LSci 51/Psych 56L: Acquisition of Language

Lecture 9

Phonological development II

Announcements

Be working on the review questions for phonological development

Be working on HW3 (due 11/2/20)

Cross-linguistic variation in speech production

Interactive chart of the International Phonetic Alphabet

http://www.ipachart.com/

Click on a symbol to hear the sound it represents.

Pulmonic consonants

	Bi-labial		Labio-dental		Dental		Alveolar		Post alveolar		Retroflex		Palatal		Velar		Uvular		Pharyngeal		Glottal	
Plosive	p	b					t	d			ʈ	ɖ	c	ɟ	k	g	q	ɢ			ʔ	
Nasal		m		ɱ				n				ɳ		ɲ		ŋ		ɴ				
Trill		ʙ						r										ʀ				
Tap or Flap								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						

Where symbols appear in pairs, the one to the right represents a voiced consonant.
Areas shaded grey indicate articulations judged impossible.

Other symbols

ʍ	Voiceless labial-velar fricative
w	Voiced labial-velar approximant
ɥ	Voiced labial-palatal approximant
ʜ	Voiceless epiglottal fricative
ʢ	Voiced epiglottal fricative
ʡ	Epiglottal plosive
ɕ	Voiceless alveolo-palatal fricative
ʑ	Voiced alveolo-palatal fricative
ɺ	Alveolar lateral flap
ɧ	Simultaneous ʃ and x

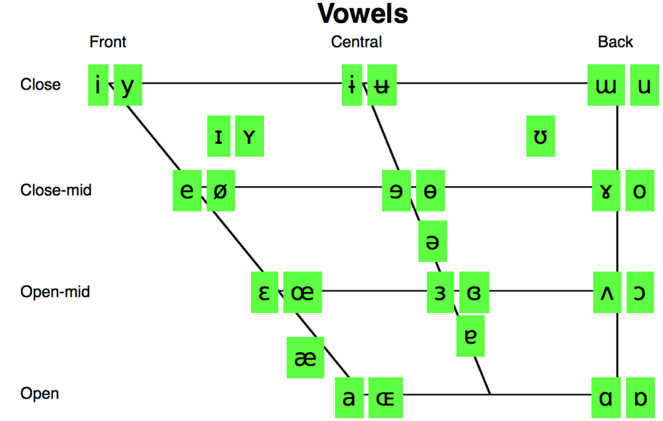
Affricates

t͡s	Voiceless alveolar affricate
t͡ʃ	Voiceless palato-alveolar affricate
t͡ɕ	Voiceless alveolo-palatal affricate
t͡ʂ	Voiceless retroflex affricate
d͡z	Voiced alveolar affricate
d͡ʒ	Voiced post-alveolar affricate
d͡ʑ	Voiced alveolo-palatal affricate
d͡ʐ	Voiceless retroflex affricate

Non-pulmonic consonants

Clicks		Voiced implosives		Ejectives	
ʘ	Bilabial	ɓ	Bilabial	pʼ	Bilabial
ǀ	Dental	ɗ	Dental/alveolar	tʼ	Dental/alveolar
ǃ	(Post)alveoalar	ʄ	Palatal	kʼ	Velar
ǂ	Palatoalveolar	ɠ	Velar	sʼ	Alveolar fricative
ǁ	Alveolar lateral	ʛ	Uvular	ʼ	*etc...*

Vowels



Where symbols appear in pairs, the one to the right represents a rounded vowel.

Describing speech sounds: Recap

Where is the air-flow blocked? (**place** of articulation)
labial, alveolar, palatal, velar etc.

Where/how is the air flowing? (**manner** of articulation)
nasal/oral, *stop*, *fricative, liquid, tap/flap* etc.

What are the vocal folds doing? (**voicing**)
voiced vs. *voiceless*

Features

Prediction: by combining a small number of atomic features, it should be possible to create a larger number of speech sounds

Goal: a set of universal features should make it possible to describe the speech sounds of all of the languages of the world

Different languages choose different feature combinations

	(bi)labial	labio-dental	inter-dental	al-veolar	post-alveolar	palatal	velar	glottal
(oral) stop	p b			t d			k g	
nasal (stop)	m			ŋ			ŋ	
fricative		f v	θ ð	s z	ʃ ʒ			h
affricate						tʃ dʒ		
liquid				l ɹ				
glide					j		w	
flap				ɾ				

	(bi)labial	labio-dental	inter-dental	al-veolar	post-alveolar	palatal	velar	glottal
(oral) stop	p b			t d			k g	
nasal (stop)	m			n		?	ŋ	
fricative	?	f v	θ ð	s z	ʃ ʒ		?	h
affricate						tʃ dʒ		
liquid				l ɹ		?		
glide					j		w	
flap				ɾ				

	(bi)labial	labio-dental	inter-dental	al-veolar	post-alveolar	palatal	velar	glottal
(oral) stop	p b			t d			k g	
nasal (stop)	m			ŋ		?	ŋ	
fricative	ɸ β	f v	θ ð	s z	ʃ ʒ		?	h
affricate						tʃ dʒ		
liquid				ɹ		?		
glide					j		w	
flap				ɾ				

"Fuji" "Cuba"

	(bi)labial	labio-dental	inter-dental	al-veolar	post-alveolar	palatal	velar	glottal
(oral) stop	p b			t d			k g	
nasal (stop)	m			n		ɳ	ŋ	
fricative	ɸ β	f v	θ ð	s z	ʃ ʒ		?	h
affricate								
liquid				l ɹ		?		
glide					j		w	
flap				ɾ				

“año”

	(bi)labial	labio-dental	inter-dental	al-veolar	post-alveolar	palatal	velar	glottal
(oral) stop	p b			t d			k g	
nasal (stop)	m			n		ɳ	ŋ	
fricative	ɸ β	f v	θ ð	s z	ʃ ʒ		x ɣ	h
affricate								
liquid				l ɹ				
glide					j		w	
flap				ɾ				

“Bach”
“agua”

?

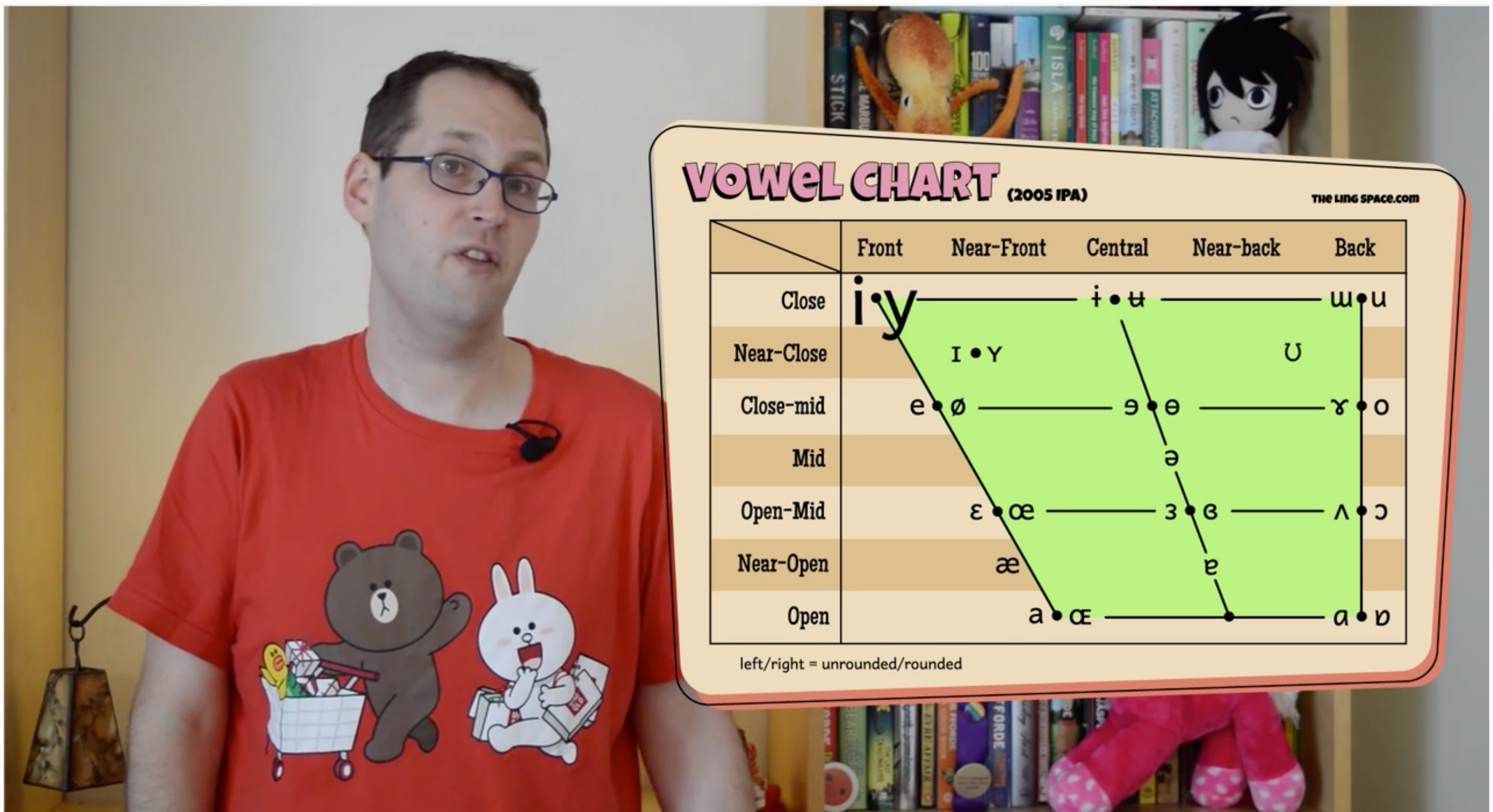
	(bi)labial	labio-dental	inter-dental	al-veolar	post-alveolar	palatal	velar	glottal
(oral) stop	p b			t d			k g	
nasal (stop)	m			n		ɳ	ŋ	
fricative	ɸ β	f v	θ ð	s z	ʃ ʒ		x ɣ	h
affricate						tʃ dʒ		
liquid				[illegible]		ʎ		
glide					j		w	
flap				ɾ				

