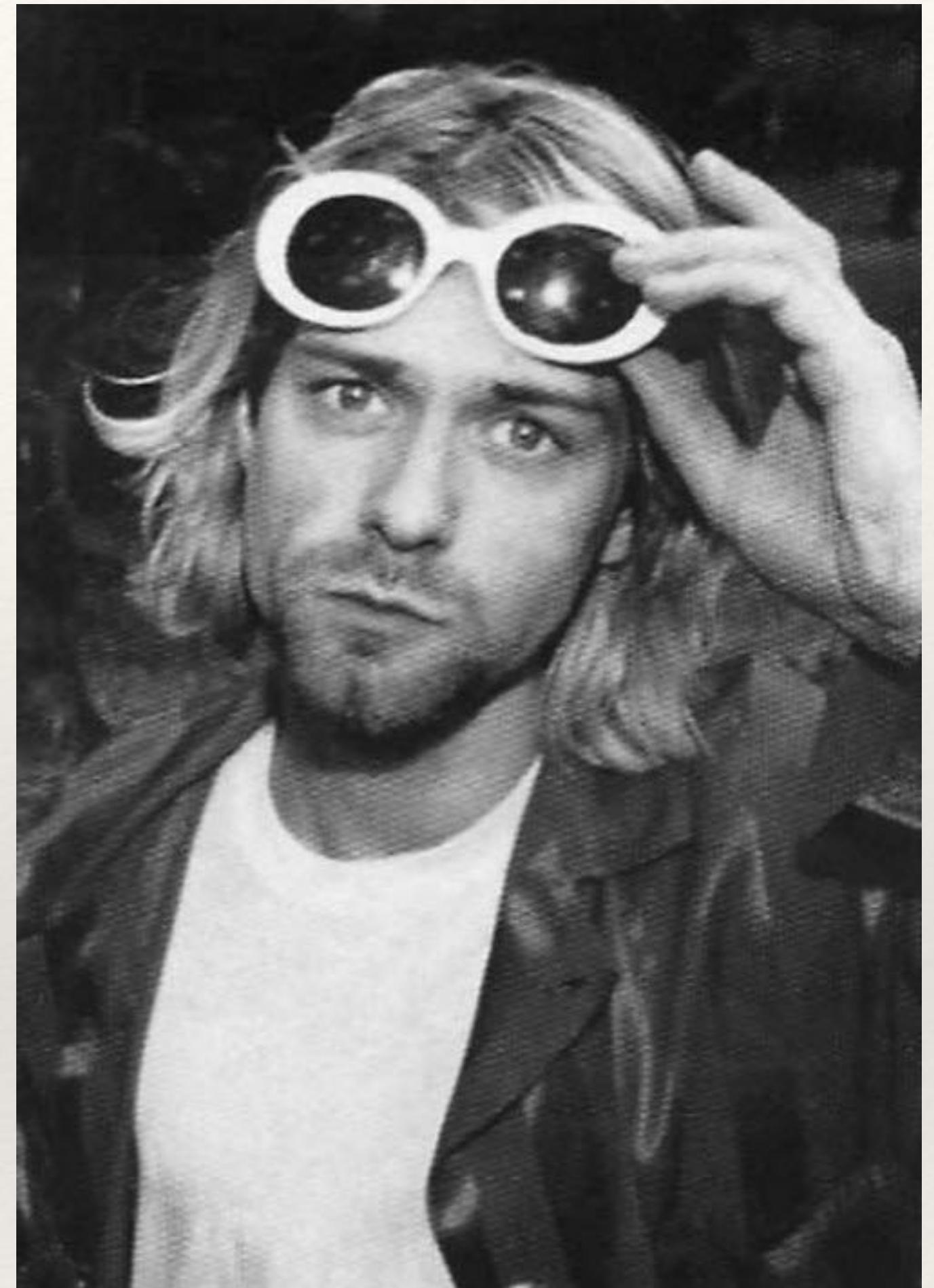


Description of Rule	Example	Formalization (Old)	Formalization (New)
A vowel in between two nasal consonants becomes nasal itself	/nænsi/ → [n̥ænsi]	/æ/ → [æ] / n_n	[+syllabic] → [+nasal] / $\begin{bmatrix} +\text{nasal} \\ -\text{continuant} \end{bmatrix}$ – $\begin{bmatrix} +\text{nasal} \\ -\text{continuant} \end{bmatrix}$
The plural -s becomes voiced if the phoneme before it is voiced	/dags/ → [dagz]	/s/ → [z] / g_#	/s/ → [z] / [+voice] _ #
The plural -s becomes voiced if the phoneme before it is a vowel	/kuɔs/ → [kuɔvz]	/s/ → [z] / ov_#	No rule necessary, covered by above rule!
