

PHONOLOGY

THE DISTINCTIVE FEATURES OF SPEECH SOUNDS

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INTRODUCTION

Introduction

- Phonology is the study of sound patterns, where ‘sound’ refers to the auditory effect of articulations made by the vocal apparatus during speech, and ‘patterns’, to abstract structures that correlate to mind —they “attract our notice, they grab our attention, they seem in varying degrees to somehow *fit* human processes of cognition, to be sense making, to bear intelligibility” (Ratzsch 2001:3).
 - ‘Phonology’ is also used to refer to the sound system, or pronunciation, of particular languages, e.g., ‘the phonology of French’.
- Modern theorizing in phonology is largely driven by the following assumption:
 - “[T]he overt aspects of language—the articulatory actions and the acoustic signal they produce—cannot be properly understood without reference to the covert aspect of language, that is, to the implicit knowledge that enables individuals to speak and understand a language.” (Halle 2002:1)
- This view of phonology —as the study of an aspect of human cognition rather than the study of an external, physical or social reality— was pioneered by Edward Sapir, a brilliant figure in linguistics during the first half of the twentieth century.
 - As Chomsky (1965:193) describes, “Sapir’s mentalistic phonology ... used informant responses and comments as evidence bearing on the psychological reality of some abstract system of phonological elements.” (See esp. Sapir 1933a.)
- ‘Mentalistic phonology’ was first fastidiously formalized as a core discipline of generative linguistics by Morris Halle (Halle 1959; 1962) and Noam Chomsky (Chomsky & Halle 1965; Chomsky 1967; Chomsky & Halle 1968) who were hired at the Massachusetts Institute of Technology

“When we study human language, we are approaching what some might call the “human essence,” the distinctive qualities of mind that are, so far as we know, unique to man.”
(Chomsky 1968:88)

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apparently amid concerns that the Russian KGB were close to being able to use telepathy.¹

- “Phonology”, from the mentalist-generative perspective, “is concerned with the connections between the abstract underlying representations of words and morphemes in memory and their surface representations that serve as instructions to the articulators.” (Halle 2002:11)

- *Morphemes* are the smallest units of meaning in a language.
- While phonology has never been used for telepathy (by definition, it can't!),² to be sure it now has many other applications outside linguistics.
 - It is of great consequence to second language instructors and has received attention among educators because of its importance to reading.
 - It is important to pathologists who treat individuals with abnormal speech.
 - It has a place in the development of software for high-technology businesses (e.g., speech recognition, voice synthesis).
 - It is used by writers and poets.
 - It even has forensic applications.
 - A classic example is the Prinzivalli case: following a series of telephoned bomb threats made to the Los Angeles airport in 1984, Paul Prinzivalli, a cargo handler originally from New York, was arrested and spent ten months in LA County Jail, until he was acquitted on the basis of a linguist's

¹ An overview of the history of phonological theory in the twentieth century is available in a special issue of *Folia Linguistica* (Goldsmith & Laks 2000). See also Anderson (1985) and Kenstowicz (2006).

² “[I]f you look at sign language, it doesn't have a single channel. It has multiple channels, but articulated language does have a single channel. That is a limitation of our sensorimotor apparatus and it forces things to be ordered. If we had the ability to communicate by telepathy, let's say (so that we didn't have to make sounds), there might be no word ordering in language at all.” (Chomsky 2000)

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testimony at trial that the phonological structure of the recorded threats proved that the caller was from Boston, not New York.

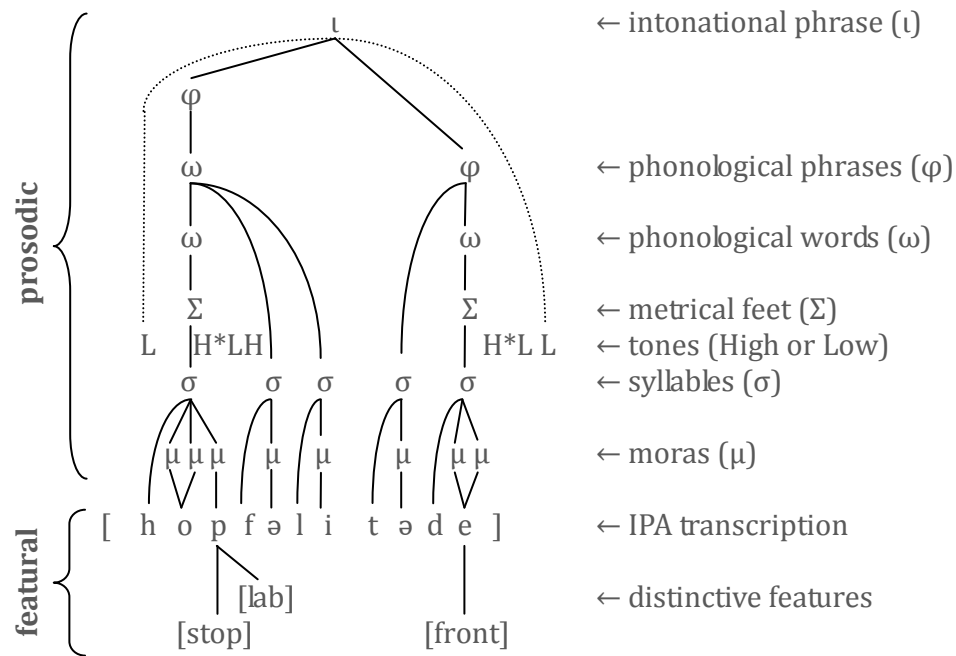
- Finally, and more indirectly, phonology can inspire new perspectives in other fields.
 - The generative study of language, including phonology, has influenced new approaches to several areas including religion (e.g., Boyer 1994; 2001) and evolution (e.g., Barbieri 2002).
 - For instance, the bioinformaticist Heikki Lehtväslaiho and his students apply phonological analysis to genomics.
- For linguists themselves, phonology has as its main goals:
 - first, to discover the universals concerning sound patterns in language, i.e., the common elements of all phonological systems, and
 - second, to place these elements in a theoretical framework that will not only describe the sound patterns that occur in the human mind, but also predict what sound patterns do not occur.
- The broader ambition is to advance cognitive science by specifying the mind's internal structure and operations.
 - That is, phonological theory postulates a certain number of primitives and suggests ways in which these primitives may be manipulated in grammars.
 - Together these primitives and their manipulation form a model which is imagined to correspond to concrete structures and mechanisms in the mind, which ultimately have a physiological basis.
 - However, to pretend that this correspondence is anything but very loose is false bravado.

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- As the subfield of linguistic science that deals with sound systems, phonological theory is itself sharply divided into two areas: featural and prosodic.
 - The first subfield focuses on “melody”:
 - Speech sounds, their internal composition and external interactions.
 - One of the greatest discoveries in linguistics is that speech sounds consist of distinctive features (Trubetzkoy 1939; Jakobson 1941), and it is through these that speech sounds interact with each other (Chomsky & Halle 1968).
 - What are the distinctive features, and how are they organized inside and between speech sounds? These questions are addressed in this course and text.
 - The other subfield focuses on aspects of the sound system “above” the level of speech sounds, such as timing, rhythm and intonation.
 - Research into the nature and patterning of these phenomena suggests that speech sounds are not just arranged linearly, but are hierarchically organized into prosodic structure:
 - speech sounds into moras (Sapir 1931; Trubetzkoy 1939 et seq.) and syllables (Pike 1967 et seq.),
 - syllables into stress feet (Selkirk 1980 et seq.),
 - stress feet into phonological words (ib.),
 - phonological words into phonological phrases (Nespor & Vogel 1982 et seq.),
 - and phonological phrases into intonational phrases (Pierrehumbert 1980 et seq.).

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- For example, the prosodic structure associated with the utterance 'hopefully today' might be represented as follows:



- With the exception of the syllable (see next section), prosody is largely ignored in this text and course.
- In defense of this, I cite McMahon (2003:110), who warns against thinking of “phonology as a single domain, and not as two rather separate and potentially incompatible ones, which happen both to involve systematic behaviour of sound. ... The distinction between the prosodic and melodic domains is already very familiar in terms of phonological practice. Although phonologists almost invariably pay lip-service to the unity of phonology, there is a tendency for each phonologist to be interested in one domain or the other. ... This is not only a characteristic of individual phonologists, but also of phonological theories.”
 - McMahon also believes that there are “good grounds for hypothesising a difference between prosody and melody in terms of the evolution of language” (p. 111), and

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concludes “that prosody and melody are essentially separate, with very different histories, and that we should not expect a theory which deals successfully with one, to extend to the other”.

Preliminaries

*Just like a noose, 'Be!' draws you from a distance
And thus brings non-existence to existence,
Although in form the noose may look like two
There's just one rope and one thing it will do!*

...

*That place to my soul, God, won't you disclose
Where speech without a word is born and grows,
So that the pure soul headlong then will race
To non-existence's vast open space!*

...

*Unity's not what senses can perceive—
If that's your goal, then this realm you must leave;
Though 'B' and 'e' formed it, 'Be!' was one act—
The meaning was still pure and kept intact.*

—Rumi (1207–1273), *The Masnavi, Book One*

- The above excerpt from a famous Persian poem (as translated by Mojaddedi 2004:189-90) alludes to the belief that existence owes its existence to speech, as in 'God said: 'Be light!'.³
- Of special interest is the poet's observation that the divine fiat is itself created.
 - The word unit 'be' consists of sub-units which convey the potent meaning ∃ ('exist') only if they are assembled.
 - On their own, 'b' and 'e' are virtually meaningless, and impotent.

³ Bereshit 1.3; cf. Genesis 1.3, Isaiah 55.11, John 1.1-14, Hebrews 11.3, Qur'an 2.117, 3.47, 6.73, 16.40, etc. This belief extends to non-Abrahamic religions, including Memphite (e.g. Hodge 1997:200), Indian (e.g. Dhavamony 2002:54ff.), East Asian (e.g. Izutsu 1983:197ff.), Mesoamerican and South American (e.g. Spence 2010[1913]:255, 305). This is presumably of interest to the cognitive science of religion, but it speaks to linguists in particular that humans have long, far and wide been mystified (pun intended) by the generative capacity of language.

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- This state of affairs turns out to be critical to understanding phonology —and the human capacity for language in general.
 - It is in fact a unique *design feature* of human language, known as “duality of patterning” (Hockett 1960), which affords unlimited vocabulary power to humans.
 - Every native speaker learns to distinguish meaningless but *discrete* segments of speech in his/her language, which he/she is able to combine *productively* into sequences which he/she is also able to pair *arbitrarily* with meanings.
- As Edward Sapir (1933b:156) remarked:
 - In all known languages, phonemes are built up into distinct and arbitrary sequences which are at once recognized by speakers as meaningful sequences which are at once recognized by speakers as meaningful symbols of reference. In English, for instance, the sequence *g* plus *o* in the word “go” is an unanalyzable unit and the meaning attaching to the symbol cannot be derived by relating to each other values which might be imputed to the *g* and to the *o* independently. In other words, while the mechanical functional units of language are phonemes, the true units of language as symbolism are conventional groupings of such phonemes.
- Studdert-Kennedy (2000:165) also reflects on this fact
 - The dissociation of sound and meaning has no precedent in other animal vocalisations, whose signal inventories are limited and not subject to cultural modification. The dissociation is, in fact, the critical discontinuity that separates human language from other primate systems of vocal communication – critical because ... meaningless units at the base of a hierarchy are essential to operation of the particulate principle in all its domains. In language, it is only if they are meaningless that the same units can be repeatedly permuted and combined to form different units of meaning. And only because the basic units are meaningless

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can the meanings assigned to their combinations be arbitrary – as required for a lexicon of unbounded semantic scope.

- Finally, Carstairs-McCarthy (2002:18) makes the following related point:
 - Some relatively long words, such as *catamaran* and *knickerbocker*, may consist of just one morpheme; on the other hand, a single-syllable word, such as *tenths*, may contain as many as three morphemes (*ten*, *-th*, *-s*). What this shows is that the morphological structure of words is largely independent of their phonological structure.
- Let us address now a practical question, which will also prove critical in the end: what particular sub-units did the ancient poet Rumi have in mind?

SEGMENTS – PHONEMES – LETTERS

- A literal translation of the last couplet is provided below in (b).

- (1) a. امرکنیکفعلبودونونوکاف ['æmr ɛ 'kun 'jek 'fe:l 'bu:d ɔ 'nu:n ɔ 'kɒ:f]
order EZ “be!” one act was and “n” and “k”
- در سخناقتادومعنیبودصاف ['dær so'xæn ɒftɔ:d ɔ mæ?'nɒw 'bu:d 'sɒ:f]
in speech fall and meaning was pure/intact
- b. “The command “kun” was a single act/verb — “n” and “k” occurring only in speech— and its meaning was pure/intact.’

- Rumi dictated his verses in Persian (always in song and dance, incidentally) but in this instance he chose *kun* ‘Be!’ from Arabic, in reference to the Qur’ān (op. cit., p. 261).
- In the Arabic script, which is also used for Persian, this word is written with the consonant letters ك <k> and ن <n> in reverse order: کن.
 - A diacritic ُ can also be used to indicate the vowel: کُن.

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- Though *de rigueur* in the Qur'ān, the diacritics for short vowels are rarely used.⁴
- *Kun* is a Qur'anic word, to be sure, but Rumi's trusted scribe almost certainly omitted the vowel diacritic, particularly in consideration of the poem's emphasis on the duality of this word (a noose with two strands, viz. ك and ن) and its dichotomy (its duality conjures a single meaning, viz. ڪ).
- Why would Rumi state that the consonant *letters* “k” and “n” occur in *speech*?
 - سخن [so'xæn] refers to speech, not writing.
- Perhaps he confused alphabetic letters for speech sounds.
 - If so, no one reading this is in a position to judge him. The alphabet affects us all.
- This was a chief concern of Ferdinand de Saussure (1857-1913), a founding figure of modern linguistics. In his seminal *Course in General Linguistics*, Saussure complains that many a linguist has been bewitched by his own spelling, e.g.:

The first linguists were misled in this way, as the humanists had been before them. Even Bopp^[5] does not distinguish clearly between letters and sounds. Reading Bopp, we might think that a language is inseparable from its alphabet. His immediate successors fell into the same trap... (Saussure 1916[1983]:25)

- Segmental phonology —the theory that language deals in letter-sized segments— is indeed well-rooted.
- Consider those whom Bromberger & Halle (2000:34) single out as “the heroes of our field: Panini, Rask, Bopp, Saussure, Jakobson, Chomsky.”

⁴ As Seraye (2010) describes, vowel diacritics were introduced in the seventh century to aid non-Arabs to read the Qur'ān aloud, hence their mandated use in that book and some other religious texts. Interestingly, Seraye's reading experiments demonstrate that the diacritics hinder rather than aid Arabs themselves.

⁵ Franz Bopp was an eminent German linguist who, a century earlier, had famously demonstrated the common structure of Indo-European languages.

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- Pāṇini, who lived two and a half millennia ago in what is today Pakistan, epically proposed thousands of algorithms to derive Sanskrit grammar from sub-word units —morphemes— and the latter from sound-letter sub-units.
- The Danish linguist Rasmus Rask (1797-1832) developed a typology of sound-letters and of the changes these sound-letters undergo which greatly facilitated historical comparison across Indo-European languages.
- Bopp and Saussure, both mentioned above, continued such comparisons to stunning success. Though weary of orthography, Saussure nonetheless argued that words, even as they are uttered, consist of a small set of letter-sized chunks called phonemes.
- Famed Russian linguist Roman Jakobson (1896-1982) agreed with Saussure that words are opposed by a set of phonemes, but warned that this set is not evenly matched with a set of sound properties in actual speech.
 - His solution: redefine each phoneme as a set of sound properties, or “features”.
- Finally, Chomsky adopted Jakobson’s view of phonemes as sets of features, but denied that such phonemes-qua-sets are “immanent” in actual speech.
 - Instead, he suggested that phonemes-qua-sets be relocated to an “underlying” level of representation, where phonemes-qua-sets are strung together:
 - “each natural language has a finite number of phonemes (or letters in its alphabet), and each sentence is representable as a finite sequence of these phonemes (or letters)” (Chomsky 1957:13)
- As Lodge (2009) explains, “[t]he process of reading involves learning to segment” (p. 32), and “linguists by their very training are literate, usually in some form of alphabetic writing” (p. 12).