"caballo"

	(bi)labial	labio-dental	inter-dental	al-veolar	post-alveolar	palatal	velar	glottal
(oral) stop	p b			t d			k g	
nasal (stop)	m			n		ɳ	ŋ	
fricative	ɸ β	f v	θ ð	s z	ʃ ʒ		x ɣ	h
affricate						tʃ dʒ		
liquid				l ɹ		ʎ		
glide					j		w	
flap				ɾ				

Cross-language differences

https://www.youtube.com/watch?v=arMntA15A0s
http://www.thelingspace.com/episode-27
4:10 through 5:08



[Extra]

Cross-language differences

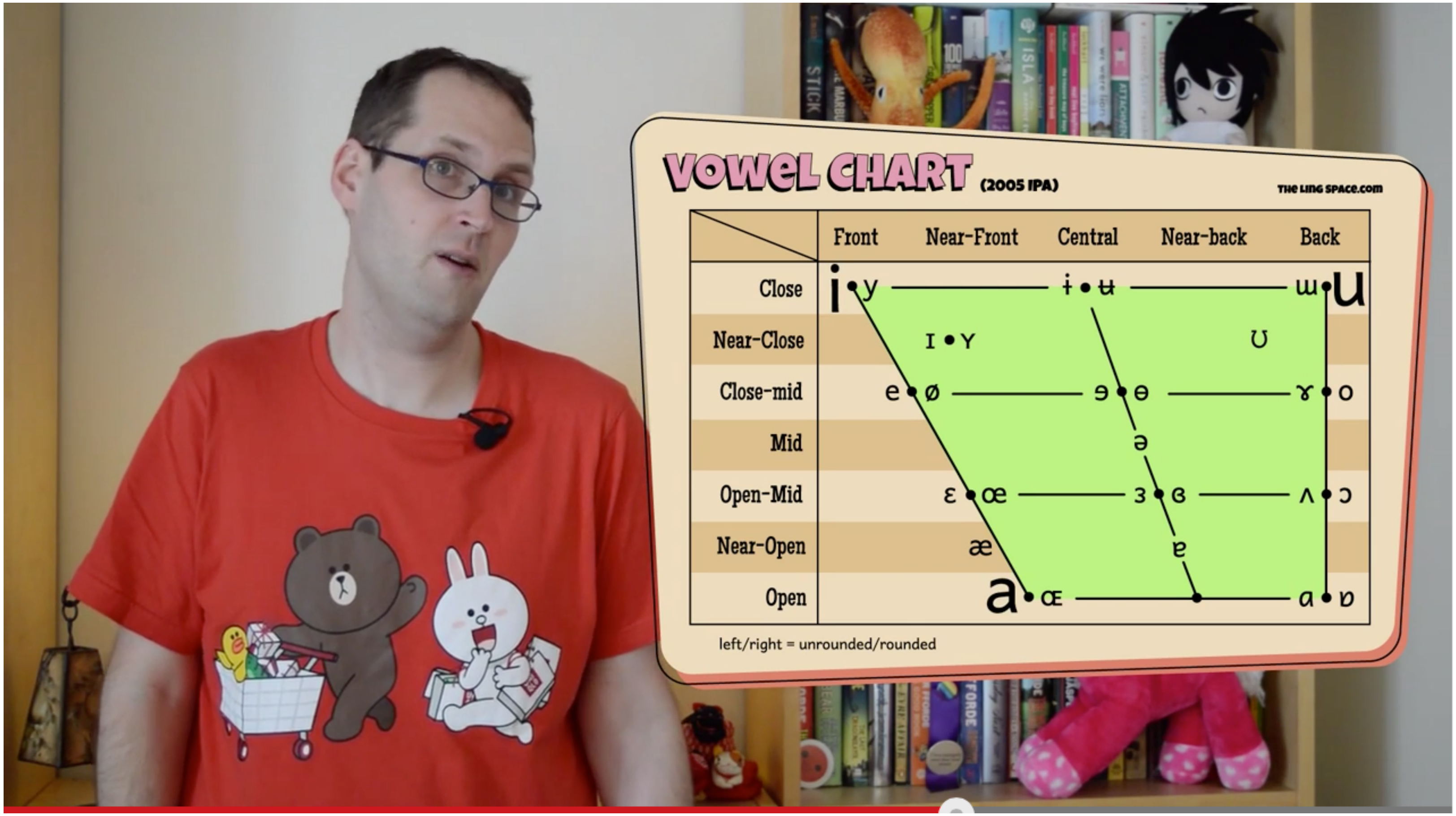
Feature Combinations

- English: back vowels are rounded, others are not
- German/French has high, front, rounded vowel [y]
- Russian has high back unrounded vowel [ɯ]

- Many languages don't make the tense/lax distinction found in English (ex: Spanish [i], rather than [i] and [ɪ])
- Many languages distinguish short and long vowels (unlike English), ex: Japanese [i] vs. [iː]

Cross-language differences

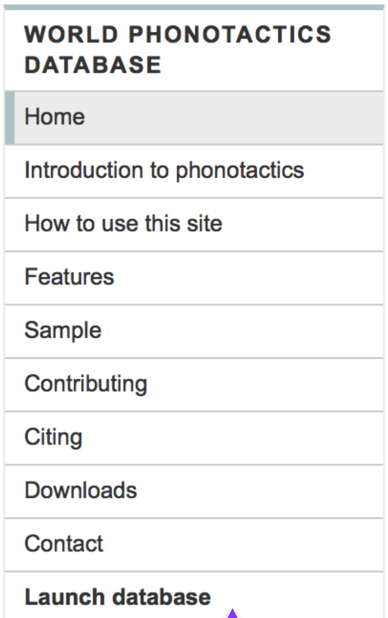
https://www.youtube.com/watch?v=arMntA15A0s
http://www.thelingspace.com/episode-27
5:08 through 7:02