Schwa epenthesis in between stridents	/maʊs-s/ → [maʊsəz]	/Ø/ → [ə] / $\left\{ \begin{array}{l} s \\ z \\ ʃ \\ ʒ \\ tʃ \\ dʒ \end{array} \right\} - \left\{ \begin{array}{l} s \\ z \\ ʃ \\ ʒ \\ tʃ \\ dʒ \end{array} \right\}$	/Ø/ → [ə] / [+strident] _ [+strident]

"Real World" Phonology



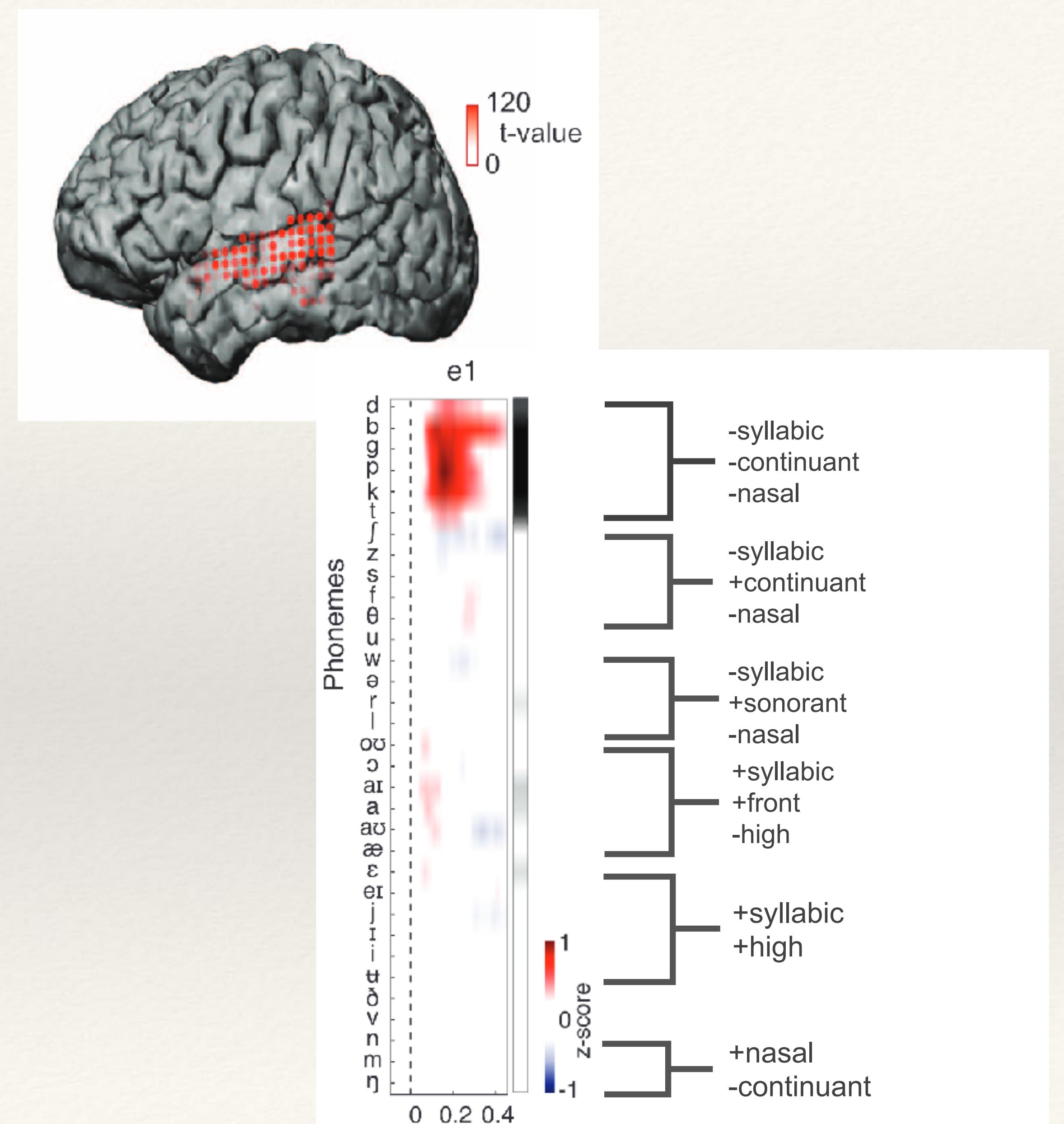
- ❖ A common pathology treated by speech-language pathologists is **speech sound disorders**, which are governed by rules too, just the wrong rules/contexts
 - ❖ Gliding: /ʃ/ → [*w]
 - ❖ Fronting: /s/ → [*θ]
 - ❖ Stopping: /s/ → [*t]
- ❖ SLPs usually target sounds in specific contexts during treatment, aiming to eventually generalize to less constrained contexts