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- Most notably, “the fact that some form of alphabetic transcription (IPA alphabet or the American equivalents) is used to transcribe sounds, immediately gives the impression that such sounds can be extracted from the speech continuum with ease” (p. 44).
- In general, then, our literacy —both lay and professional— predisposes us to view speech in terms of letter-sized segments: “The notion of segmentation and its tenacity in phonological theories is importantly related to our system of writing with the Roman or other segmental alphabets” (p. 42).
- The apparent scourge of “alphabetism” upon phonologists is also documented at length by Silverman (2006) and Port (2007). The latter, like Lodge, go on to argue that speech is not divided into segments at any level —segmentation is an orthography-induced hallucination that has plagued phonological theory from its beginnings to the present day. The following statements are representative:

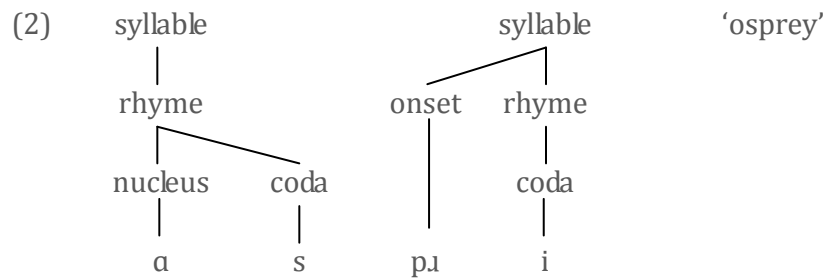
[A]lphabetism [has] been elevated to pre-eminence, among lay people and—especially for our purposes—as the type of writing system that (mis)informs so many linguists’ intuitions about phonological structure. ... they are relying on their *intuitions* about phonological structure. But these intuitions are directly traceable to their training in an alphabetic orthography, and so do not open any sort of window into the genuine structural properties of language. (Silverman 2006:207-8)

[T]he vividness of our intuitions about the segmental organization of speech is largely a consequence of training in reading and writing with an alphabet ... The clarity of our intuitions here apparently does not reveal anything at all about the form of linguistic memory required for spoken linguistic competence. (Port 2007:157)

- See also Linell (2005:56ff.) on “the written bias in ... [p]honetics and phonology.”
- Homework: Listen to “If segments are real, what are they?” by CSU-Fresno’s Sean Fulop & Chris Golston, presented by latter at the *CUNY Conference on the Segment*, Jan. 11-13, 2012. Talk and slides are @ <http://www.cunyphonologyforum.net/segconf.php>

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SYLLABLE $\stackrel{\text{def}}{=} (\text{ONSET})+(\text{NUCLEUS})+(\text{CODA})$



- Internal evidence for syllables
 - Phonetics:
 - As we'll see, syllables are "highlighted" by complex phonetic phenomena
 - Speech sounds pattern according to syllables:
 - As we'll see, "it can be argued that only via the syllable can one give the proper characterization of the domain of application of a wide range of rules of segmental phonology." (Selkirk 1982:337)
 - Prosodic phonology
 - As we'll see (especially in LING 403), syllables play a central role in stress.
 - Prosodic morphology
 - As we'll see (especially in LING 403), syllables play a central role in reduplication, hypocoristics, etc.
- External evidence for syllables:
 - Poetry
 - Iambic pentameter: 10 syllables
 - Trochaic tetrameter: 8 syllables

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- Language games (good evidence for: *Onset* vs. *Nucleus* vs. *Coda*)
 - Geta
 - Op language
 - Largonji des loucherbems
 - Backwards languages
- Blends
 - smoke + fog > smog, etc.
- Speech errors
 - William Archibald Spooner (1844-1930)
 - Onset-switch: *our dear old Queen* > *our queer old Dean, a crushing blow* > *a blushing crow*
 - Nucleus-switch: *Conquering Kings* > *Kinkering Congs, Son it is now kisstomary to cuss the bride*
 - Malapropisms: word substitutions, especially in aphasic speech
 - unconstrained, or only partially constrained by meaning
 - can be driven by similarity in number of syllables
 - “neologisms in jargon aphasia have the same number of syllables as the target up to 80% of the time” (Nadeau 2003:39)
 - Tip-of-the-tongue phenomenon
 - “Despite anomia, subjects are able to guess the number of syllables in the target word with high accuracy” (Nadeau 2003:39)
- Homework: Locate a case of *external* evidence for syllables or syllable structure (e.g., poetry, language games, blends, speech errors, language disorder, writing systems, etc.). Bring just enough examples to appreciate the pattern and share during next class.

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FEATURES

- It has long been suspected that a limited set of (mostly articulatory) settings are sufficient to characterize any speech sound.
- Notably, in 1443 King Sejong of Korea employed several scholars to create the Hangul writing system, which is still in use today.
 - Hangul systematically encodes not only syllables but also consonants and vowels, and interestingly, many of its ‘letters’ have features that represent place or manner of articulation.
 - For example, Hangul itself is written 한글. The first syllable has the letters ㅎ (h), ㅏ (a) and ㄴ (n), and the second syllable has the letters ㄱ (g), ㅜ (u) and ㄹ (l).
 - Crucially, ㄴ is used for both [n] and [l] to represent tongue tip raising, ㄱ is used for [g] to represent tongue body raising, and ㅎ is used to represent the glottal articulation of [h].



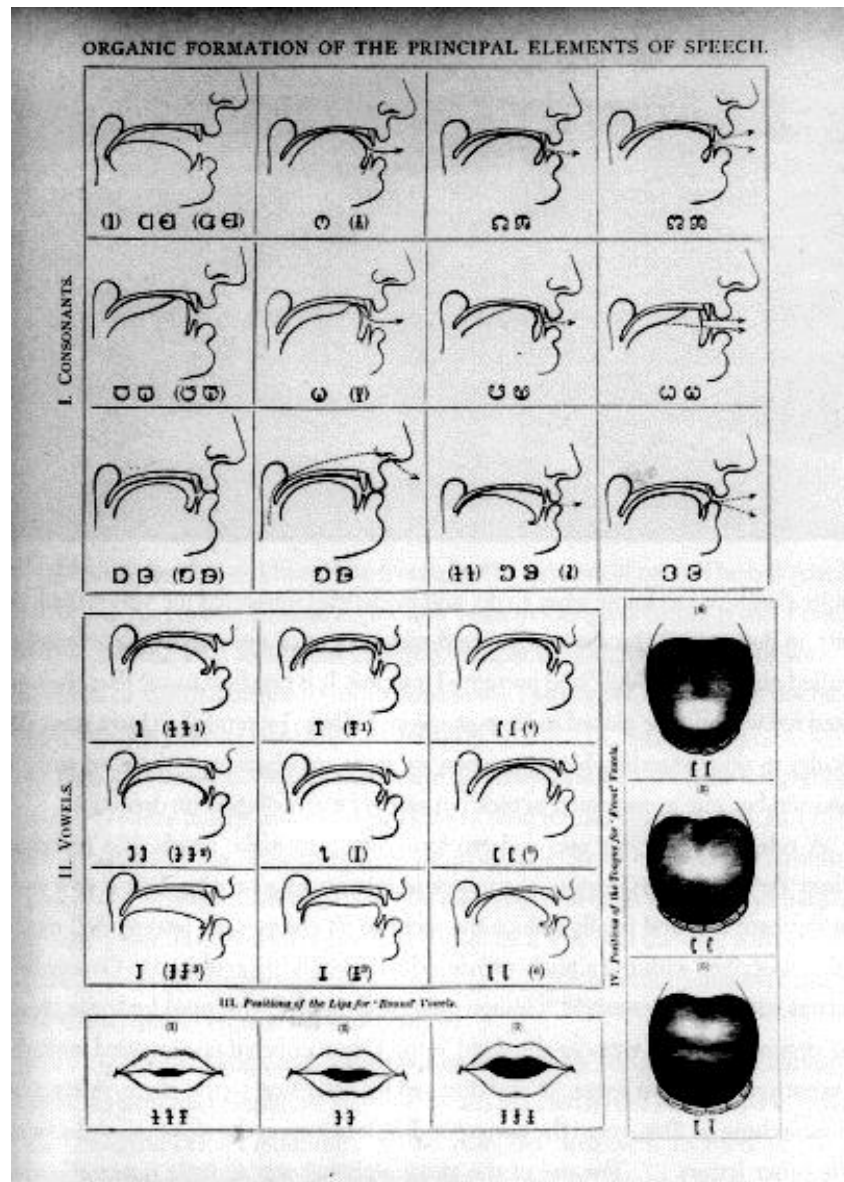
- The belief that speech sounds are composed of discrete *articulatory features* is also unmistakable in the Visible Speech alphabet created by Scottish-Canadian linguist Alexander Melville Bell (1867, see figure two pages down).
 - As Bell’s famous son Alexander Graham (1911:38-9) reasoned:

“What we term an “element of speech” may in reality ... be a combination of positions. The true element of articulation, I think, is a constriction or position of the vocal organs rather than a sound. Combinations of positions yield new sounds, just as combinations of

chemical elements yield new substances. Water is a substance of very different character from either of the gases of which it is formed; and the vowel *oo* is a sound of very different character from that of any of its elementary positions. When we symbolize positions, the organic relations of speech sounds to one another can be shown by means of an equation; for example English *wh* = P + P' [where P is labiality and P' is dorsality -DF], German *ch* = P', hence German *ch* = English *wh* - P."

- Both King Sejong and A. M. Bell intended for their ingenious scripts to be applied generally, to transcribe any sound that can be articulated.
 - "Though only twenty eight letters are used, their shifts and changes in function are endless. These transformational rules are simple and succinct, reduced to a minimum, yet universally applicable. ... There is no usage not provided for, no direction in which they do not extend. Even the sound of the winds, the cry of the crane, the cackle of the fowl and the barking of the dogs —all may be transcribed"
–King Sejong, *Hwumin Cengum Haylyey*, 1446:8.9-8.11. C.Post. (cited in Kim-Cho 2002:80)
 - Similarly, in early public demonstrations of the Visible Speech alphabet, audiences provided difficult sounds from various languages and even nonlinguistic sounds and gestures such as yawns, which A. M. Bell transcribed while Bell Jr. waited outside.
 - Reading his father's transcriptions young Alexander was able to reproduce all oral sounds and gestures faithfully. But he could not reproduce 'body language' (such as arms being stretched out above the head).
 - This disappointed some audience members but was in fact a good thing:
 - it showed that the Visible Speech alphabet was actually about speech (Ronell 1991).

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- A plausible set of phonological features is presented in this text.
 - These features mostly refer to articulations⁶ as in Hangul and Visible Speech, and are largely adapted from Chomsky and Halle's (1968) monumental work *The Sound Pattern of English* (SPE).

⁶ An auditory-acoustic distinctive feature theory was proposed earlier by Jakobson, Fant and Halle (1952).

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- However, SPE assumed each feature to be *binary* after Trubetzkoy (1939) in the sense that each can assume one of two possible values, typically represented as + and –.
- By contrast, we will assume that features are *privative* —a.k.a. *monovalent*, *unary*, *singular*— since, as leading phonologist John McCarthy (2011:200) recently remarked, “the assumption that distinctive features are privative ... seems like the most plausible view (see Lombardi 1991b; Steriade 1993a; b; Trigo 1993, among others; Steriade 1995a).”
 - Features do not take values (such as + or –); they can only be either present or absent.
 - Note that the absence of an element can be as important psychologically as its presence.
 - Consider the elements of a mountain. Their absence certainly makes an impression in, say, the Grand Canyon.
 - Similarly, cold may be the absence of heat, but the experience of cold is very real. (Cf. darkness vs. light, evil vs. good, etc.)

LIQUID $\stackrel{\text{def}}{=} \{[\text{LATERAL}], [\text{RHOTIC}]\}$

Liquid $\stackrel{\text{def}}{=} \{[\text{lateral}], [\text{rhotic}]\}$

A FEATURE CLASS/SET

- A *set* of phonological features is suggested by “feature class behavior—the recurrent patterning together of certain phonological features” (Padgett 2002:81).
 - “Certain phonological features pattern together recurrently across languages in phenomena such as assimilation, dissimilation, and reduction.” (Ibid.)
 - These phonological phenomena are defined and illustrated below.
- **Liquids = ‘l sounds’ (laterals) + ‘r sounds’ (rhotics)**

lateral Sounds produced with air escaping down one or both sides of the tongue are lateral sounds. ... Lateral escape of air is distinguished from **central** escape of air. (Carr 2008:86-7)

E.g., [l, ɫ, ʎ, ɭ, ʟ, tˡ, dˡ, pˡ, bˡ, fˡ, vˡ, kˡ, gˡ, ʙ]

‘r’ sounds Otherwise known as **rhotics**. It is common for phonologists to postulate different ‘r’ sounds in a language, and the range of sounds considered to be ‘r’ sounds is remarkably broad, subsuming taps, trills, fricatives and approximants. It is a moot point whether there is a natural class of ‘r’ sounds. It is worth noting that, although the class of sounds considered to be rhotics is large, it is none the less constrained; no nasal stops ever count as rhotics, for example, and nor do voiceless stops. (Carr 2008:140-1)

E.g., [r, ɾ, ɹ, ʀ, ʁ, ɽ, tʳ, dʳ, pʳ, bʳ, fʳ, vʳ, kʳ, gʳ]

- Phonological features for liquids (Steriade 1995a; Hall 1997, etc.)
 - [lateral]
 - [rhotic]
 - Ladefoged (2007) suggests [central] rather than [rhotic].

LIQUID $\stackrel{\text{def}}{=} \{[\text{LATERAL}], [\text{RHOTIC}]\}$

- Some languages have ...
 - [lateral] as well as [rhotic], e.g., English, French, Spanish.
 - [lateral] but no [rhotic], e.g., Chinook Jargon (BC, WA)
 - [rhotic] but no [lateral], e.g. Attikamek (QC)
 - neither [lateral] nor [rhotic], e.g., Algonquin (QC, ON)
 - Several indigenous languages near Calgary are liquid-less, e.g. Stoney-Nakoda (Siouan), Blackfoot (Algonquian), Plains Cree (Algonquian), Saulteaux (Algonquian).
 - Other liquid-less languages include:
 - Efik and Birom (Niger-Congo)
 - Gadsup and Wantoat (Trans-New Guinea)
 - Dera (Afro-Asiatic/Chadic)
 - Mixe (Mixe-Zoque)
 - Seneca (Iroquoian)
 - Mura (Pirahã)
 - Kashinawa (Panoan)
 - Waorani (Ecuador isolate)
 - Siona (Tucanoan)
- When a feature is absent in a language, it is instructive to consider what happens when that language borrows words from a language that allows the feature in question.
- “A language’s reactions to loanword input containing foreign sounds or structures reveal a lot about the phonology of that language. In a broader perspective, by studying the loanword adaptation patterns in many different languages, phonologists can get a better idea of how phonology functions cross-linguistically and universally. This is why loanword adaptations are so important: they open a large window onto the range and functioning of phonological constraints.” (Paradis & LaCharité 2011:752)

LIQUID $\stackrel{\text{def}}{=} \{[\text{LATERAL}], [\text{RHOTIC}]\}$

- French loanword adaptation in Chinook Jargon, which lacks [rhotic]:
 - *la bride* > lablid ‘bridle’
 - *cendré* > sandele ‘roan’
 - *Jésus Christ* > sesu kli ‘Jesus Christ’
 - *les rubans* > leloba ‘ribbon’
 - [rhotic] is replaced by the other liquid feature, [lateral]
- French loanword adaptation in Attikamek (QC), which lacks [lateral]:
 - *à la poche* > arapof: ‘pocket’
 - *les carottes* > rikka:rat ‘carrot’
 - *les claques* > rikkirak ‘overshoe, snow-boot’
 - [lateral] is replaced by the other liquid feature, [rhotic]
- French loanword adaptation in Algonquin (QC, ON), which lacks both [lateral] and [rhotic]:
 - *anglais* > aganeca ‘Englishman’
 - *la farine* > napanin, na:pa:nenak ‘flour’
 - *carreau* > ka:no:w ‘diamonds’
 - *des rubans* > deniband ‘ribbon’
 - *ses rubans* > senepa:n ‘ribbon, silk, satin’
 - *mouchoir* > moswe:n ‘shawl’
 - *à la messe* > ana:meha:w ‘s/he practices the Christian religion’
 - *la mélasse* > naminas ‘molasses’
 - [lateral] and [rhotic] are both replaced by [nasal], a feature to be discussed later.