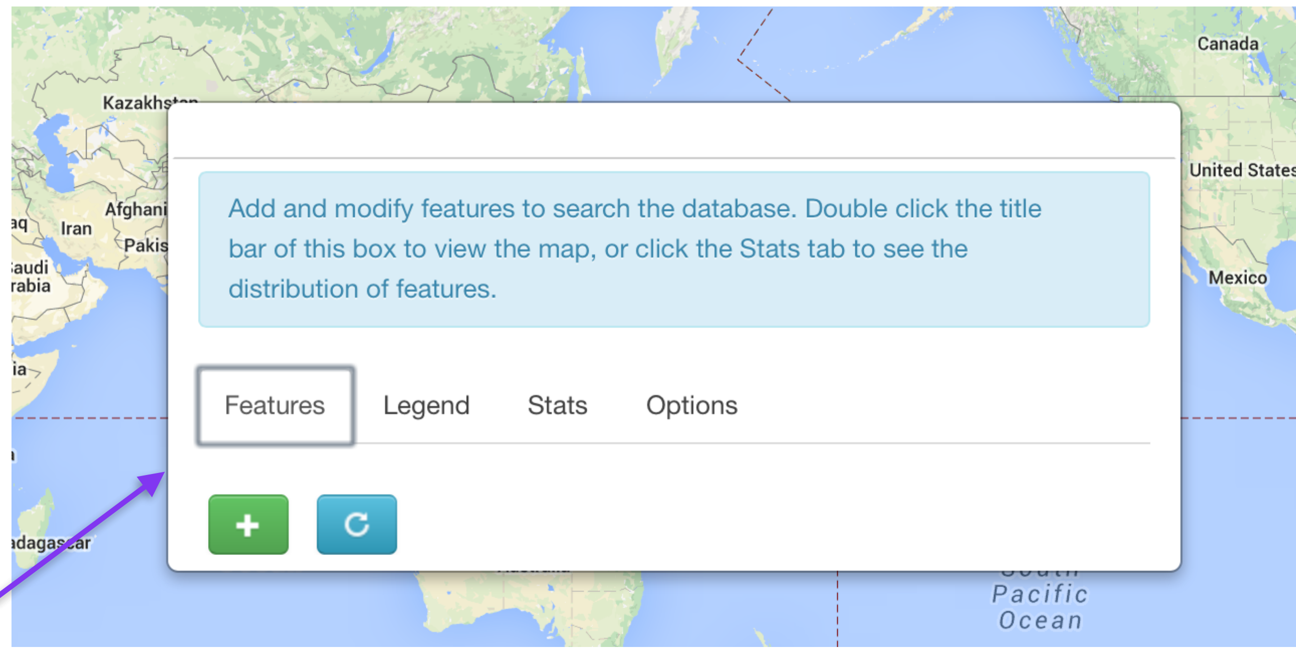


Cross-linguistic variation in sounds (called segments)

http://phonotactics.anu.edu.au/index.php

[In-class demo if the site is working]



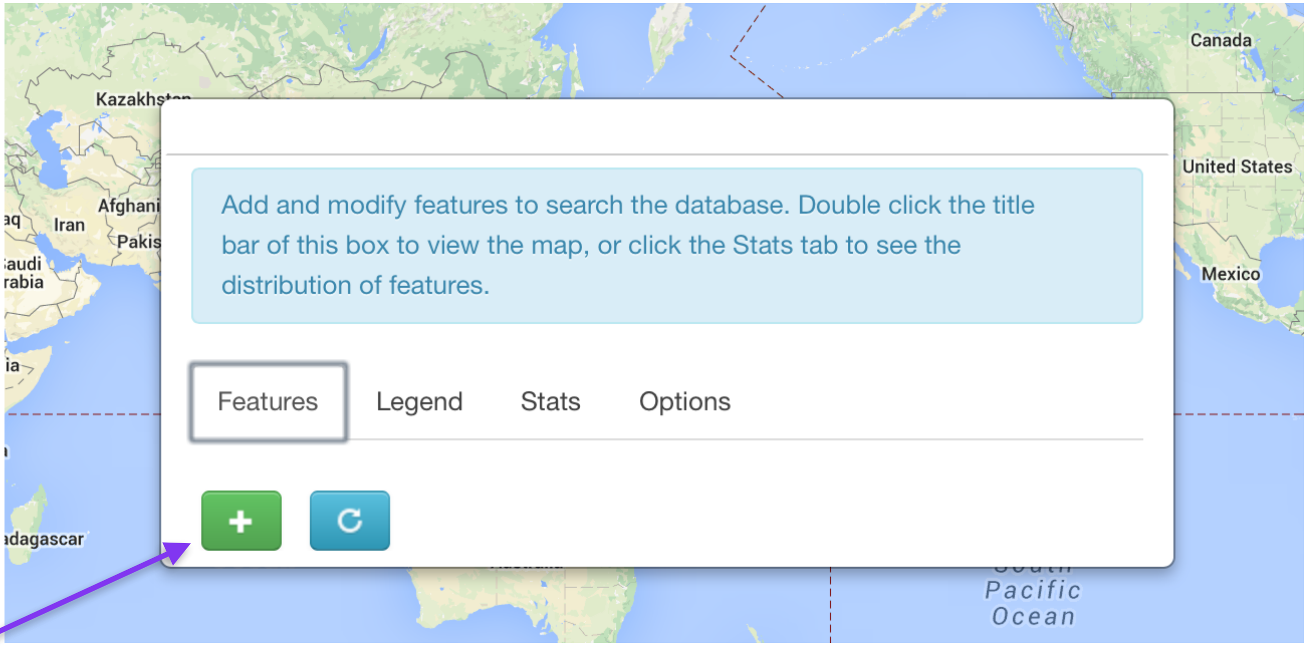


Click on this to get this

Cross-linguistic variation in sounds (called segments)

http://phonotactics.anu.edu.au/index.php

[Extra]

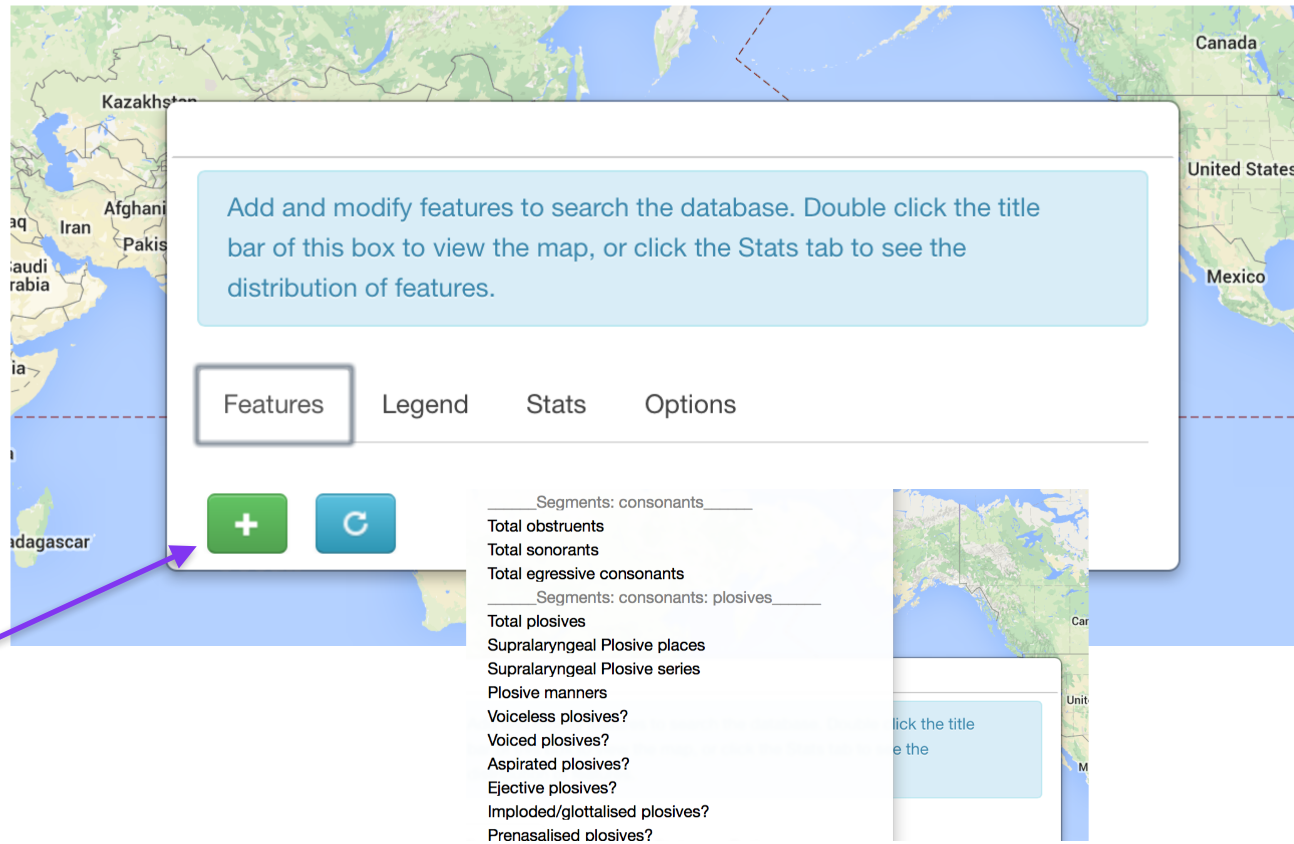


Then look through the features

Cross-linguistic variation in sounds (called segments)

http://phonotactics.anu.edu.au/index.php

[Extra]