How to target /ʃ/ in a θ _ [-continuant]# environment



- ❖ Auditory cortex activity measured by surgically implanted electrodes showed that different populations of neurons preferentially respond to different manners of articulation
(Mesgarani et al. 2014)
 - ❖ Distinct from nearby pitch areas
 - ❖ Phonological feats. may be key to how our brain organizes linguistic information during speech perception



Until next time!
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*Phonological feature
charts*



Pink Trombone



*Chrome Music Labs
spectrogram*

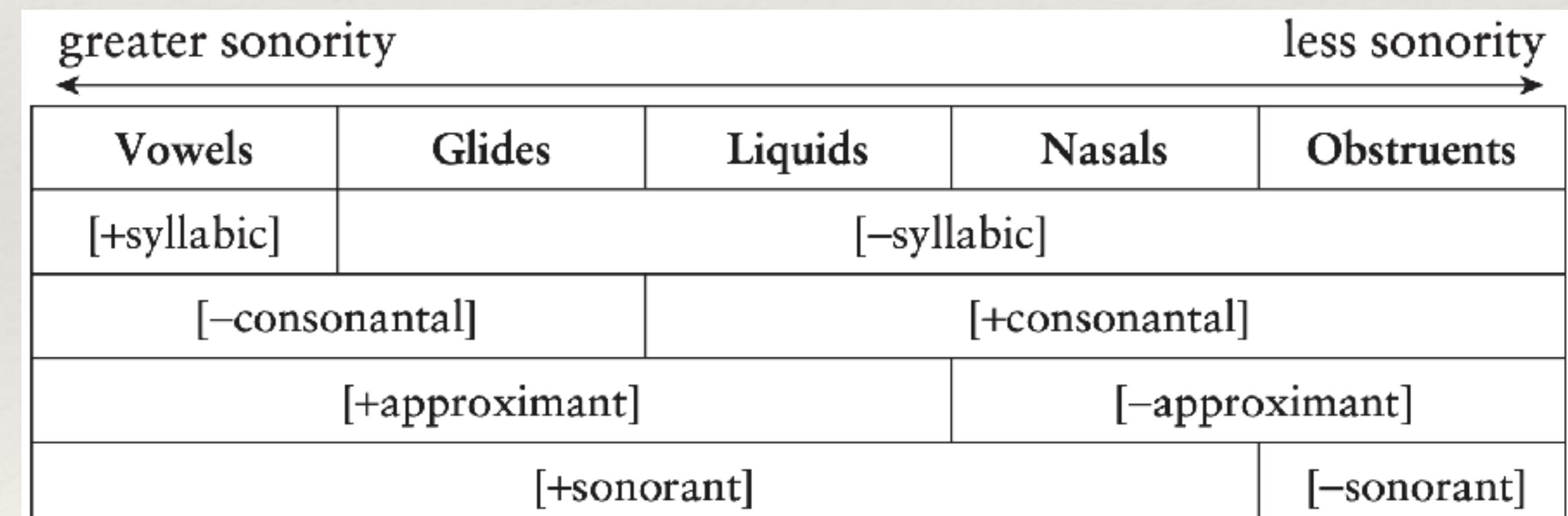
Additional Slides



- ❖ Fully explicit phonological description is often not necessary
 - Use only necessary features for your point
- ❖ Does nasal harmony need [+approximant] specified? (right)
- ❖ Feature description is most useful when documenting a change that affects a natural class

Description of Rule	Example	Formalization
A vowel in between two nasal consonants becomes nasal itself	/nænsi/ → [næ̃nsi]	/æ/ → [ã] / n_n

How should we specify the environment for this change?



If [+syllabic] is specified, is [+approximant] still informative?