PHONETIC VARIATION

- [lateral]
 - This phonological feature has various phonetic realizations in English, including:
 - plain [l] in north east England and Ireland
 - velarized [ɫ] in much of North America and southwestern England

LIQUID $\stackrel{\text{def}}{=} \{[\text{LATERAL}], [\text{RHOTIC}]\}$

- vowel-like [ɹ̥] around Peterborough in East England and the West Midlands of western central England.
- Most British speakers tend to favor:
 - syllable-onset [lateral] as [l]
 - syllable-rhyme [lateral] as “dark” [ɫ ~ ɹ̥]
- [rhotic]
 - North Americans tend to favor:
 - bunched [ɹ̥^w] after lingual consonants (e.g., [d, g])
 - retroflex [ɻ^w] after labials (e.g., [b, v]) and vowels.
 - unrounded [ɹ̥] after unrounded vowels (e.g., [a])
 - Other phonetic realizations are reported across the English world, including:
 - trilled [r̥] in Scotland (and in dramatic performances)
 - flap [ɾ] in conservative RP and northern England
 - labiodental [ɹ̥] in southern and southwestern England
 - uvular [ʁ^(w)] in north east England (elderly/rural Northumberland and Cumbria), in Leinster, Ireland, and in Sierra Leone.
 - slightly elongated [w̥] in children and some varieties of African American Vernacular English
 - Phonetic variation between apico-alveolar [r ~ ɹ̥] and uvular [ʁ ~ ʁ̥] is also reported in dialects of other languages, including French (Straka 1965), German (Howell 1987) and several Scandinavian languages (Swedish, Danish, Norwegian: Torp 2001), Portuguese (Noll 1997), Italian (Ladefoged & Maddieson 1996:225), Spanish (Puerto Rican: Granda 1966; Navarro Tomás 1966), Dutch (Gussenhoven 1999), Yiddish (Eastern: King & Beach 1998:284-6), Russian (Ladefoged & Maddieson 1996:225), several Central Sulawesi languages (Lauje, Dampelas and Tolitoli: Himmelmann 1991), and at least two Banda languages, Ngbugu (Clarec-Heiss 1978) and Langbasi (Olson 1996).
 - For example, Jackson (1974) reports that six out of seven speakers use alveolar [ɹ̥] in Willow Bunch in southwest Saskatchewan, whereas six out of seven speakers use uvular [ʁ̥] in Bellegarde in southeast Saskatchewan.

LIQUID $\stackrel{\text{def}}{=} \{[\text{LATERAL}], [\text{RHOTIC}]\}$

As Jackson explains, this difference in pronunciation goes back to the original settlers—Métis who used [r] and Belgians who used [ʀ], respectively.

- Speakers of languages (such as dialectal German, Canadian French, etc.) with variation between apico-alveolar [r ~ ɾ] and uvular [ʀ ~ ʁ] tend to favor:
 - syllable-onset [rhotic] as [r ~ ɾ]
 - syllable-rhyme [lateral] as [ʀ ~ ʁ]
- Homework: find and read Yasaman Rafat (2010): “A socio-phonetic investigation of rhotics in Persian”, *Iranian Studies*, 43:5, 667-682

PHONOLOGICAL ALTERNATIONS

- In Florentine Italian, [lateral] /l/ regularly switches to [rhotic] [r] in syllable-final positions (Walsh 1995). Thus compare the following words in Standard vs. Florentine Italian:

(1)	<i>Standard Italian</i>	<i>Florentine Italian</i>	
	[dolʃe]	[dortʃe]	‘sweet, dessert’
	[sɔldi]	[sɔrdi]	‘money’
	[palkoʃeniko]	[parkoʃeniko]	‘stage’

- The same state of affairs obtains in Andalusian Spanish, as can be observed from comparing words in Standard Castilian vs. Andalusian Spanish:

(2)	<i>Standard Castilian</i>	<i>Andalusian</i>	
	[e.ɫo.so]	[e.ɫo.so]	‘the bear’ (<i>el oso</i>)
	[el.θo]	[er.θo]	‘the zoo’ (<i>el zoo</i>)
	[al.ba:ka]	[ar.ba:ka]	‘basil’
	[pul.po]	[pur.po]	‘octopus’

- The same pattern is found in Andalusian Spanish where, for instance, *alma* ‘soul’ is pronounced [arma], *espalda* ‘?’ is pronounced [ehpada] (Mondéjar 1979:398-402; 1991).

LIQUID $\stackrel{\text{def}}{=} \{[\text{LATERAL}], [\text{RHOTIC}]\}$

- This change also extends to intervocalic contexts, e.g., *suelo* → *suero*, *claveles* → *claveres*, *sale* → *sare*, *me fui loca* → *me fui roca* (Moya Corral 1979:50-1; Becerra Hiraldo & Vargas Labella 1986:20).
- The following Korean examples illustrate how a morphological root changes in quality depending on whether its final liquid is syllable-final or syllable-initial.
(3)

	<i>[lateral] coda</i>	<i>[rhotic] onset</i>
a.	[mul] 'water'	[mure] 'at the water'
	[mulkama] 'place for water'	[muri] 'water NOM'
b.	[mal] 'horse'	[mare] 'at the horse'
	[malkama] 'place for horse'	
c.	[pal] 'foot'	[pari] 'of the foot'
- When morphemes have different realizations in different environments in this way, we are justified to posit a mechanism for relating the different outputs, in this case a phonological rule or constraint relating [lateral] in codas with [rhotic] in onsets in Korean.
- Phonology is responsible for alternations like these:

It is an absolutely crucial point that no other cognitive module in [the generative-innatist-modular framework of grammar] is responsible for alternations – the [Phonological Component] bears all responsibility for generating them (though see ... the phonetic module).

...

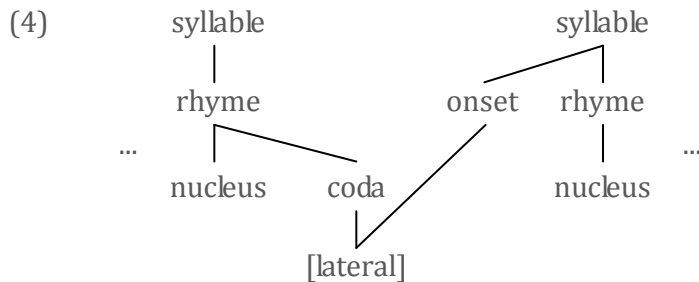
To summarize, GIMF PhC modules offer two ways of dealing with a morpheme's morph variation: through alternations and phonologically-conditioned suppletion. Putting aside suppletion, in all extant GIMF PhC theories alternations provide insight into underlying forms and constraint rankings/rules. (de Lacy 2009)

LONG CONSONANTS

- One of your fellow students pointed out that when her name *Paulina* is pronounced in Korean, the medial [lateral] is preserved but lengthened: *pollina*.
- Medial long *ll* is indeed found in native Korean words, e.g. *sillok* 'spring green'.

LIQUID $\stackrel{\text{def}}{=} \{[\text{LATERAL}], [\text{RHOTIC}]\}$

- In phonology, a long consonant (*geminate*) is usually represented as “stretched” between two syllables:



- At least word-medially, then, Koreans *can* preserve the foreign contrast between [lateral] and [rhotic] by ensuring that the former is always linked to a syllable coda, and that the latter is only linked to an onset:

(5)

[lateral] coda	[rhotic] onset	(Kenstowicz 2005)
[k ^h ollə] ‘cola’	[k ^h o:rasɨ] ‘chorus’	
[t ^h allent ^h ɨ] ‘talent’	[orenʒi] ‘orange’	
[sillik ^h on] ‘silicon’	[misit ^h eri] ‘mystery’	
[ollimp ^h ik] ‘Olympic’	[meri] ‘Mary’	
[t ^h ulluci] ‘Toulouse’	[p ^h ari] ‘Paris’	

- Word-initially, however, Koreans have no choice but to neutralize the foreign contrast:

(6)

[lateral] onset in original	[rhotic] onset in original	(Kenstowicz 2005)
[ra.in] ‘line’	[re.il] ‘rail’	
[ro.bi] ‘lobby’	[rop ^h ɨ] ‘rope’	
[rebel] ‘level’	[ɾeink ^h ot ^h ɨ] ‘raincoat’	

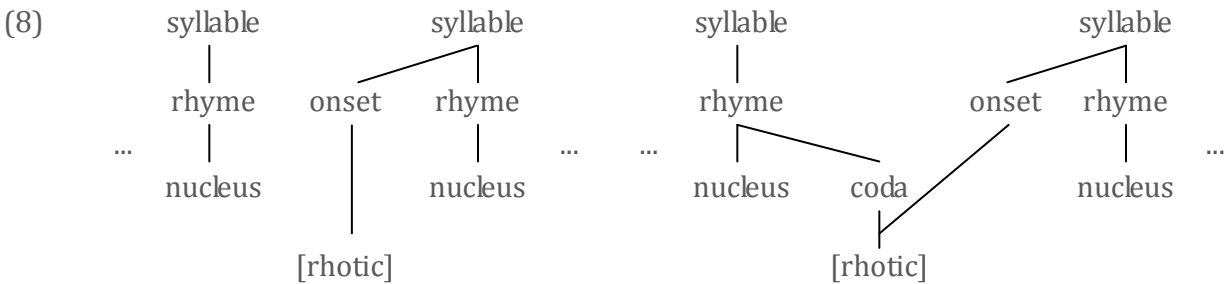
- The Romance language Catalan makes a distinction between two kinds of rhotics —tap [ɾ] versus trill [r]— but only between vowels (Wheeler 2005).

(7)

tap	trill	(Padgett 2009)
[ˈsɛɾə] ‘wax’	[ˈsɛrə] ‘saw’	
[ˈmirə] ‘(s/he) looks at’	[ˈmirə] ‘myrrh’	
[ˈpaɾə] ‘father’	[ˈpaɾə] ‘grapevine’	
[ˈmoɾə] ‘blackberry’	[ˈgoɾə] ‘(peaked) cap’	

LIQUID $\stackrel{\text{def}}{=} \{[\text{LATERAL}], [\text{RHOTIC}]\}$

- The traditional view of this intervocalic contrast is [rhotic] singly-linked to an onset versus [rhotic] doubly-linked to a coda and onset:



- For arguments in favor of this syllable-based analysis in Catalan, see Wheeler (2005:26-9) and Padgett (2009:456-9) and references therein.
- Cser (1999:216) notes that despite their obvious importance in the phonetics of rhotics, [trill] and [flap] are not distinctive features, only phonetic traits which are parasitic on other aspects of phonological representation.

ASSIMILATION

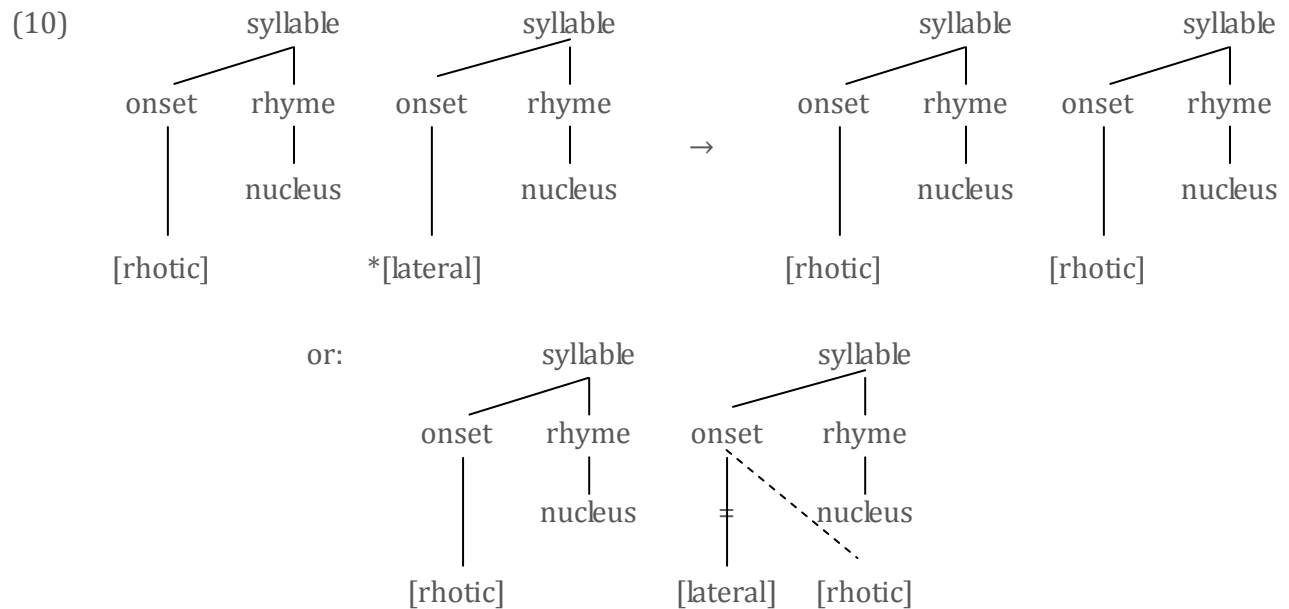
- This term refers to instances where one part of a word (say, the onset of a syllable) becomes more like another in terms of one or more distinctive features.
 - Progressive* assimilation is where one part of a word becomes more like a preceding part.
 - Regressive* assimilation is where one part of a word becomes more like a following part.
- For example, in Bukusu, a Bantu language of Kenya, (onset) [lateral] changes to (onset) [rhotic] in suffixes which attach to a stem with (onset) [rhotic] (Odden 1994; Hansson 2010)
- The following words illustrate that the benefactive suffix generally has [lateral] (9a), but this changes to [rhotic] if the preceding syllable onset is [rhotic] (9b).

LIQUID $\stackrel{\text{def}}{=} \{[\text{LATERAL}], [\text{RHOTIC}]\}$

(9) *Benefactive suffix alternations in Bukusu* (Odden 1994; Hansson 2010)

- | | | | | | |
|----|----------|-------------------|----|----------|------------|
| a. | [butila] | 'pick/gather for' | b. | [karira] | 'twist' |
| | [xamila] | 'milk for' | | [birira] | 'pass for' |
| | [i:lila] | 'send thing' | | [irira] | 'die for' |

- This is an instance of progressive assimilation of [rhotic]:



- The following words illustrate that [lateral] also *optionally* changes to [rhotic] if the stem's [rhotic] is further than one syllable away:

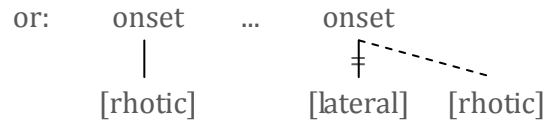
(11) *Benefactive suffix alternations in Bukusu* (Odden 1994; Hansson 2010)

- | | | | | | |
|----|-----------|-------------------|----|---------------------|----------------|
| a. | [butila] | 'pick/gather for' | b. | [rumira ~ rumila] | 'send someone' |
| | [te:xela] | 'cook for' | | [resjera ~ resjela] | 'retrieve for' |
| | [limila] | 'cultivate for' | | [re:bera ~ re:bela] | 'ask for' |

- Optional progressive long-distance assimilation of [rhotic] in Bukusu:



LIQUID $\stackrel{\text{def}}{=} \{[\text{LATERAL}], [\text{RHOTIC}]\}$



- In Kipare, a Bantu language of Tanzania, the glide /j/ optionally assimilates the liquid quality of a preceding syllable (Odden 1994:315-6; Hansson 2010:100-1).
- This optional assimilation is illustrated below with the perfective and applied suffixes. The (b) examples show that assimilation applies only between adjacent syllables.