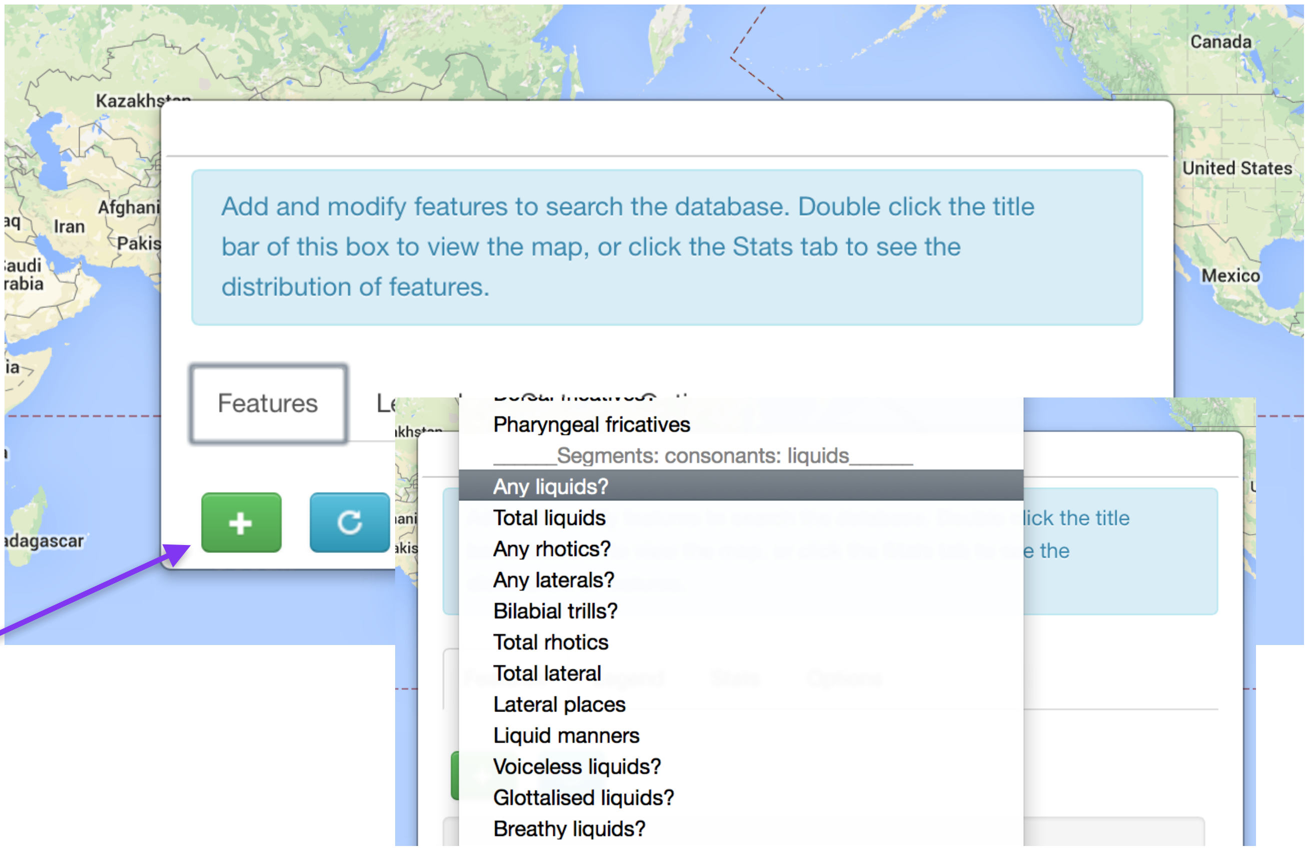


Then look through the features till you find segments

Cross-linguistic variation in sounds (called segments)

http://phonotactics.anu.edu.au/index.php

[Extra]

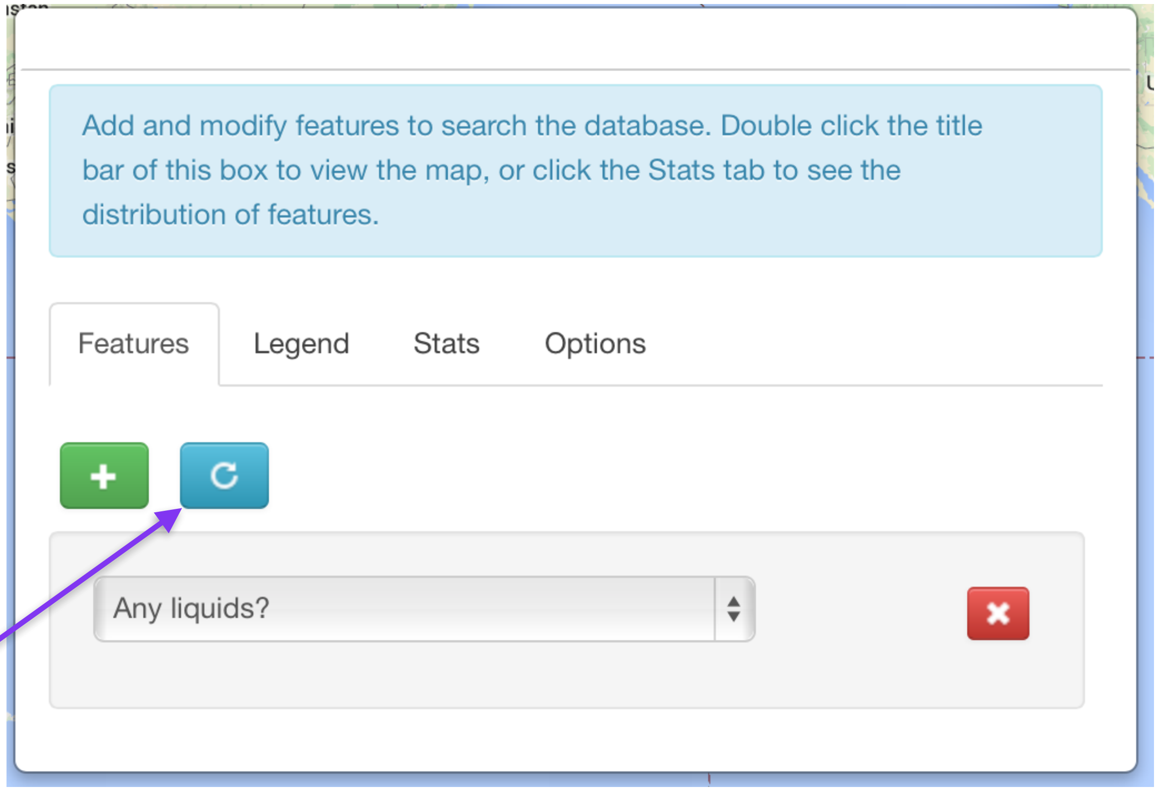


Select something of interest

Cross-linguistic variation in sounds (called segments)