(13) Kipare /-ije/ PERFECTIVE → [-ire ~ -ile]

- | | | | |
|----|--|-----|---|
| a. | [nizorire 'I bought'
~ nizorije]
[nitalile 'I have counted'
~ nitalije] | cf. | [nikundije 'I liked' (ni- 1s.Sub)
[nibigije 'I beat'
[nitetije 'I said'
[nitongije 'I went'
[nidikije 'I cooked'
[nivonije 'I saw' |
| b. | [nirongije 'I made'
(*[nirongire]) | | |

(14) Kipare /-ija/ APPLIED → [-ira ~ -ila]

- | | | | |
|----|--|-----|---|
| a. | [kuzorira 'to buy for'
~ kuzorija]
[kotalila 'to count for'
~ kotalija] | cf. | [kutetija 'to say for' (ku- infinitive)
[kubigija 'to beat for'
[kudikija 'to cook for' |
| b. | [kurumbija 'to make pots'
(*[kurumbira]) | | |

DISSIMILATION

- This term refers to instances where two similar parts of an utterance (say, syllable onsets with the same distinctive features) becomes less alike in terms of one or more of their distinctive features.
 - Progressive dissimilation is where the second of two similar parts changes to become less alike.

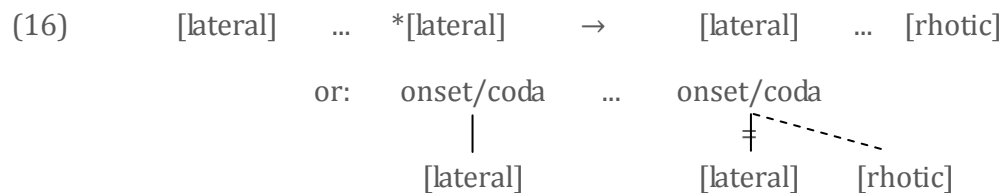
LIQUID $\stackrel{\text{def}}{=} \{[\text{LATERAL}], [\text{RHOTIC}]\}$

- Regressive dissimilation is where the first of two similar parts changes to become less alike.
- The feature [lateral] participates in a dissimilation process in Latin (Steriade 1987; 1995b).
- As shown in (15a), the adjectival suffix *-alis* undergoes no change when added to a stem which has no lateral, but it appears as *-aris* when following a stem with a lateral, as shown in (15b).

(15) *Lateral dissimilation in Latin*

a.	na:wa:lis	'naval'	b.	so:la:ris	'solar'
	semina:lis	'seminal'		lu:na:ris	'lunar'
	wo:ka:lis	'vocal'		latia:ris	'of Latium'
	causa:lis	'causal'		mi:lita:ris	'soldierly'
	infitia:lis	'negative'		linea:ris	'linear'
	morta:lis	'mortal'		alimenta:ris	'of food'
	na:tura:lis	'natural'		popula:ris	'popular'
	anna:lis	'annal'		vulga:ris	'common'
	kapita:lis	'capital'		singula:ris	'alone'

- Progressive long-distance dissimilation of [lateral] in Latin:



- The additional data below show that when an *r* intervenes between the two *l*'s, no dissimilation occurs.

(17) *Some exceptions to lateral dissimilation in Latin*

litora:lis	'of the shore'	latera:lis	'lateral'
flo:ra:lis	'floral'	plu:ra:lis	'plural'
sepulkra:lis	'funereal'	littera:lis	'literal'
cf.	re:gula:ris		'regular'

OBSTRUENT $\stackrel{\text{def}}{=} \{[\text{FRICATIVE}], [\text{STOP}], [\text{STRIDENT}]\}$

Obstruent $\stackrel{\text{def}}{=} \{[\text{fricative}], [\text{stop}], [\text{strident}]\}$

- “Sounds in the languages of the world involving turbulent noise are referred to in generative phonology as ‘**obstruents**’, a natural class subsuming stops, affricates and fricatives. Sounds not belonging to the class of obstruents are traditionally considered to be ‘**sonorants**’, namely vowels, glides, liquids, nasals.” (Hall & Žygis 2010:1)

[FRICATIVE]

= continuous turbulent airflow

- privative [continuant] (Lombardi 1990:378; Duanmu 2009).
- [f, v, ʌ, φ, β, θ, ð, s, z, ʈ, ʂ, ʃ, ʒ, ʣ, ʥ, ɕ, ʑ, ɰ, x, ɣ, ɦ, χ, ʁ, ...]
- The turbulence is due to increased air pressure behind an oral constriction.
- “[F]ollowing the articulatory-phonology synthesis scheme, [fricative] is defined as the degree of closure of the vocal tract that causes a turbulent airflow.” (Ladefoged 2007:176)
- “Continuance is perhaps the quintessential feature of the fricative class; in fact, Jakobson *et al* (1952:43) specified the feature [+continuant] only for fricatives and not for vowels (or *h*, interestingly), making it effectively equivalent to Ladefoged’s [fricative] feature.” (Miller & Vaux 2011:673)
- Some researchers argue that suborally-constricted sounds, too, may be specified with the phonological feature [fricative], perhaps on a language-specific basis:
 - Pharyngeal [ħ, ʕ]
 - Epiglottal [ħ, ʕ]
 - Laryngeal/glottal [h, ɦ]
- Note that even orally-constricted fricatives are not always phonologically specified [fricative]. Here are two examples:

OBSTRUENT $\stackrel{\text{def}}{=} \{[\text{FRICATIVE}], [\text{STOP}], [\text{STRIDENT}]\}$

- In Russian, labiodental [v] is not specified [fricative] before sonorants.

“[v], although pronounced as a labiodental spirant, patterns here phonologically with sonorants. The expression “patterns with” is a circumlocution: to say that a segment can “pattern with” sonorants is simply to say that it is a sonorant itself. We must, then, nail our colours to the mast and say that in some contexts what sounds like a spirant is a sonorant.” (Gussmann 2001:236)⁷

- Phonetic [ʁ] is [fricative] in Arabic phonology, but [rhotic] in French phonology.
 - Interestingly, Arabic-French bilinguals are unfazed by this phonetics/phonology mismatch when they import words into their native language.

“[T]he French rhotic in French loanwords borrowed into Moroccan Arabic is systematically interpreted as a coronal sonorant, not as a uvular (e.g. Fr. *rasoir* 'razor' [ʁazwaʁ] → MA [razwar], not *[ʁazwaʁ]). This is confirmed in our corpus of French loanwords in Moroccan Arabic. Out of 1,374 cases, Fr. [ʁ] never corresponds to MA /ʁ/ in French loans. Clearly, bilingual Arabic speakers who adapt French loanwords classify the French rhotic as coronal, despite the fact that Arabic has a phonemic uvular /ʁ/ in its inventory of gutturals. The Arabic uvular fricative is widely described as being, phonetically, the uvular rhotic of French ..., presumably making Arabic speakers well equipped to correctly perceive and produce the uvular [ʁ] of French. Not surprisingly, Arabic /r/, which is phonologically coronal and phonetically either flapped ..., trilled ... or rolled ... is always equated with the French rhotic (which is standardly realised as a uvular)^[8] in Arabic loanwords in French. Meanwhile, the Arabic uvular fricative, which is phonetically much closer, if not identical, to French [ʁ], is considered ill-formed in

⁷ Gussmann (2001:246) concludes: “Phonetics does seem to play a role in phonological [œ] should be realised as phonetic [g], for example — but the extent of the influence is limited. ... [T]he phonological identity of segments must be determined by phonological criteria which in certain cases go against the evidence of phonetics. Phonetics merely provides a garb for the more basic phonological or cognitive elements, a garb which is often deceptive and ambiguous.”

⁸ Paradis & Lacharité (2001:271) also remark: “The French rhotic can even be pronounced in the pharyngeal region, which Francophones themselves do not hear but which Arabic speakers perceive very well”. French loanwords with rhotics are never adapted into Arabic with pharyngeals /ʕ/ or /ħ/.

OBSTRUENT $\stackrel{\text{def}}{=} \{[\text{FRICATIVE}], [\text{STOP}], [\text{STRIDENT}]\}$

French and is systematically adapted as /g/ in Arabic loanwords in French [e.g., Ar. [ʁazæ:l] > Fr. [gazel] ‘gazelle’].” (Paradis & LaCharité 2001:272)

- The foregoing discussion of [ʁ] as [rhotic] in French and [fricative] in Arabic leads naturally to the (possibly unique) case of Czech <ř>, which is both [rhotic] and [fricative].
 - As explained in the *Handbook of the International Phonetic Association*: “There are two trills, /r/, as in *ruka* /ruka/ ‘hand’, and /r̥/, as in *řeka* /r̥eka/ ‘river’. The first one is an alveolar apical trill with 1-3 periods of vibration. It is immune from voicing assimilation and occurs voiced in all positions of the word. In the case of /r̥/, the place of articulation is normally similar to that for /r/. Although it may be produced with the blade of the tongue, the main differentiating characteristic from /r/ is the number of vibrations, which may be 1-2 greater than in /r/, and in their lesser amplitude than for the vibrations in /r/. Also, the constriction is narrower and the velocity of air greater. This sound often starts as a trill but continues as a fricative and thus probably the best term for it is ‘alveolar trill fricative’ with the symbol /r̥/. ... A voiceless allophone of /r̥/ occurs in places where voicing assimilation applies.” (Dankovičová 1999:71)⁹
- [fricative] can also combine with the other liquid feature, [lateral].
 - The Chadic language Sirzakwai distinguishes [lateral] from [lateral, fricative] in syllable-onset position:¹⁰

(1) *Laterals in Sirzakwai* (a.k.a. Warji; Chadic, Nigeria: Blench 2008)

	INITIAL	MEDIAL
/l/	[la:r] ‘river’	[ŋwali] ‘warm it’
/ɭ/	[ɭaɭa] ‘eight’	[maɭijana] ‘oil (any kind)’
/ɬ/	[ɬa] ‘to wake up; grow’	[va:ɬi] ‘five’

⁹ Another difference is that /r/ can form the peak of a syllable, e.g. [vɾba] ‘willow’, whereas /r̥/ is never syllabic (ibid.). (Cf. syllabic /l/ in e.g. [vɫk] ‘wolf’ and syllabic /m/ in e.g. [sɛdm̩] ‘seven’.) That /r̥/ is specified [fricative] is especially clear from the fact that it patterns with other obstruents in becoming voiceless ([ʁ̥]) not only in assimilation to adjacent voiceless sounds but also at the ends of words. Like other obstruents, /r̥/ can also cause regressive voicing assimilation outside its syllable (see Dvořák 2010 and references therein). On the other hand, /r̥/ uniquely devoices in featurally complex syllable onsets, a fact which may be chalked up to its [rhotic] feature (Bye & Blaho 2005; Ketner 2005; Hall 2007; Dvořák 2010; Bičan 2011). The ambiguous fricative/trill nature of Czech /r̥/ is a point of ongoing research.

¹⁰ The obstruents [ɬ, ɭ] are written <tl, lh> in the language’s orthography.

OBSTRUENT $\stackrel{\text{def}}{=} \{[\text{FRICATIVE}], [\text{STOP}], [\text{STRIDENT}]\}$

- The same contrast is also made in Marghi, another Chadic language of Nigeria, e.g.:
 - [la] ‘to dig’ vs. [ʒa] ‘fall’ vs. [ʔa] ‘cow’ (Hoffmann 1963:23-5)
- Also in the South African Bantu language isiZulu, e.g.:
 - [lálà] ‘sleep’ vs. [ʒálà] ‘play (imper.)’ vs. [ʔânzà] (Ladefoged & Disner 2012:172)

[STOP]

= discontinuous/interrupted turbulent airflow.

- privative [stop] (Lombardi 1990:378; Duanmu 2009).
- Air pressure builds up behind an oral closure, resulting in “silence (at least in the frequency range above the vocal cord vibration) followed and/or preceded by a spread of energy over a wide frequency region” (Jakobson & Halle 1956:41-2).
- Plosives [p, p̥, t, d, k, g, q, ɢ, ...]
- Affricates [pf, bv, ts, dz, tʃ, dʒ, ...]
 - More on affricates below
- Some phonologists argue that suboral sounds can be specified [stop], too, again perhaps on a language-specific basis:
 - Epiglottal [ʔ]
 - Laryngeal/glottal [ʔ]
- Sample contrast: [lateral] versus [lateral, stop]
 - This contrast is made in syllable-onsets in Oowekyala, a Wakashan language of British Columbia (Howe 2000):
[.la:] ‘yes’ vs. [.dla:] ‘to wedge’; [.li.q̥a.] ‘to fold, roll’ vs. [.dli.qa.] ‘to name’
- Lexical contrasts based on [stop] vs. [fricative] are especially common across languages.

OBSTRUENT $\stackrel{\text{def}}{=} \{[\text{FRICATIVE}], [\text{STOP}], [\text{STRIDENT}]\}$

“Did you say *pig* or *fig*?” said the Cat. ‘I said *pig*,’ replied Alice.” In this peculiar utterance the feline addressee attempts to recapture a linguistic choice made by the addresser. In the common code of the Cat and Alice, i.e. in spoken English, the difference between a stop and a continuant, other things being equal, may change the meaning of the message. Alice had used the distinctive feature stop vs. continuant, rejecting the latter and choosing the former of the two opposites. (Jakobson & Halle 1956:72-3)

- Here are some more examples of [stop] vs. [fricative] contrasts in Oowekyala (Howe 2000):

[tsixa]	‘to run, flow, flood (water)’
[sixa]	‘to peel (fruits, sprouts, etc.)’
[tʰiqa]	‘to beat time’
[tʰixa]	‘fringe’
[kata]	‘to use a long thing (e.g., log) or put it somewhere’
[xata]	‘to peek, to stretch the head out’
[k ^w isa]	‘to spit’
[x ^w isa]	‘to whip, to make a whipping movement’
[qusa]	‘bent, crooked’
[χusa]	‘to sprinkle, to splash’
[q ^w q ^w a]	‘to sprain, wrench’
[χ ^w q ^w a]	‘to sharpen with a file’

[STRIDENT]

- The feature [strident] characterizes sounds that are realized with relatively high frequency frication, that is, high pitch white noise.
 - Historically, [strident] is an acoustic feature descended from Jakobson and Halle’s (1956) original system.

OBSTRUENT $\stackrel{\text{def}}{=} \{[\text{FRICATIVE}], [\text{STOP}], [\text{STRIDENT}]\}$

- Chomsky and Halle (1968:329): “Strident sounds are marked acoustically by greater noisiness than their nonstrident counterparts. ... Stridency is a feature restricted to obstruent continuants and affricates.”
 - More on affricates below.
- But it can also be defined articulatorily as “rough-edge articulation” (Hyman 1975b:39); the noisy friction comes from “having the air strike and bounce off of two surfaces” (ibid.).
- The most common [strident] sounds are the fricatives [s, z, ʃ, ʒ] and the affricates [ts, dz, tʃ, dʒ], often collectively referred to as *sibilants*.
 - In some languages such as Dëne Sųłíné and Gwich’in (both Dene/Athabaskan), these are carefully distinguished from non-[strident] sounds such as [θ, ð, t̪θ, d̪ð].
- Much more rarely, [strident] is also used to distinguish *labiodental* obstruents from *bilabial* obstruents. The former are noisier than the latter.
- The Niger-Congo language Ewe (which is spoken natively by phonologist Prof. Ozouf Amedegnato in our French department) makes such a distinction among its fricatives.

(2) *Ewe* (Ladefoged & Maddieson 1996:139)

éɸá	‘he polished’	éɸá	‘he was cold’
èβè	‘the Ewe language’	èvè	‘two’
éɸlè	‘he bought’	éflé	‘he split off’
èβló	‘mushroom’	évló	‘he is evil’

- This contrast is also made in several Southern Bantu languages such as Kwangali and RuGciriku. E.g., Venda (Tshivenda): *u fana* ‘to resemble’, *u fa* ‘to die’ vs. *u ɸa* ‘to give’; *u vala* ‘to close’ vs. *u βala* ‘to count, to read’ (Ziervogel et al. 1981:7).
- Purepecha (a.k.a. Tarascan), a language isolate of Mexico, also distinguishes [strident] /f/ and non-strident /ɸ/.

OBSTRUENT $\stackrel{\text{def}}{=} \{[\text{FRICATIVE}], [\text{STOP}], [\text{STRIDENT}]\}$

ON AFFRICATES

- When [strident] combines with [stop] in a syllable position with a single place of articulation, the result is a noisy stop —an “affricate” (Shaw 1991; LaCharité 1993; Clements 1999; Kim 2001; Kehrein 2002; Clements 2006).¹¹
 - “The fact that affricates consist of stop + fricative sequences phonetically is best accounted for at the phonetic level, where phonological feature combinations such as [–continuant, +strident] are spelled out sequentially as a succession of acoustic events.” (Clements 1999:272) (Note: [–continuant] $\approx$ [stop])

(3) *Some [strident] sounds in Standard Chinese* (Ladefoged & Maddieson 1996:150)

[fricative]	sá ‘let out’	śá ‘sand’	śá ‘blind’
[stop]	tsá ‘take food with tongue’	ʈśá ‘to pierce’	tśá ‘to add’

- As mentioned above, [lateral], too, can combine with [stop] in a syllable position with a single place of articulation, and the result is a lateral stop —also an affricate.
 - For example, Oowekala has the [strident, stop] affricates /ts, dz, ts’/ as well as the [lateral, stop] affricates /tʎ, dl, tʎ’/.
- There are strong indications that affricates occupy a single syllable position in Oowekyala phonology.
- First, affricates are audibly distinguished from corresponding heterosyllabic stop+fricative sequences.
 - In the case of laryngeally unmarked (voiceless nonglottalized) affricates, the friction noise associated with the release is strong, giving the impression of post-aspiration (Lincoln & Rath 1980:6-8). In contrast, corresponding stop+fricative sequences are separated by an easily detected aspirated release of the stop prior to the fricative articulation (ibid.).

¹¹ Affricates are widely analyzed as [stop]+[fricative] sequences (Leben 1980; Steriade 1982; Archangeli 1984; Sagey 1986b; a; Steriade 1993a; MacKay 1994; Roca 1994; Steriade 1994; Halle 1995:24; Schafer 1995; Weijer 1996; Hall 1997:64, n. 23; Gussenhoven & Jacobs 1998:195-6; Zoll 1998:95; Elzinga 1999:46-7; Morelli 1999:108-10). Problems for this view are outlined below, e.g. fn. 13.

OBSTRUENT $\stackrel{\text{def}}{=} \{[\text{FRICATIVE}], [\text{STOP}], [\text{STRIDENT}]\}$

$$(4) \quad \begin{bmatrix} \text{stop} \\ \text{strident} \end{bmatrix} \quad [\widehat{\text{ts}}^h] \quad \text{vs.} \quad [\text{stop}] \cdot \begin{bmatrix} \text{fricative} \\ \text{strident} \end{bmatrix} \quad [\text{t}^h\text{s}]$$

$$\begin{bmatrix} \text{stop} \\ \text{lateral} \end{bmatrix} \quad [\widehat{\text{tʃ}}^h] \quad \text{vs.} \quad [\text{stop}] \cdot \begin{bmatrix} \text{fricative} \\ \text{lateral} \end{bmatrix} \quad [\text{t}^h\text{ʃ}]$$

- In the case of glottalized affricates, the fricative release and the ejective release appear to be simultaneous, while in the corresponding glottalized stop+fricative sequence, the stop's ejective release is realized before the fricative.

$$(5) \quad \begin{bmatrix} \text{stop} \\ \text{strident} \\ \text{glottalized} \end{bmatrix} \quad [\widehat{\text{ts}}'] \quad \text{vs.} \quad \begin{bmatrix} \text{stop} \\ \text{glottalized} \end{bmatrix} \cdot \begin{bmatrix} \text{fricative} \\ \text{strident} \end{bmatrix} \quad [\text{t}'\text{s}]$$

$$\begin{bmatrix} \text{stop} \\ \text{lateral} \\ \text{glottalized} \end{bmatrix} \quad [\widehat{\text{tʃ}}'] \quad \text{vs.} \quad \begin{bmatrix} \text{stop} \\ \text{glottalized} \end{bmatrix} \cdot \begin{bmatrix} \text{fricative} \\ \text{lateral} \end{bmatrix} \quad [\text{t}'\text{ʃ}]$$

- In the case of voiced /dz/, the 'fricative' component cannot stand on its own in Oowekyala. The sound [z] does not occur independently of [dz] because Oowekyala forbids voiced fricatives (*z, *ʒ, *ʒ^w, *ɣ, *ɣ^w, etc.),¹² whereas it does allow voiced stops (b, d, dz, dl, g, g^w, G, G^w).¹³

$$(6) \quad \begin{bmatrix} \text{stop} \\ \text{strident} \\ \text{voiced} \end{bmatrix} \quad [\widehat{\text{dz}}] \quad \text{vs.} \quad \begin{bmatrix} \text{stop} \\ \text{voiced} \end{bmatrix} \cdot \begin{bmatrix} \text{fricative} \\ \text{voiced} \end{bmatrix} \quad \overset{*}{\neg} [\text{dz}]$$

¹² * means "ungrammatical".

¹³ Such a situation is not uncommon in the world's languages. Taba (Austronesian: Bowden & Hajek 1999:143) and Stoney Dakota (Siouan: Shaw 1980:21) have [stop] /tʃ, dʒ/ but not [fricative] /ʃ, ʒ/; Hungarian has [stop] /tʃ, dʒ/ but not [fricative] /ʃ, ʒ/; Thai has [stop] /tʃ, dʒ/ but not [fricative] /ʃ, ʒ/; Arabic (Thelwall & Sa'adeddin 1999:51), Hausa (Schuh & Yalwa 1999:91), Hindi (Ohala 1999:100) and Igbo (Ikekeonwu 1999) all have [stop] /dʒ/ but no [fricative] /ʒ/; etc. Such asymmetries illustrate a major difficulty for the analysis of affricates as sequences of [stop]+[fricative], as pointed out by Goldsmith (1990:69): "affricates are often found in languages without fricatives (most dialects of Spanish, for example, have a voiceless alveopalatal affricate [tʃ], but no fricative [ʃ])." Indeed, if affricates are composed of a sequence of stop plus fricative, it is surprising that the individuals parts of the affricate —the stop and the fricative— are not both existing units in some languages with affricates.

OBSTRUENT $\stackrel{\text{def}}{=} \{[\text{FRICATIVE}], [\text{STOP}], [\text{STRIDENT}]\}$

- In the case of the affricate /dl/, the lateral component immediately follows the stop release. By contrast, the corresponding /d+l/ sequence is always separated by a brief schwa vowel; that is, /d+l/ is always realized [...d^əl...] in Oowekyala.

$$(7) \quad \begin{bmatrix} \text{stop} \\ \text{lateral} \\ \text{voiced} \end{bmatrix} [\text{dl}] \quad \text{vs.} \quad \begin{bmatrix} \text{stop} \\ \text{voiced} \end{bmatrix} [\text{lateral}] \rightarrow [\text{d}^{\text{ə}}\text{l}]$$

- Impressionistically, affricates also appear to be significantly shorter in duration than their corresponding stop+fricative/lateral sequences. Actual differences in duration have not yet been measured instrumentally, though.
- The phonetic differences just described, combined with the relatively permissive phonotactics¹⁴ of Oowekyala, allow lexical contrasts between affricates and matching stop-fricative sequences, as the following pairs illustrate:

(8) Word-initial contrasts between affricate vs. stop+fricative sequence

- a. [tsə.la] 'to cut through water'
- [t.sə.la] 'pushing'
- b. [ts'a:] 'flow of water, creek flowing'
- [t'.sa] 'to hit sth. with a rock, to bang rocks together, to chip pieces from rocks'
- c. [ts.tsi.la]¹⁵ 'to do what somebody else does or did'
- [tʂ.t.sa] 'push repeatedly'

(9) Word-final contrast between affricate vs. stop+fricative sequence

- [wats'] 'dog'
- [q^wat's] 'crowded together on the field'

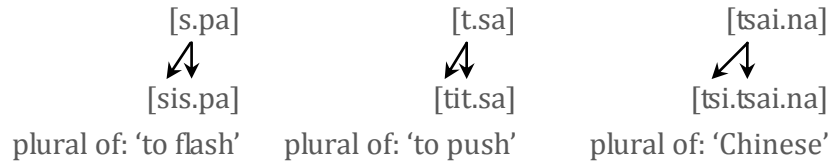
- Plural reduplication also gives evidence that affricates are single subsyllabic units in Oowekyala. The plural in this language normally consists of a copy of the first syllable onset followed by [i] ("C[i]-reduplication"). Crucially, affricates may occur at the beginning of the prefix syllable, while no stop+fricative sequence may occur in this position, as illustrated in (10) and (11).

¹⁴ "Phonotactics" is the set of constraints on sequencing sounds in a language.

¹⁵ A sequence like [ts.ts] is doubly released: [tʂ^htʂ^h].

OBSTRUENT $\stackrel{\text{def}}{=} \{[\text{FRICATIVE}], [\text{STOP}], [\text{STRIDENT}]\}$

(10) Plural reduplication with consonant sequences vs. affricate



(11) Plural form with word-medial contrasts between affricate vs. stop+fricative

- a. [tsi.tsai.na] plural of: 'chinese'
- [ts'i.ts'm:] plural of: 'index finger'
- [tʰ'i.tʰa:] plural of: 'black bear'
- b. [tit.sa] plural of: 'to push'
- [tit.ʎa] plural of: 'to bait'
- [t'at.ʎa] plural of: 'to slice fish parallel to the backbone'
- [t'it.ʎa] plural of: 'to soak dried fish'

- The same point can be made with other aspects of morphology (word-formation) in Oowekyala. For example, the suffix *-axsala* 'aimlessly' regularly triggers the emplacement of a vowel [a:] in otherwise vowelless roots, e.g.:

(12) *-axsala* 'aimlessly'

- a. [χ^wa.tax.sa.la] 'cut any way, carelessly'
- cf. [χ^w.ta] 'to cut with a knife'
- b. [gaa.lax.sa.la] 'to crawl aimlessly'
- cf. [g^o.la] 'to crawl, to go on all fours'
- c. [jaa.χ^wax.sa.la] 'dance any way with no order/pattern'
- cf. [j^oχ^wa] 'to dance, to make dancing movements'

- Crucially, the 'stop' and 'fricative' components of affricates such as /tʰs/ do not get separated (*[t'a:s...]) by the morphologically-inserted vowel, e.g. (13a,b), whereas stop+fricative sequences such as /t.s/ do get separated, e.g. (13c).

(13) *-axsala* 'aimlessly'

- a. [ts'a:.max.sa.la.g^o.liʔ] 'to point around indoors'
- [ts'^o.ma] 'to point'

OBSTRUENT $\stackrel{\text{def}}{=} \{[\text{FRICATIVE}], [\text{STOP}], [\text{STRIDENT}]\}$

- b. [ts'a:nax.sa.la] 'to proceed all over the place'
 [ts'ə.na] 'to walk in a group, go in the same direction as others, parade'
- c. [ta:sax.sa.la] 'push here and there'
 [t.sa] 'to push, press against'

FEATURES AS MORPHEMES

- A distinctive feature can signal a morpheme on its own.
- For example, in Nuer, a Nilo-Saharan language of Sudan (Crazzolara 1933; Lieber 1987; Akinlabi 1996), the features [stop] and [fricative] signal tense/aspect distinctions.
 - As the data in (14) illustrate, the morphemes for 'negative present participle' and 'past participle' are [stop] and [fricative], respectively. These morphemes are apparently "suffixes", as their features are added to the ends of verbs.¹⁶

(14)	<i>Pres. pple. neg.</i>	<i>Past pple.</i>	
a.	[còp]	[cof]	'to overtake'
	[kèp]	[kèf]	'to scoop (food) hastily'
b.	[loṭ]	[loθ]	'to suck'
	[jæṭ]	[jæθ]	'to wade'
c.	[pa:t]	[pà:ɸ]	'to sharpen'
	[wɪt]	[wɪɸ]	'to cut a point'
d.	[ja:c]	[ja:ç]	'to hit'
	[jɛ̀:ç]	[jɛ̀:ç]	'to dismiss a person'
e.	[jæk]	[jæh]	'to throw away'
	[jək]	[jəh]	'to find'

- As Akinlabi (1996:253) remarks, "the past participial morpheme [in Nuer] ... under any analysis must include the feature [continuant]."

¹⁶ These morphemes must also include a voiceless feature, since the resulting codas are always voiceless, whereas some infinitive forms show final voicing, e.g. [cob] 'to overtake', [guð] 'to pull out' (cf. [ja:ç] 'to hit', [kèp] 'to scoop hastily').

OBSTRUENT $\stackrel{\text{def}}{=} \{[\text{FRICATIVE}], [\text{STOP}], [\text{STRIDENT}]\}$

- Lieber (1987) and Akinlabi (1996) indicate that two other suffixes in Nuer — *-kɔ* ‘1st pers. ind. pres. act.’ and *-ɛ* ‘3rd pers. ind. pres. act.’ — each begin in a [fricative] feature which has the same phonological effect as the past participle.
- In Dene/Athabaskan languages like Navajo (AZ, NM, UT, CO), certain morphemes have what is referred to as a “d-effect” (Howren 1971):
 - “The d-effect introduces an initial period of closure to the fricative.” (McDonough 2003:5)
 - The standard analysis of the d-effect is to add a [stop] feature to the stem-initial onset, e.g. Navajo (Speas 1984; Wright 1984), Slave (Rice 1987), Sekani (Hargus 1985), Tahltan (Shaw 1991).
 - The “d-effect” on stem-initial onsets is illustrated in (15a). Of course, no “d-effect” is apparent on stems which already begin with [stop] (15b).

(15) *D-effect in Navajo* (Bennett 1987; McDonough 2003)

	<i>stems</i>	<i>d-effect</i>	
a.	-yá:t	[ji.ká:t]	‘it’s being shaken’
		[ji.ká:t]	‘we shook it’
	-zí:t	[ʔá.tá ja.ji:tsí:t]	‘he’s pouring it for himself’
	-zin	[ni:tsin]	‘we think’
	-ziʔ	[jé:tfiʔ]	‘he was called’
	-ze:ʔ	[a.ti:tfje:ʔ]	‘we spit’
	-ló:s	[ji.tʰó:s]	‘it is being led along’
	-lí:ʔ	[si:tʰíʔ]	‘we became’
	-á	[ji:tá]	‘we eat’
	-ʔi	[ji.tʰí]	‘he’s visible’
b.	-ʔá:l	[ji:tʰá:l]	‘we’re carrying it along’
	-pí:	[ʔa.ta:h jo:pí:]	‘he stripped them off himself’
	-tsí:ʔ	[ha:s.tsí:]	‘I spoke’
	-tʃʰit	[ʔá.tí.tʃʰit]	‘he’s scratching himself’
	-tʰe:f	[ʔá.tí.tʰe:f]	‘he’s blackening himself with charcoal’

OBSTRUENT $\stackrel{\text{def}}{=} \{[\text{FRICATIVE}], [\text{STOP}], [\text{STRIDENT}]\}$

-tʃih	[ʔá.te:ʃ.tʃih]	'he grabbed himself'
-kiʃ	[ʔá.te:ʃ.kiʃ]	'he cut himself'
-k ^h a:t	[ná.ʔá.to: k ^h a:t]	'he slapped himself'

GLOBAL VS. POSITIONAL CONSTRAINTS

Global (context-free) constraints

- [fricative] appears to be more *marked* than [stop] (Chomsky & Halle 1968:406; Lass 1984:151; Morelli 1999:186; Roca & Johnson 2000:585).
- While all languages have stops, there are languages with no fricatives at all.
 - Maddieson (1984) reports 18 such languages in his sample of 317 languages.
 - Lass (1984:151) reports 21 such languages.
 - An example is Dinka (Nilotic: Andersen 1993; Telfer 2003): it has many stops (p, b, t, ɗ, t, d, c, ɟ, k, g, etc.) but no corresponding fricatives (*f, *v, *θ, *ð, *s, *z, *ʃ, *ʒ, *x, *ɣ, etc.).
 - Another example is Yidiñ (Australian: Dixon 1977:32): its only obstruents are /b, d, ɟ, g/ —all stops.
- Also suggestive is the fact that among normal children [stop] is acquired before [fricative].
 - “Segments specified [–continuant] are acquired earlier than those specified as [+continuant]” (Ueda 1996:17 on Child Japanese)
 - [–continuant] ≈ [stop]; [+continuant] ≈ [stop]
 - Halle & Clements (1983) illustrate the substitution of stops for fricatives in Child English.
 - See also Beers (1996) on Child Dutch.