http://phonotactics.anu.edu.au/index.php

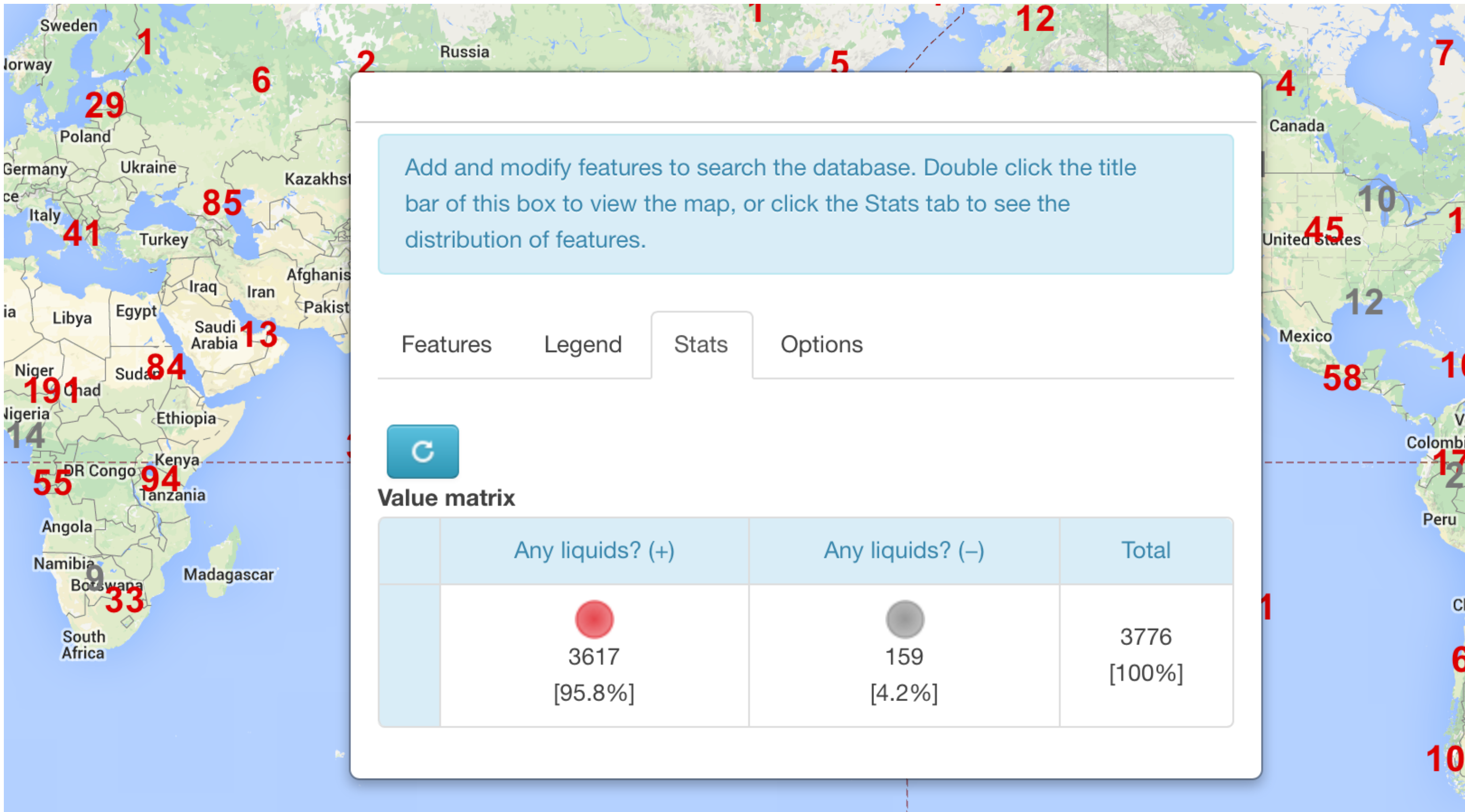
[Extra]



And see how the languages of the world look

Cross-linguistic variation in sounds (called segments)

[Extra] http://phonotactics.anu.edu.au/index.php

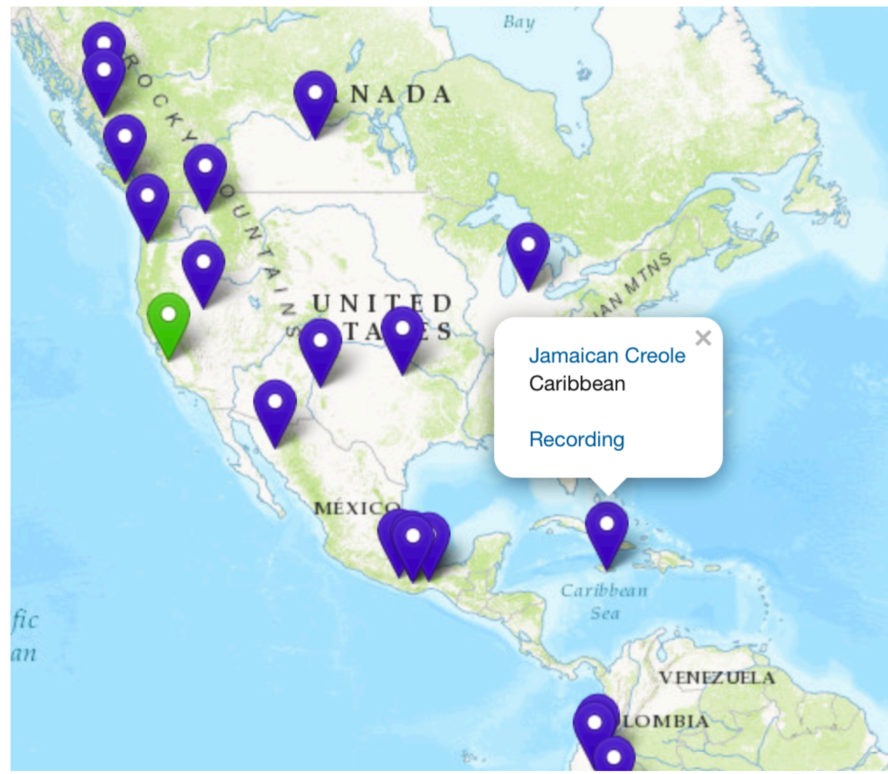


The world's languages are full of lots of fun variation when it comes to the sounds they use.

[Extra]

Pronunciations of different languages

https://richardbeare.github.io/marijatabain/ipa_illustrations_all.html



[Extra]

More details of American English pronunciation

http://en.wikipedia.org/wiki/General_American

Monophthongs	Front	Central		Back
		plain	rhotacized	
Close	i			u
Near-close	ɪ			ʊ
Close-mid	e[4]			o[4]
Mid		ə	ɚ	
Open-mid	ɛ		ɝ	ʌ • ɔ
Near Open	æ			ɑ

Depending on one's analysis, people who merge the vowels of *cot* and *caught* to /ɑ/ either h
/nɔɹθ/ and /hɔɹs/, but since all accents with *cot* and *caught* merged to /kɑt/ have also underg
in these cases, the [ɔ] before /ɹ/ can be analyzed as an allophone of /o/. [ɝ] and [ɚ] are ofte
unstressed syllables. Since the occurrence of [ə] is mostly predictable, it need not be consid

Among speakers who distinguish between /ɑ/ and /ɔ/, the vowel of *cot* (usually transcribed /ɑ
closer to [ɒ].[6] Among cot-caught merged speakers, /ɑ/ usually remains a back vowel, [ɑ], s
/ɔ/, their retracted allophones for /ɑ/ may be identical to the lowered allophones of /ɔ/ among