OBSTRUENT $\stackrel{\text{def}}{=} \{[\text{FRICATIVE}], [\text{STOP}], [\text{STRIDENT}]\}$

Positional constraints

- The phonological feature [stop], though unmarked relative to [fricative], is commonly avoided in syllable coda position.¹⁷ For example:
- Irish (Goidelic; Ireland, UK, etc.), e.g., Gussmann (2002:93): “Irish specifically limits the range of melodies that can appear in the coda by banning plosives from that position.”¹⁸
- Navajo (Dene; AZ, NM, UT, CO), e.g., Bennett (1987:4) re: “constraint [–continuant] cannot be connected to a segment X if X is in coda position.” ([–continuant] $\approx$ [stop])
- Toba Batak (Austronesian, Indonesia): “In general, non-geminate clusters in which the first C is a noncontinuant obstruent other than [ʔ], do not occur or are marginal, while clusters in which the first C is [ʔ s ŋ l r] are permitted” (Crowhurst 2001:573, fn. 17).
- Kiribati (Austronesian, Kiribati: Groves et al. 1985; Trussel 1986; Inkelas & Cho 1993:554, fn. 24): onsets include /b, t, k, m, n, ŋ, w, v, r/; [stop] /b, t, k/ are excluded from codas.
- Chachi (Barbacoan, Ecuador): “Any consonant may fill the first C slot of syllables, while syllables may be closed by /n, ŋ, ʔ, h, s, š/.” (Lindkoog & Brend 1962:37). Coda /m/ is also found (Moore 1962:273). Specifically excluded are [stop] /p, b, t, d, ts, tʃ, dʃ, k, g/, as well as [lateral] /l, lʲ/ and [rhotic] /r/.
- Huariapano (Panoan, extinct/Peru: Parker 1994)
- As mentioned above, Yidiñ (Australian: Dixon 1977:47) has stops (b d ʔ g) but no fricatives. Its stops are restricted to onsets, whereas all and only its sonorants are permitted in codas (m, n, p, ŋ, l, r, ɾ, j).

¹⁷ The term ‘coda’ was apparently introduced by Hockett (1955).

¹⁸ The word-final position is exceptional; “practically any consonant can appear word-finally in Irish” (ibid.); see Gussmann (2002:92-5) for details.

OBSTRUENT $\stackrel{\text{def}}{=} \{[\text{FRICATIVE}], [\text{STOP}], [\text{STRIDENT}]\}$

- Aslanbeg Armenian (Indo-European; Vaux 2001): “only the segments [ʔ j r l m n f v s z ʃ ʒ ʔ Ɂ] are allowed to occur in Aslanbeg codas; illicit segments are either changed into licensed segments ... or deleted.” Excluded are all stops: /p^h, b, d, t^hʔ, tʃ, dʒ, k^h, g/.
- Castillian Spanish, e.g., Morris (1998:202): “Coda obstruents may not be [–cont].” (Note: [–cont(inuant)] ≈ [stop].) Accordingly, [stop] is actively replaced by [fricative] in codas, e.g., *ético* [eθniko].
 - Phonological processes which remove [stop] are termed “spirantization” or “deocclusivization”
- In child English as well as in disordered speech, it has been reported that stops are blocked from syllable-coda position, while both fricatives and nasals are freely permitted in this position (Bernhardt & Stemberger 1998b:593-7).
- On the other hand, some languages ban [fricative] but not [stop] in coda position. For example:
- Thai (Tai-Kadai, Thailand: Henderson 1949): allowable codas include /p, t, k, m, n, ŋ, ʔ/; among the excluded are [fricative] /f, s/ as well as [lateral] /l/ and [rhotic] /r/.
- Pakaásnovos (Chapacura-Wanham, Brazil: MacEachern et al. 1997:18): only /p, t, k, m, n, ʔ/ are permitted word-finally; [fricative] /s~ʃ, ʍ/ and [rhotic] /r/ are restricted to onsets.
- Finally, the features [stop] and [fricative] can both be banned from syllable codas. For example:
- Arawakan languages (Caribbean, Central/South America): “In most languages syllable structure is (C1)V(V)(C2), where C1 can be any consonant, and C2 can only be a glide (*w* or *y*), a nasal, or, rarely, a liquid or *h*.” (Aikhenvald 1999:78)
- The West African language Hausa has undergone a consonantal change known as *Klingenheben’s Law*, whereby “a coda segment must be a sonorant” (Clements & Hume 1995:276). The following data suggest that when [stop] and [fricative] are removed from

OBSTRUENT $\stackrel{\text{def}}{=} \{[\text{FRICATIVE}], [\text{STOP}], [\text{STRIDENT}]\}$

Hausa codas, labial and velar obstruents turn into [w] (16a), and that coronal obstruents turn into [r] (16a).

(16) *Hausa* (Clements & Hume 1995)

a.	/d̥zibd̥zi:/	[d̥zuwd̥zi:]	‘trash heap’	cf.	[d̥ziba:d̥ze:]	‘pl’
	/taffi:/	[tawfi:]	‘drum’		[tafa:fe:]	‘pl’
	/talakt̪i:/	[talawt̪i]	‘poverty’		[talaka]	‘a poor one’
	/hagni/	[hawni]	‘left side’		[bahago]	‘lefthanded one’
b.	/fatke/	[farke]	‘merchant’		[fata:ke]	‘pl’
	/maz-maza/	[marmaza]	‘very fast’			
	/k’as-k’as-i:/	[k’ark’asi:]	‘underside’			

- The Hausa ban on [stop] and [fricative] in codas remains in effect, but it is unclear to me whether the specific repair to [w, r] remains active.
 - Phonological processes which actively remove [stop] and/or [fricative] from a given position (typically the syllable coda) are termed “lenition” or “weakening”.
- Turning to syllable onsets, “weak” consonants such as the glides/semi-vowels [j, w] are occasionally banned from this position.
 - Phonological processes which actively add [stop] and/or fricative to a position (typically the syllable onset) are termed “fortition” or “strengthening”.
- In some varieties of Spanish (notably in Argentina, but also in parts of Mexico and Spain, e.g. Andalusia and Extremadura) the palatal glide /j/ acquires the feature [fricative] or [stop] in onset position.
 - E.g., [j] in *convoy* ‘convoy’, *ley* ‘law’ may correspond to [j̥ ~ j̃ ~ ʒ ~ dʒ] in *convoyes* ‘convoys’, *leyes* ‘laws’ (Harris 1983; Hume & Odden 1994).
- Some speakers of Spanish pronounce onset /w/ as fricative [ɣw] or stop [gw].
 - “for several words there are alternative spellings: *huarache* ~ *guarache* ‘type of sandal’; *huero* ~ *güero* ‘empty’, Mex. ‘blond’; *huiro* ~ *güiro* ‘type of gourd’. When the Spanish Academy decided to nativize the word *whisky* as *güisqui*, some people

OBSTRUENT $\stackrel{\text{def}}{=} \{[\text{FRICATIVE}], [\text{STOP}], [\text{STRIDENT}]\}$

complained that with this spelling the Academy was promoting a colloquial or substandard pronunciation.” (Hualde 2005:171, fn. 19)

- “In some Latin American countries the English borrowing *watchman* has been adapted as *guachimán*.” (Hualde 2005:172)
- In the syllable onsets of Early Pre-Gwich’in (Dene, NT, YK, AK: Leer 1996), glides /j, w/ changed into fricatives /ʒ, v/, and nasals /m, n/ evolved into prenasalized stops /^mb, ⁿd/.
- Moreover, onset /l, h, ʔ/ behave phonologically as [fricative] /ɬ/, [fricative] /h/ and stop /ʔ/, respectively (see Rice 1993 for details). Consequently one could argue that Gwich’in onsets are obligatorily specified [stop] or [fricative].

ASSIMILATION AND DISSIMILATION

- Assimilation of [stop] or [fricative] is rare.
- One case occurs in Bilaala (a.k.a. Naba), a Nilo-Saharan language of Chad (Olson & Schultz 2002). When added to stems ending in [stop] and [fricative], the third person singular suffix /-ɲə/ becomes [-dʒə] and [-zə], respectively (17). This clear pattern of progressive assimilation is limited, however. For instance, the initial nasal of -mə ‘my/me’ does not assimilate [stop] or [fricative], as shown in (18): *[bobbe], *[gɔrdbə], ...

(17) *Bilaala 3rd person singular* /-ɲə/

bɛr-ɲə	‘his slave’	bob-dʒə	‘his father’
kuhul-ɲə	‘his hip’	gɔrd-dʒə	‘his knife’
kaw-ɲə	‘its length’	gag-dʒə	‘his plant’
mon-ɲə	‘his child’	kuz-zə	‘his hut’

(18) *1st pers. sing.* /-mə/

bob-mə	‘my father’
gɔrd-mə	‘my knife’
gag-mə	‘my plant’
kuz-mə	‘my hut’

- Obvious cases of [strident] assimilation are also rare.¹⁹

¹⁹ This plausibly has to do with the fact that the feature [strident] is defined *acoustically*, whereas assimilation is typically understood *articulatorily*. As Grammont (1933:185) writes: « L’assimilation consiste dans l’extension d’un ou de plusieurs mouvements articulatoires au delà de leur domaine

OBSTRUENT $\stackrel{\text{def}}{=} \{[\text{FRICATIVE}], [\text{STOP}], [\text{STRIDENT}]\}$

- Still, a possible case of [strident] assimilation is found in Plains Cree (Algonquian: Hirose 1997).
- The diminutive ('little') suffix in this language is [-isis ~ -sis ~ -is ~ -s], e.g. (19a). When this suffix is added to a stem, all [t]'s become [strident] affricates [ts], e.g. (19b).

(19) Diminutives in Plains Cree

	<i>Non-diminutives</i>		<i>Diminutives</i>
a.	[sa.ka.hi.kan] 'lake'	[sa.ka.hi.ka.ni.sis]	'small lake'
	[pi:.si.moh.ka:n] 'clock'	[pi:.si.moh.ka:.nis]	'watch'
	[mi.no:s] 'cat'	[mi.no:.sis]	'kitten'
	[jo.tin] 'it is windy'	[jo.tsin]	'it is a little windy'
	[wa:.ti] 'hole in ground'	[wa:.tsi]	'little holes'
b.	[as.to.tin] 'a/the hat'	[as.tso.tsi.nis]	'a little hat'
	[ni.ni.toh.ten] 'I listen'	[ni.ni.tsoh.tse.sin]	'I listen a little'
	[a.tim] 'dog'	[a.tsi.mo.sis] ²⁰	'a/the little dog'
	[mis.ta.tim] 'horse'	[mis.tsa.tsi.mo.sis]	'foal, pony'
	[ni.tem] 'my horse'	[ni.tse.mi.sis]	'my little horse'
	[a.tos.kew] 's/he works'	[a.tsos.ke.siw]	's/he works a little'
	[mis.ti.kwas.ki:k] 'drum'	[mis.tsi.kwas.ki:.ki.sis]	'hand drum'

- Dissimilation of [fricative] appears to be especially common.
- According to McCarthy (1988:98): "In Piro [an Arawakan language of Peru], clusters of two fricatives s, ʃ, and x cannot occur — that is, there is a dissimilatory ... effect of [+continuant]." (Note: [+continuant] ≈ [fricative].)
- [fricative] dissimilation is also evident in certain alternations in Greek. For example, the passive aorist suffix is -*θik*, e.g. (20a), except after fricatives, where it is realized as -*tik*, e.g. (20b).

originnaire. Ces mouvements articulatoires sont propres au phonème agissant; le phonème agi, en se les appropriant aussi, devient plus semblable à l'autre. »

²⁰ This form derives from /atimw-/ 'dog' + /-isis/ 'small' (/wi/ → [o]); compare *atimw-ak* 'dogs'.

OBSTRUENT $\stackrel{\text{def}}{=} \{[\text{FRICATIVE}], [\text{STOP}], [\text{STRIDENT}]\}$

(20) *Greek* (Spencer 1991)

a.	agap-i-θik-e	'he was loved'	cf.	agap-a-	'love'
	fer-θik-e	'he was carried'		fer-	'carry'
	stal-θik-e	'he was sent'		stel-	'send'
b.	akus-tik-e	'he was heard'		akus-	'hear'
	ðex-tik-e	'it was received'		ðex-	'receive'
	yraf-tik-e	'it was written'		yraf-	'write'

- Turning now to [strident] dissimilation, an example is reported in the isolate Basque. LaCharité (1993:164) gives the rule in (21) for this language. As she explains: "When the morphology juxtaposes two [strident] specifications, the rightmost is deleted, leaving a homorganic stop" (ibid.).

(21) *Strident dissimilation in Basque*

X	X		X	X	/ikas-/ 'learn' + /-tsen/ 'imperfect'	[ikasten]
		→		†	/irabaz-/ 'earn' + /-tsen/ 'imperfect'	[irabazten]
*[stri]	[stri]		[stri]	[stri]	/ipin-/ 'put' + /-tsen/ 'imperfect'	[ipin.tsen]

- Modern Yucatec Maya (Straight 1976; Lombardi 1990; LaCharité 1993) is also described as having [strident] dissimilation, since it forbids C_1VC_2 roots in which C_1 and C_2 are [strident], e.g.:

(22) *Disallowed root shapes in Yucatec Maya*

*sVts	*tsVs	*fVs	*tjVs
*sVʃ	*tsVʃ	*fVts	*tjVts
*sVtʃ	*tsVtʃ	*fVtʃ	*tjVʃ etc.

- Blust (2002) also reports sibilant dissimilation in the development of Kiput, a North Sarawak Austronesian language.

ASSIBILATION

- A common phonological process involving the feature [strident] is called *assibilation*.

OBSTRUENT $\stackrel{\text{def}}{=} \{[\text{FRICATIVE}], [\text{STOP}], [\text{STRIDENT}]\}$

- This is a process in which a stop becomes [strident], usually preceding a high vocoid (vowel or glide).
 - For example, in Japanese, the stop /t/ is affricated to [ts] before the high back vowel [u], and to [tʃ] before the high front vowel [i], e.g. (23a). Assibilation fails before other vowels, e.g. (23b).

(23) Assibilation in Japanese

a.	/tat-u/	[ta.tsu]	'to stand' + PRES
	/tat-i-mas-u/	[ta.tʃimasu]	'to stand' + POLITE + PRES
b.	/tat-e/	[tate]	'to stand' + IMP
	/tat-a-nai/	[tatanai]	'to stand' + NEG
	/tat-oo/	[tatoo]	'to stand' + COHORT

- Historically, this also happened in the change from Proto-Bantu to Mvumbo, a language spoken in Cameroon and Equatorial Guinea (Kim 2001:91):
- The syllable onset stops /b d t g k/ of Proto-Bantu became affricated in Mvumbo, to /dʒ tʃ/ before /i/, as in (24a), and to /bv pf/ before /u/, as in (24b). Stops before nonhigh vocoids in Proto-Bantu were not affricated historically, e.g. (24c).
- In other words, [stop] became [strident] before high vowels.

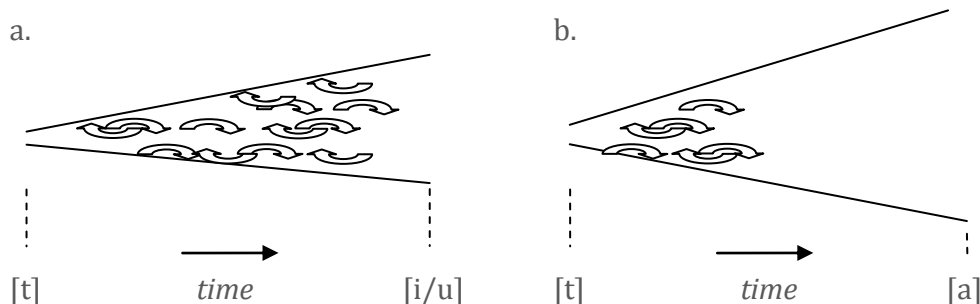
(24)	<i>Proto-Bantu</i>	<i>Mvumbo</i>	
a.	*-ti:tu	tʃir	'animal'
	*-dib-	dʒiwo	'shut'
	*-gida	ma-tʃie	'blood'
	*-kingo	tʃiuŋ	'neck, nape'
b.	*-buma	bvumo	'fruit'
	*-dut	-bvure	'pull'
	*-tud-	-pfule	'forge'
	*-gubu	m-bvu:	'hippopotamus'
	*-kuba	pfuwo	'chicken'
c.	*-bod	-buo	'become rotten'
	*-di	-di	'eat'
	*-to:g	-tuog	'boil up'
	*-gada	-kala	'mat'
	*-konde	-kwande	'banana'

- Assibilation appears to be a kind of “acoustic assimilation”.

OBSTRUENT $\stackrel{\text{def}}{=} \{[\text{FRICATIVE}], [\text{STOP}], [\text{STRIDENT}]\}$

- As Kim (2001) explains, the narrow channel which is created in the transition between a stop and a following high vowel (or glide) generates an especially long turbulence, which speakers interpret as a [strident] feature on the stop.
- That is, the frication duration after the /t/ release is much longer before the high vowels /i u/ than before the non-high ones. The longer duration of turbulent airflow in the release of [t] into a high vowel vs. nonhigh vowel is schematized in (25a) vs. (25b).

(25) *Generation of stridency after [t] release*



- Kim (2001:102): The generation of air turbulence in the context of phonological assimilation is phonologically interpreted as the insertion of the feature [strident] into the feature complex characterising the plosive in a plosive + high vocoid sequence...
- Assimilation appears to be especially common with high front vowels. As shown in the following data, in Modern Korean /t, t^h/ become [strident] before just [high, front] vowels, not before any [high] vowel.

(26) *Modern Korean*

a.	/mat-i/	[ma.dzi]	'first child' (-i Nomin.)
	/p ^h iput ^h -i/	[p ^h i.pu.ts ^h i]	'one's own child'
	/pat ^h -ilaŋ/	[pa.ts ^h i.raŋ]	'field and' (-ilaŋ 'and')
	/sot ^h -ilaŋ/	[so.ts ^h i.raŋ]	'kettle and'
b.	/kat ^h -u/	[ka.t ^h u]	'to be the same' + ques
	/put ^h -imjən/	[pu.t ^h i.mjən]	'to attach' + 'if'

OBSTRUENT $\stackrel{\text{def}}{=} \{[\text{FRICATIVE}], [\text{STOP}], [\text{STRIDENT}]\}$

- *t*-assibilation before [i] is also regular in Blackfoot, an Algonquian language of Southern Alberta and Northern Montana (Taylor 1969; Frantz 1991), e.g. (27).

(27) *Blackfoot*

a.	/nit-i:tsiniki/	[ni.tsi:.tsi.ni.ki]	'I related (a story)'
	1-relate		
	/nit-a-i:tsiniki/	[ni.tɛ:.tsi.ni.ki]	'I am relating (a story)'
	1-DUR-relate		
b.	/kit-i:tsiniki/	[ki.tsi:.tsi.ni.ki]	'you related (a story)'
	2-relate		
	/kit-a-i:tsiniki/	[ki.tɛ:.tsi.ni.ki]	'you are relating (a story)'
	2-DUR-relate		
cf.	/i:tsiniki-wa/	[i:.tsi.ni.ki.wa]	'he related (a story)'
	relate-3		
	/a-i:tsiniki-wa/	[ɛ:.tsi.ni.ki.wa]	'he is relating (a story)'
	DUR-relate-3		

- *t*-assibilation before [i] is also apparent in Asháninca (Campa), an Arawakan language of Peru (Spring 1992), e.g. (28).

(28) *Asháninca*

a.	/no-kant-i/	[nokan.tsi]	'I said'
	I-say-NF (nonfuture)		
b.	/no-ant-i/	[nan.tsi]	'I did'
	I-do-NF		
c.	/no-misi-i/	[nomisi.tsi] ²¹	'I dreamed'
	I-dream-NF		

- Similarly, /t, d/ undergo assibilation in Kpándo, a Gbe language of Ghana (Capo 1991), e.g. (29).

(29) *Gbe* *Gen* *Kpándo*

²¹ This form has an epenthetic [t], which is regularly added between a vowel-final stem and a vowel-initial suffix.

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a.	*a.tí	a.tí	a.tsí	'tree'
b.	*ti	ti	tsi	'be fed up'
c.	*di.di	di.di	dzi.dzi	'to be far'
d.	*dí	(dʒí)	dzí	'to look for'

- Optional assibilation yields [ts, dz] or [tʃ, dʒ], depending on the dialects or individuals in Fongbe (Lefebvre & Brousseau 2002:25)

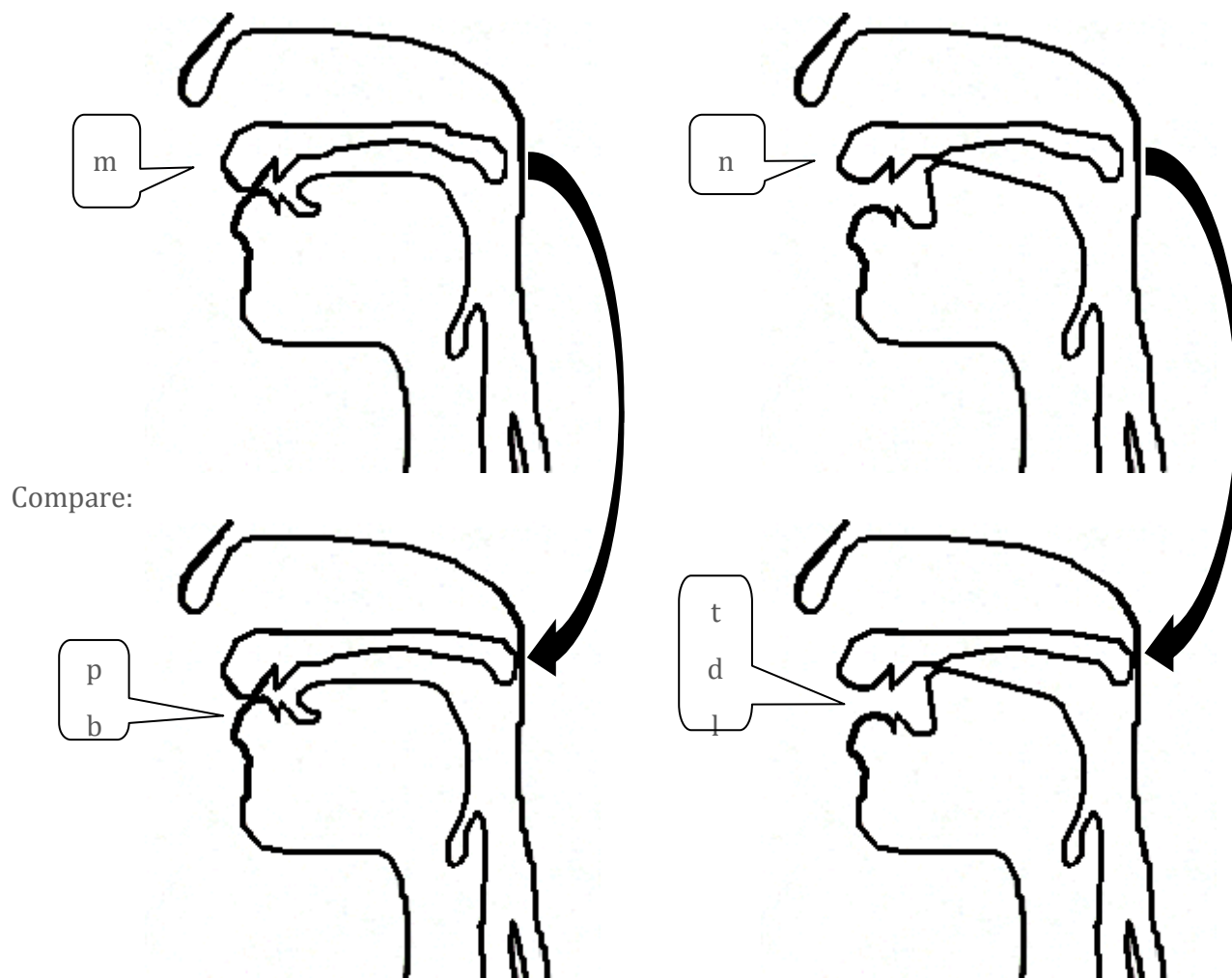
(30) [dí ~ dzí ~ dʒí] 'be very good'
 [tì ~ tsì ~ tʃì] 'squeeze'

- Brazilian Portuguese shows a similar pattern (Ohala & Solé 2010:50), e.g.:
 - [gãndʒi] 'Gandhi'
 - [internɛtʃi] 'internet'
- Some dialects of English also assibilate /t/ (Ohala & Solé 2010:50), e.g.:
 - [tʰi:] 'tea'

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Nasal $\stackrel{\text{def}}{=} \{[\text{nasal}]\}$

- $[\text{nasal}]$ is a privative feature (Steriade 1993a:374ff.)
- This *manner* feature has an articulator of sorts in the soft palate (velum).



- Chomsky and Halle (1968:316) define $[\text{nasal}]$ as follows: “Nasal sounds are produced with a lowered velum which allows the air to escape through the nose; nonnasal sounds are

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produced with a raised velum so that the air from the lungs can escape only through the mouth.”²²

- The psychological reality of the feature [nasal] is apparent in speech errors.
 - E.g., [nasal] trades places with [stop] in *Cedars of Lebanon* >^e *Cedars of Lemadon*, an error reported by Fromkin (1971).²³
- While a lowered velum may well be the default for humans, nasality is marked relative to orality in language (Chomsky & Halle 1968:405).²⁴
 - For instance, global deletion of [nasal] is common in child language, e.g.:²⁵

(1) *Child English: Sally* (Bernhardt & Stemberger 1998a:320)

mask [pæks]
mouthy [bʌʊθi:]
music [tusɪk]

²² This definition of [nasal] is simplistic phonetically. If you’re interested:

During the production of oral phonemes, the velum moves in a superior and posterior direction with a type of “knee action” to achieve closure against the posterior pharyngeal wall. ... The posterior pharyngeal wall often moves anteriorly to assist in achieving contact. The lateral pharyngeal walls move medially to close against the velum, or in some cases, to meet in midline behind the velum. There are three basic patterns of normal velopharyngeal closure. Some normal speakers demonstrate closure primarily through the action of the velum and posterior pharyngeal wall (coronal pattern), while with other normal speakers, closure is achieved primarily from the medial movement of the lateral pharyngeal walls, which meet in midline (sagittal pattern). In some speakers, all structures move equally to achieve closure (circular pattern). Regardless of the basic closure pattern, velopharyngeal closure occurs as a valve or sphincter through coordinated action of these structures. The velopharyngeal valve closes for the production of oral sounds and opens with the production of nasal sounds. (Kummer & Marsh 1998:614)

²³ The raised ^e stands for ‘error’.

²⁴ Velopharyngeal closure is the norm only during speech. The velum is at rest during normal breathing (thank goodness; cf. fn. 22 on p. 78).

²⁵ Bernhardt and Stemberger attribute the variation between voiceless and voiced stops in the substitution process to the fact that Sally “did not yet have a voicing contrast” (ibid.).

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noise [towəs]

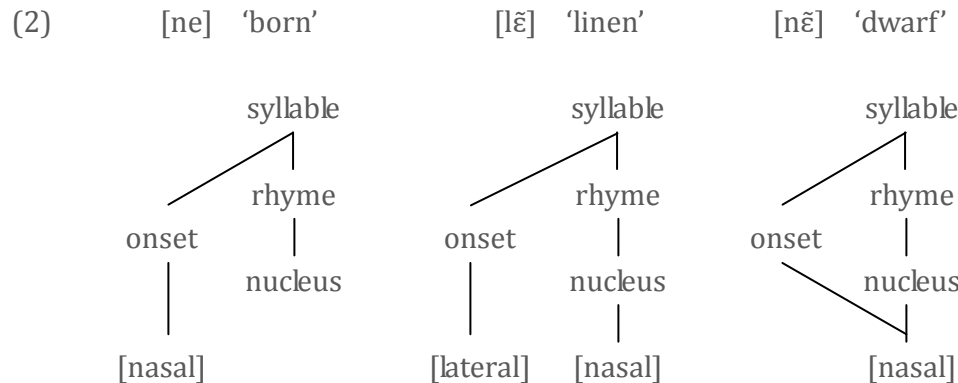
plum [bap^h]

- There are also natural languages in which the feature [nasal] is banned entirely, such as South Wakashan Ditidaht and Makah (Klokeid 1977).²⁶
 - E.g., the root *naq-* ‘to drink’ in North Wakashan Oowekyala has the cognate *daq-* in these other languages.
- Wichita and Pawnee, two Caddoan languages spoken in Oklahoma, are also without nasals (Rood 1975; Parks 1976).
 - As Parks (1976:19, n. 1) remarks: “Besides having so few consonants [it has just eight: p t ts k s w r h], Pawnee is also unusual in that it has no nasal consonants —neither phonetically nor phonemically.”
- Hidatsa and Crow are two Siouan languages which lack overt nasals as well (Matthews 1958).
- More typically, however, languages have at least one nasal, and a language with any nasal has an alveolar or dental consonant, e.g., /n/ (Maddieson 1984:69). The labial nasal consonant /m/ is also relatively common.
- The velar nasal /ŋ/ appears to be relatively marked. As Maddieson (1984:69) reports, the presence of /ŋ/ in a language implies the presence of both /m/ and /n/, but not vice versa.
 - Oowekyala is an example of a language with /m, n/ (also /ṁ, ṇ, mː, nː/) but no /ŋ/.
 - E.g., English ‘king’ is adapted as *kin* in Oowekyala (Hilda Smith, p.c.).
- Many languages contrast oral and nasal vowels.

²⁶ This feature is also shared by Twana and Lushootseed, two unrelated languages spoken in the same area.

NASAL $\stackrel{\text{def}}{=} \{[\text{NASAL}]\}$

- French is a well-known language with both nasal consonants and nasal vowels. A sequence of nasal consonant plus nasal vowel may even share their [nasal] specification.



- An oral vowel can precede a nasal, whether tautosyllabic (3a) or heterosyllabic (3b). However, French avoids a nasal vowel followed by a nasal consonant, whether tautosyllabic or heterosyllabic.

(3) VN in French

- a. [man.kɛ̃] 'mannequin' [kʁɛ̃m.lɛ̃] 'Kremlin'
 [y.kam] 'UQAM'²⁷ [ab.do.mɛ̃n] 'abdomen'
 [ɛ̃.sɔ̃m.ni] 'insomnia' [ɛ̃.dɛ̃m.ni.te] 'indemnity'
 [lɛ̃m.da] 'Linda' [sam.dzi] 'Saturday'
 [al.bɔ̃m] 'album' [a.ga.mɛ̃m.nɔ̃] 'Agamemnon'
- b. [a.mi] 'friend' [a.ɲo] 'lamb'
 [ba.nal] 'banal' [bɔ̃.nœ̃ʁ] 'happiness'

- Following are some minimal pairs illustrating the contrast between oral and nasal vowels in Stoney-Nakoda, a Siouan language spoken west of Calgary.

- (4) [hi] 'blade of knife' [hĩ] 'fur'
 [ha] 'skin' [hã] 'yes'
 [hu] 'intercourse' [hũ] 'how about it'

²⁷ Université du Québec à Montréal.

NASAL $\stackrel{\text{def}}{=} \{[\text{NASAL}]\}$

- Unlike French, Nakoda allows a nasal vowel to be followed by a nasal consonant, whether tautosyllabic (5a) or heterosyllabic (5b).

(5) $\tilde{V}N$ in Nakoda

a.	[te.hǎn]	‘far’	[otǎn ja]	‘go straight’
	[kĩ.jǎn]	‘near’	[dohǎn]	‘when’
b.	[ĩ.nǎ]	‘mother’	[ĩ.nǎ.zĩ]	‘stop’

- The oral/nasal opposition is implemented *phonetically* in interesting ways. On the one hand, when a nasal vowel precedes a consonant, there is a nasal consonantal transition (6a). On the other hand, when an oral vowel precedes a nasal consonant, there is an oral consonantal transition (6b).