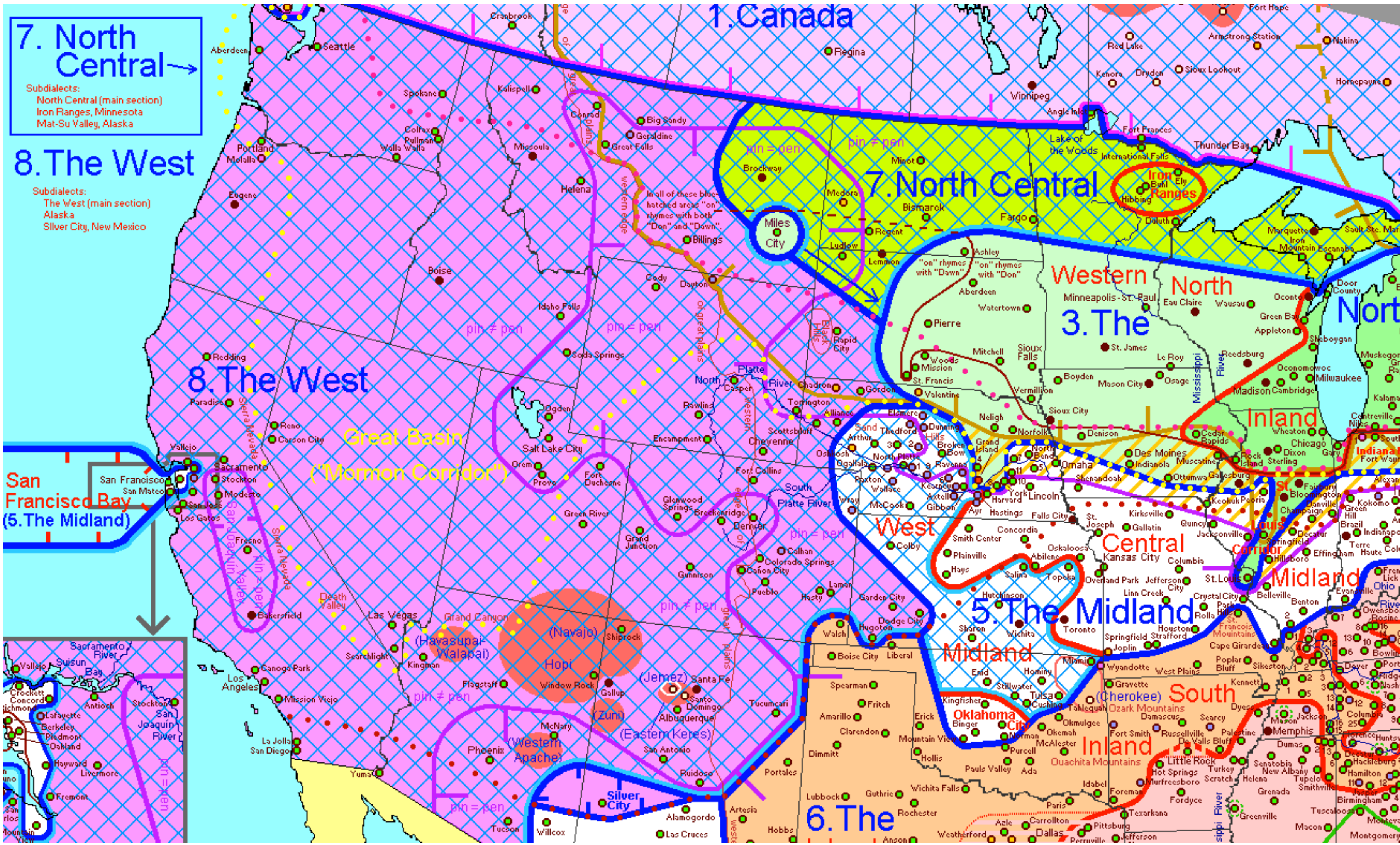
The diphthongs of General American are shown in the next table:

Diphthongs	Offglide is a front vowel	Offglide is a back vowel
Opener component is unrounded	aɪ eɪ[4]	aʊ
Opener component is rounded	ɔɪ	oʊ[4]

[Extra]

Dialect variation in North American English

http://aschmann.net/AmEng/



Prelinguistic “speech” production

Stages of prespeech vocal development

Newborns make biologically-related sounds: reflexive crying, burping, breathing, sucking

Helpful: infants' vocal cords vibrate & airflow through the vocal apparatus is stopped and started

Stages of prespeech vocal development

Around 6-8 weeks: infants start cooing (sounds that result from being happy).

First coos sound like one long vowel - but over many months, babies acquire a variety of different vowel sounds.

Stages of prespeech vocal development

Around 16-30 weeks: vocal play. Infants use a variety of different consonant-like and vowel-like sounds. At the end of this stage, infants form long combinations of the sounds (marginal babbling).

Recognizable vowel sounds heard at the beginning, while recognizable consonant sounds (usually velars like k/g) are usually heard around 2-3 months. Recognizable consonant sounds occurring near the front of the mouth (n/m/p/b/d) come in around 6 months of age.

Stages of prespeech vocal development

Around 6-9 months: canonical/reduplicated babbling, with actual syllables in the sounds produced (ex: [dadada]). These syllables are often repeated in a row.

Social aspect: babies don't give any indication that they're initially babbling to communicate (no intentionality at this point) even though sometimes it may look like it. They babble in the car and their crib, showing no sign that they expect any reply.

Note: even deaf infants babble, but they tend to produce marginal babbling instead of canonical babbling.

Stages of prespeech vocal development

After canonical babbling: nonreduplicated/variegated babbling, with non-repetitive syllables and more variety in consonant and vowel sounds. Infants also incorporate prosody (the rhythm of the language) into their babbling, which makes it sound much more like they're trying to talk. However, the "words" in this kind of babbling are usually only 1 or 2 syllables.

http://www.youtube.com/watch?v=_JmA2ClUvUY

Developmental links of babbling

nonreduplicated babbling

Farquharson, Hogan, Hoffman, Wang, Green, & Green 2018. Children with more complex babbling between 9 and 30 months do better at core skills needed for literacy at age 6.

https://www.sciencedaily.com/releases/2018/10/181010141736.htm

Stages of prespeech vocal development

0 weeks — reflexive crying, biological-based sounds

6-8 weeks — cooing

16 weeks — vocal play begins

36 weeks — reduplicated/canonical babbling

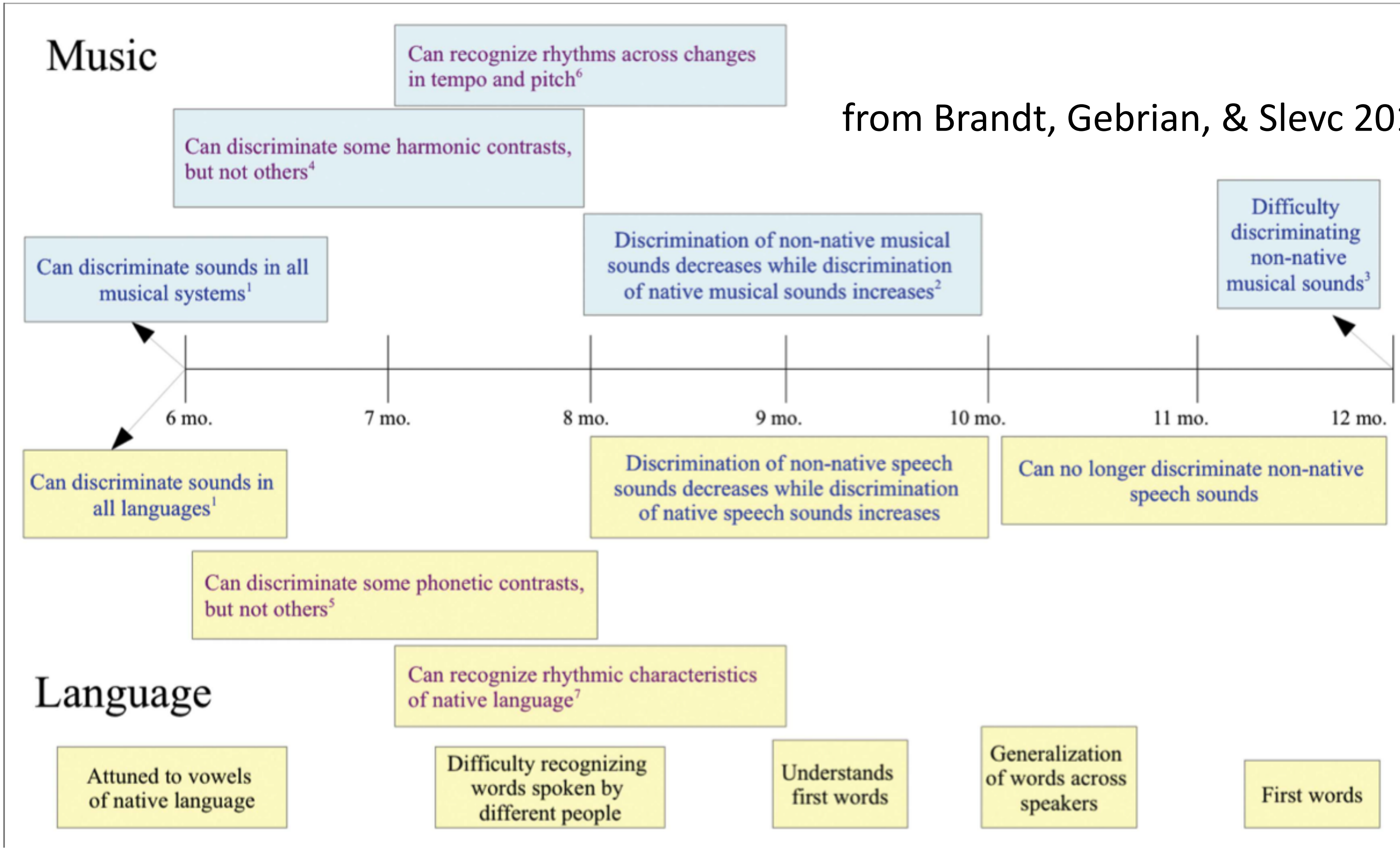
48 weeks — nonreduplicated babbling

First Word

Language- and culture-specific effects: Language and music

[Extra]

from Brandt, Gebrian, & Slevc 2012

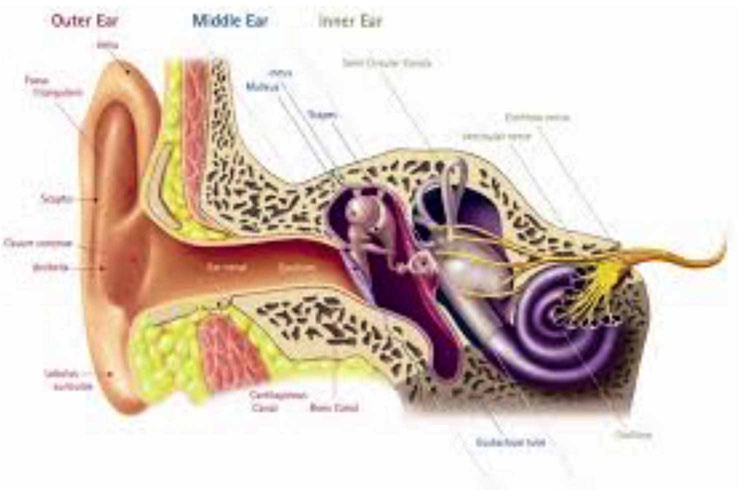


Language and music

Similarity in inner ear processing of speech sounds & music sounds + different from other auditory processing

On Warren, Ramamoorthy, Ciganovic, Zhang, Wilson, Petrie, Wang, Jacques, Reichenbach, Nuttall & Fridberger 2016:

"…the parts of the inner ear that process sounds such as speech and music seem to work differently than other parts of the inner ear. "



https://www.sciencedaily.com/releases/2016/07/160711092510.htm

Language and music

But there are neural specializations for language vs music

On Albouy, Benjamin, Morillon, & Zatorre 2020:

"…the two hemispheres respond to speech and music differently…we show that this hemispheric specialization is linked to basic acoustical features that are relevant for speech and music. "

https://www.sciencedaily.com/releases/2020/02/200227144317.htm

Language and music: Developmental linking

On Gordon et al. 2014:
"Though the grammatical and musical tests were quite different, Gordon found that children who did well on one kind tended to do well on the other, regardless of IQ, music experience and socioeconomic status…Perhaps children who are better at detecting variations in music timing are also better at detecting variations in speech and therefore have an advantage in learning language…"

http://www.sciencedaily.com/releases/2014/11/141105101238.htm

Language and music: From music to language

On Zhao & Kuhl 2016:
"Babies in the music group had stronger brain responses to the disruption in both music and speech rhythm in both the auditory and the prefrontal cortex, compared with babies in the control group. This suggests that participation in the play sessions with music improved the infants' ability to detect patterns in sounds."

https://www.sciencedaily.com/releases/2016/04/160425161148.htm

https://www.youtube.com/watch?v=whzxMNvHBD4&feature=youtu.be
Musical stimuli example: 0:09-0:26

Language and music:
From music to language

4- to 5-yr-old Mandarin-speaking children receiving piano lessons for 6 months vs. extra reading lessons for 6 months:

“Children who had piano lessons showed a significant advantage over children in the extra reading group in discriminating between words that differ by one consonant.”

https://www.sciencedaily.com/releases/2018/06/180625192827.htm

Language and music: From music to language

For hearing-impaired children with cochlear implants (Torppa & Huotilainen 2019):

"…musical activities [especially singing] develop children's perception of prosody, such as rhythm and pitch variation, and spoken language."

https://www.sciencedaily.com/releases/2019/06/190627114029.htm

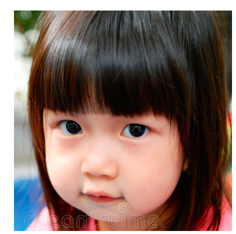
Language and music:
Not from language to music

On Langus et al. 2016:
"Several clues, like the fact that many of the cortical auditory regions responsible for linguistic and musical processing are the same and the existence of auditory illusions dependent on the mother tongue or dialect, have led investigators to hypothesize that native listening transfers also to non-linguistic sound stimuli such as music. [However,] Alan Langus…and other colleagues demonstrat[ed] that there is no transfer to the non-linguistic domain."

https://www.sciencedaily.com/releases/2016/02/160224070645.htm

Language and music:
Yes from language to music

Creel, Weng, Fu, Heyman, & Lee 2018 — pitch perception in 3- to 5-yr-olds: "…we compared the pitch perception of Chinese children who spoke a tone language (i.e., Mandarin) with English-speaking American children. We found that Mandarin-speaking children were more advanced at pitch processing than English-speaking children but both groups performed similarly on a control music task (timbre discrimination). The findings support…that tone languages drive attention to pitch in nonlinguistic contexts, and suggest that language learning benefits aspects of music perception in early development."



Language-specific effects

"From the moment of birth, babies cry in the accent of their mother's native language…" – Annie Murphy Paul, 2011 *Ted Talk: What We Learn Before We're Born*

Is all babbling the same?

Besides the differences between the vocal babbling of deaf children and non-deaf children, babies' babbling is also influenced by the language they hear.

How do we know?

(1) Test competent native speakers.

Record the babbling of babies who are learning to speak different languages (ex: French, Arabic, Chinese, English). See if native speakers can identify which baby's babble is from their language (ex: asking French mothers to choose between Arabic babble and French babble as French.)

De Boysson-Bardies, Sagart, and Durand (1984): recordings of 8-month-old babblings can be recognized by language.

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Lee, Jhang, Chen, Reylea & Kimbrough Oller 2016: recordings of 8-month-olds, 10-month-olds, and 12-month-olds can be recognized by language (English vs. Chinese), though only when the babblings are word-like.

Is all babbling the same?

Besides the differences between the vocal babbling of deaf children and non-deaf children, babies' babbling is also influenced by the language they hear.

How do we know?

(2) See if babbling features accord with language features

Determine which vowels and consonants (and other features) appear in babbling, and how frequently they appear. Compare to target language's features.

Ex: Japanese & French words contain more nasal sounds than Swedish & English words; Japanese & French babbles contain more nasal sounds than Swedish & English babbles.

NASAL Vowels

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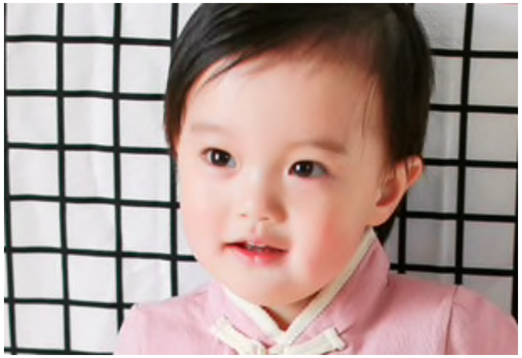
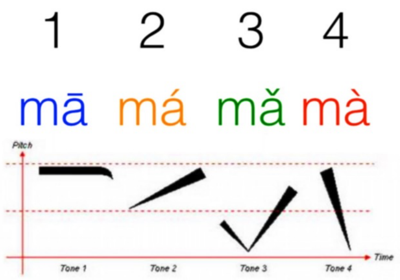


Determine which vowels and consonants (and other features) appear in babbling, and how frequently they appear. Compare to target language's features.

Ex: Mandarin Chinese uses tone-like pitches to distinguish meaning, and Mandarin babbles also use these tone-like pitches while English babbles do not (Meltzoff et al. 2009).



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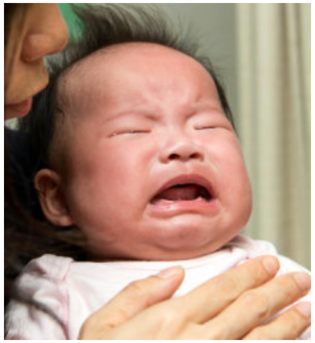
Even Mandarin Chinese newborn cries carry the tonal contours of Mandarin (Wermke, Teiser, Yovsi, Joscha Kohlenberg, Wermke, Robb, Keller, & Lamm 2016).



https://www.sciencedaily.com/releases/2016/08/160819084631.htm

Processes underlying speech sound development

Three main factors

- Physical growth & development of the vocal tract
- Development of brain & other neurological structures responsible for vocalization
- Experience

Processes underlying speech sound development

Physical growth & development of the vocal tract

A newborn's vocal tract is smaller & shaped differently from an adult's. (Ex: The tongue fills the entire mouth, limiting range of motion.)

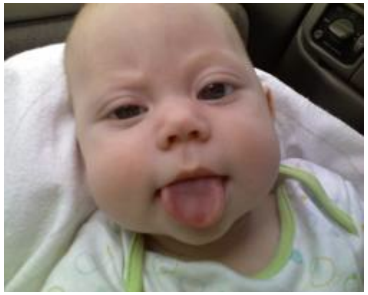
"A newborn has a vocal tract like a nonhuman mammal. The larynx comes up like a periscope and engages the nasal passage, forcing the infant to breathe through the nose and making it anatomically possible to drink and breathe at the same time." – Steven Pinker, *The Language Instinct*

Processes underlying speech sound development

Physical growth & development of the vocal tract

"By three months the larynx has descended deep into the throat, opening up the cavity behind the tongue (the pharynx) that allows the tongue to move forwards and backwards and produce the variety of vowel sounds used by adults."

– Steven Pinker, *The Language Instinct*



As the facial skeleton grows, the tongue gets more room. This happens during the vocal play stage, and the exploration of this new vocal freedom may be the cause of the vocal play itself.

Processes underlying speech sound development

Development of brain & other neurological structures responsible for vocalization

Later neurological developments in higher brain structures correlate with developments in vocalization.

Ex: Onset of cooing at 6-8 weeks coincides with development of limbic system (associated with expression of emotion in both humans and other animals).

Ex: Maturation of areas in the motor cortex may be required for the onset of canonical babbling.

Processes underlying speech sound development

Experience

Experience 1: Hearing the speech adults produce (this influences the sounds children choose to babble and the prosodic character of later babbling)

Choi, Cutler, & Boersma 2017:

Speech heard before six months impacts a child's ability to produce those sounds later, even if the child switches to a completely different language environment afterwards: "The subconscious knowledge can then be tapped to speed up learning of the pronunciation of sounds of the lost tongue."

https://www.sciencedaily.com/releases/2017/01/170118082828.htm

Processes underlying speech sound development

[Extra]

Experience

Experience 1: Hearing the speech adults produce (this influences the sounds children choose to babble and the prosodic character of later babbling)

From Curtin & Zamuner 2014 (Box 1):

The amount of time 12-month-olds spend listening to speech is related to vocabulary size at 18 months (Newman et al. 2006).

Processes underlying speech sound development

[Extra]

Experience

Experience 1: Hearing the speech adults produce (this influences the sounds children choose to babble and the prosodic character of later babbling)

https://www.sciencedaily.com/releases/2016/05/160523141552.htm

Value for learning words later on:

"…we show that experience is essential in guiding infants, with increasing precision, to single out which signals from the initially privileged set they will continue to link to meaning and which they will tune out." — Sandra Waxman

"…merely exposing 6-month-old infants to nonhuman primate vocalizations permits them to preserve, rather than sever, their early link between these signals and categorization."

Processes underlying speech sound development
[Extra]

Experience

Experience 1: Hearing the speech adults produce (this influences the sounds children choose to babble and the prosodic character of later babbling)

https://www.sciencedaily.com/releases/2016/10/161005105845.htm

https://www.sciencedaily.com/releases/2016/08/160810113842.htm

Value for learning words later on:

"…infants also pay attention to language cues in deciding where to place their attention… infants focused on the object that had first been presented by the native speaker for a longer period of time.…"

Marno, Guellai, Vidal, Franzoi, Nespor, & Mehler 2016

Processes underlying speech sound development

Experience

Experience 1: Hearing the speech adults produce (this influences the sounds children choose to babble and the prosodic character of later babbling)

Important: There appears to be a social component involved.

(1) Infants increase the complexity of their vocal output when their mother provides immediate social feedback (Goldstein, King, & West 2003).

Processes underlying speech sound development

Experience

Experience 1: Hearing the speech adults produce (this influences the sounds children choose to babble and the prosodic character of later babbling)

Important: There appears to be a social component involved.

(1) …and mothers respond more often when babbling is perceived as more mature.

"The increased rate of response meant more language-learning opportunities for the baby. The mothers' speech was also more likely to contain simplified, learnable information about linguistic structure and the objects around the baby. Thus, by varying the form and context of their vocalizations, infants influence maternal behavior and create social interactions that facilitate learning."

https://www.sciencedaily.com/releases/2018/01/180118142545.htm

Albert, Schwade, & Goldstein 2016

Processes underlying speech sound development

Experience

Experience 1: Hearing the speech adults produce (this influences the sounds children choose to babble and the prosodic character of later babbling)

Important: There appears to be a social component involved.

(1) …and mothers also modify their speech to be an even better language learning signal when responding to their infants' babbling.

"…adults unconsciously modify their speech to include fewer unique words, shorter sentences, and more one-word replies when they are responding to a baby's babbling, but not when they are simply speaking to a baby."

https://www.sciencedaily.com/releases/2019/08/190821125522.htm

Elmlinger, Schwade, & Goldstein 2019

Processes underlying speech sound development

Experience

Experience 1: Hearing the speech adults produce (this influences the sounds children choose to babble and the prosodic character of later babbling)

Important: There appears to be a social component involved.

(2) 8-month-old infants increase their consonant-vowel vocalizations (canonical & non-canonical babbling) when their mother responds to what she thinks they're saying. The babies also learn to direct more of their babbling to their mothers. (Gros-Louis, West, & King 2014).

http://www.sciencedaily.com/releases/2014/08/140827122632.htm

Processes underlying speech sound development

Experience

Experience 1: Hearing the speech adults produce (this influences the sounds children choose to babble and the prosodic character of later babbling)

Important: There appears to be a social component involved.

(3) Infants learn foreign sounds (ex: American infants learning Mandarin phonemes) only when the input comes from a live speaker interacting with them (and not from a television broadcast of that same speaker, for example). (Kuhl, Tsao, & Liu 2003)

Processes underlying speech sound development

[Extra]

Experience

Experience 1: Hearing the speech adults produce (this influences the sounds children choose to babble and the prosodic character of later babbling)

Important: There appears to be a social component involved.

(4) Adults also seem to pick up sounds more easily when they're engaged socially with the input source.

http://www.sciencedaily.com/releases/2013/09/130910121523.htm

(Stuart-Smith, Timmins, & Gunter 2013)

Processes underlying speech sound development

Experience

Experience 2: Hearing their own vocal output motivates infant vocalizations (also allows for calibration - matching what they produce to what they hear).

(Fagan 2014, 2015)

Links to early word forms:
Infants tend to use the sounds that they've babbled in their first words rather than the sounds that are most common in the speech that adults use with them.

Processes underlying speech sound development

Experience

Experience 2: Hearing their own vocal output motivates infant vocalizations (also allows for calibration - matching what they produce to what they hear).

(Fagan 2014, 2015)

Absence of auditory feedback may explain why deaf infants produce less elaborate vocal play than hearing infants, and reach the canonical babbling stage later.

Processes underlying speech sound development

Experience

Fagan (2014, 2015): Infants with profound hearing loss who received cochlear implants to help correct their hearing soon reached the vocalization levels of their hearing peers. Among other things, the infants with cochlear implants are able to reach the canonical babbling stage with reduplicated sounds (like "baba").

http://www.sciencedaily.com/releases/2014/09/140923182138.htm

https://www.sciencedaily.com/releases/2015/10/151022125740.htm

Recap: Speech sound development

Sounds can be represented as a collection of features reflecting place of articulation, manner of articulation, and voicing (among others). Different languages select different combinations of these features for the sounds used in the language.

Infants go through different stages of pre-speech production, which allow them to develop the motor skills to produce the speech sounds in their native language.

Physical growth, neural growth, and experience all impact children's early speech-like productions.

Questions?

You should be able to do up through question 4 on HW3, and up through question 12 on the phonological review questions.