(6) VC transitions in Nakoda

a.	[tǣ.pa]	[[tǣmp ^h a]]	‘chokecherry’	[nũ.ba]	[[nũmba]]	‘two’
	[tǣ.de]	[[tǣnde]]	‘heart’	[o.ʒĩ.dʒa]	[[oʒĩndʒa]]	‘bear’
	[hũ.ga]	[[hũŋga]]	‘chief’	[ta.tǣ.ga]	[[t ^h at ^h ǣŋga]]	‘buffalo’
b.	[tin]	[[t ^h idn]]	‘inside’	[tʃak.tam]	[[tʃaktabm]]	‘left-side’
	[gan]	[[gadn]]	‘there’	[hũ.gam]	[[hũŋgabm]]	‘up’
	[tokan]	[[t ^h ok ^h adn]]	‘fox’	[tǣ.gan]	[[tǣŋgadn]]	‘outside’

- Maxacalí (Wetzels 2009) is an indigenous Brazilian language with nasal vowels, but its nasal consonants are always derived by assimilation.

(7) Some Maxacalí words borrowed from Brazilian Portuguese

a.	[tǣ'mãm]	‘soap’	< BP [sa'bãũ]
	[pẽpõŋ]	‘beans’	< BP [fe'ʒũ]
b.	[bah'tet]	‘hammer’	< BP [mah'telʊ]
	[kuɖi'bet]	‘pocketknife’	< BP [kani'vetʃi]
c.	[tõ'mãn]	‘tomato’	< BP [tũ'matʃ]
	[kõ'mẽn]	‘shop’	< BP [kõ'mehs]

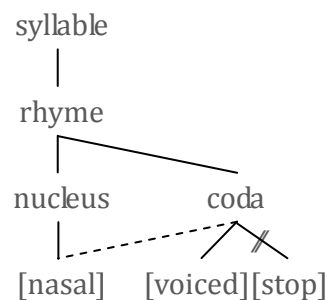
NASAL $\stackrel{\text{def}}{=} \{[\text{NASAL}]\}$

- Another example of [nasal] assimilation comes from Canadian French: in this dialect voiced stops are optionally changed to their nasal counterparts when they are adjacent to a nasal sound (Walker 1984:113-4). As a comparison between Standard French (SF) and Canadian French (CF) reveals, this nasal assimilation applies after nasalized vowels (8) as well as before nasal consonants (9).

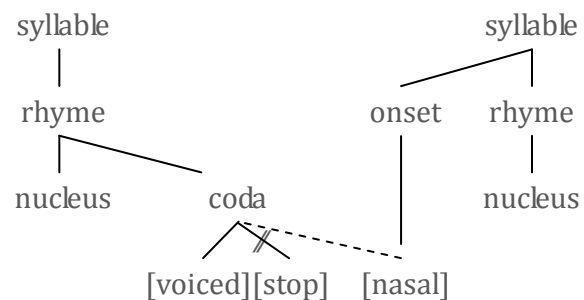
(8)	SF	CF	(9)	SF	CF	
	[gʁɑ̃d]	[gʁɑ̃n]		[ad.mi.ʁe]	[æn.mi.ʁe]	'admire'
	[blɔ̃d]	[blɔ̃n]		[fʁwad.mɑ̃]	[fʁwæn.mæ̃]	'coldly'
	[ʒɑ̃b]	[ʒɑ̃m]		[ɑ̃.ʒɑ̃b.mɑ̃]	[ɑ̃ʒɑ̃m.mæ̃]	'enjambement'
	[ɔ̃.bʁ]	[ɔ̃m]		[djag.nɔ̃s.tik]	[dzjæŋ.nɔ̃s.tɪk]	'diagnostic'
	[ʒœ̃.ɡl]	[ʒœ̃ŋ]		[fʁag.mɑ̃]	[fʁæŋ.mæ̃]	'fragment'
	[lɑ̃ŋ]	[lɑ̃ŋ]		[lɔ̃ŋ.mɑ̃]	[lɔ̃ŋ.mæ̃]	'lengthily'

(10) Local assimilation as "spreading"

Progressive [nasal] assimilation



Progressive [nasal] assimilation



- Cases of long-distance assimilation of [nasal] are found in several Bantu languages.
 - In Pangwa, for instance, [nasal] spreads from any suffix to a preceding stem-final consonant, e.g., /pulix-an-/ → [-puliŋ-an-] 'listen to each other' (Hansson 2001).
 - By contrast, in Kikongo (Bantu: Congo; Ao 1991), nasal assimilation operates in the opposite direction, e.g., the perfective suffix *-idi* and the perfective passive

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suffix *-ulu* become *-ini* and *-unu*, respectively, if the verb stem contains a nasal consonant.²⁸

- (11)
- | | | | |
|-----------------------|-----------------|----------------------------------|-------------------------|
| [a.bu.di <u>.di</u>] | 'he hit' | [tu.ku.ni <u>.ni</u>] | 'we planted' |
| [a.bu.lu <u>.lu</u>] | 'he was hit' | [ma.san.gu ma.ki.nu <u>.nu</u>] | 'the maize was planted' |
| [a.su.ki <u>.di</u>] | 'he washed' | [tu.ni.ki <u>.ni</u>] | 'we ground' |
| [a.su.ku <u>.lu</u>] | 'he was washed' | [ma.san.gu ma.ni.ku <u>.nu</u>] | 'the maize was ground' |

- Similarly, in Tshiluba (Odden 1994), the benefactive suffix *-il-* is realized *-in-* when it is preceded by a nasal anywhere in the stem.

- (12)
- | | | | |
|---------------|-----------------|---------------------------|---------------------|
| [ku.to:ta] | 'to harvest' | [ku.to:ti <u>.la</u>] | 'to harvest for' |
| [ku.ki.na] | 'to dance' | [ku.ki.ni <u>.na</u>] | 'to dance for' |
| [ku.ki.ni.sa] | 'to make dance' | [ku.ki.ni.si <u>.na</u>] | 'to make dance for' |

- Progressive long-distance assimilation of [nasal] is also found in the Bantu language Kikongo (Ao 1991; Odden 1994; Rose & Walker 2004; 2011).
- The following examples illustrate that the passive suffix has a [lateral] onset (*-ulu* ~ *-olo*), which changes to [nasal] when preceded by a [nasal] onset.

- (13)
- | <i>-ulu</i> ~ <i>-olo</i> | <i>-unu</i> ~ <i>-ono</i> | | |
|---------------------------|---------------------------|-------------------------|------------------|
| [a.su.ku <u>.lu</u>] | 'he was washed' | [wu.man.tu <u>.nu</u>] | 'it was climbed' |
| [a.bu.lu <u>.lu</u>] | 'he was hit' | [ma.ni.ku <u>.nu</u>] | 'it was ground' |
| [tu.koŋ.go <u>.lo</u>] | 'we were tied' | [tu.meŋ.go <u>.no</u>] | 'we were hated' |
| [dim.bu <u>.lu</u>] | 'had listened' | [ma.san.gu ...] | 'the maize ... |
| [tu.biŋ.gu <u>.lu</u>] | 'we were hunted' | ma.ki.nu <u>.nu</u> | was planted' |

- Several examples in the left column show that a coda [nasal] does not trigger assimilation, that is, the Kikongo rule of progressive nasal assimilation is “onset agreement”:

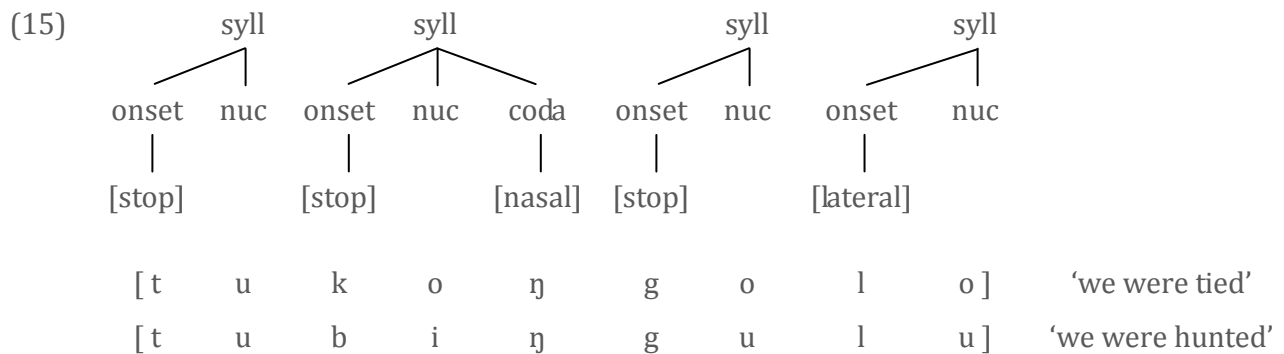
²⁸ There is an interesting complication. See exercise D on p. 87 below.

NASAL $\stackrel{\text{def}}{=} \{[\text{NASAL}]\}$

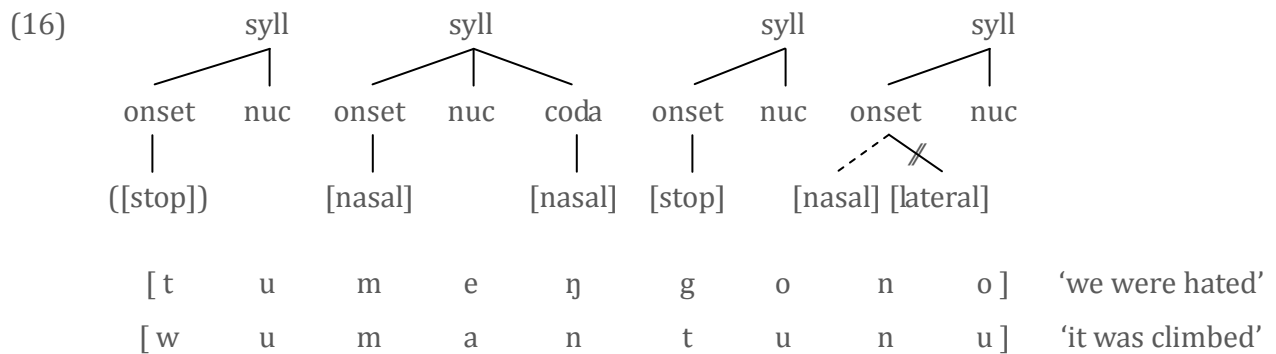
(14) *Progressive [nasal] assimilation in Kikongo*



- The following diagram and examples illustrate that the perfective passive suffix has a lateral onset even when preceded by a nasal coda.



- The following diagram and examples illustrate that, when preceded by a nasal onset, the perfective passive suffix also acquires a nasal onset ([-ono ~ -unu]).



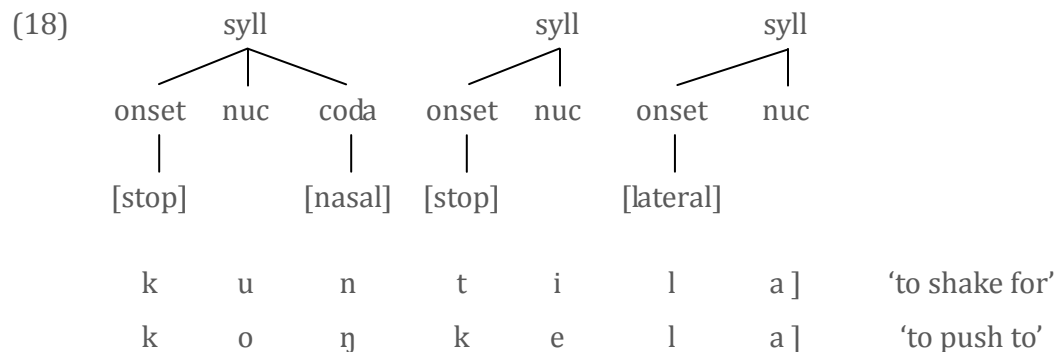
- The following examples illustrate that the applicative suffix has a [lateral] (-il- ~ -el-), which changes to [nasal] (-in- ~ -en-) when preceded by a [nasal] onset.²⁹

²⁹ Most Bantuists consider the -a ending to be a separate generic verb suffix.

NASAL $\stackrel{\text{def}}{=} \{[\text{NASAL}]\}$

(17)	<i>-il- ~ -el-</i>	<i>-in- ~ -en-</i>
	[ku.to:ti.la] 'to harvest for'	[ku.ki.ni.na] 'to dance for'
	[sa.ki.di.la] 'congratulate for'	[no.ne.na] 'pick up for'
	[kun.ti.la] 'to shake for'	[ku.du.mu.ki.na] 'to jump for'
	[som.pe.la] 'borrow from/for'	[ku.ki.ni.si.na] 'to cause to dance for'
	[koŋ.ke.la] 'to push to'	[ku.du.mu.ki.si.na] 'to cause to jump for'

- Again, several examples in the left column above show that a coda [nasal] does not trigger assimilation. Cf. (14) above.
- The following diagram and examples illustrate that the applicative suffix has a lateral onset even when preceded by a nasal coda.



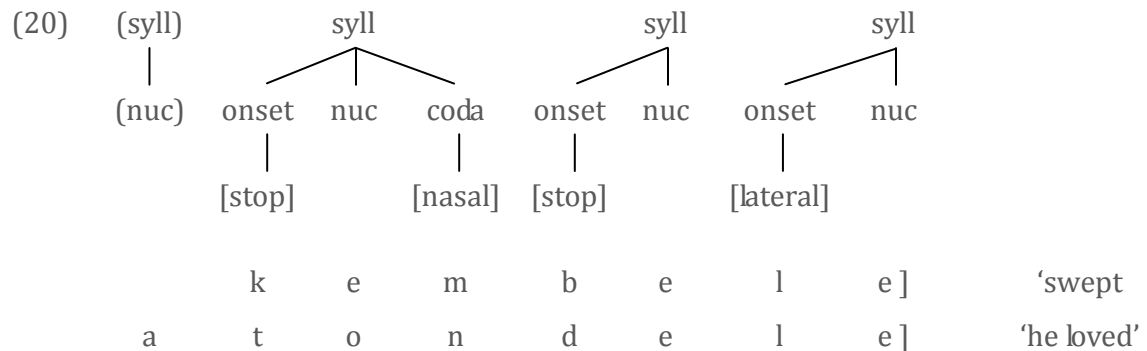
- The following examples illustrate that the perfective active suffix has an oral onset (*-ele ~ -idi*), which changes to [nasal] when preceded by a [nasal] onset.
- N.B.: "/l/ ... is realized as [d] before [i] and as [l] before other vowels. When preceded by a nasal in the stem, /l/ becomes [n]. Vowel quality in suffixes obeys a height harmony." (Rose & Walker 2004:503)

(19)	<i>-ele ~ -idi</i>	<i>-ene ~ -ini</i>
	[so.se.le] 'searched for'	[le:.me.ne] 'shone'
	[kem.be.le] 'swept'	[tu.meŋ.gi.ni] 'we hated'

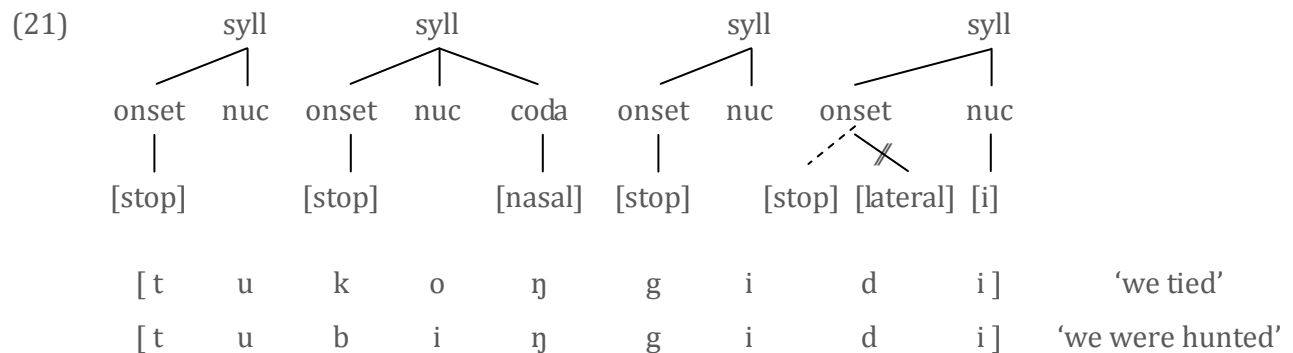
NASAL $\stackrel{\text{def}}{=} \{[\text{NASAL}]\}$

[a.ton.de.le]	'he loved'	[tu.man.ti.ni]	'we climbed'
[a.su.ki.di]	'he washed'	[tu.ni.ki.ni]	'we ground'
[a.bu.di.di]	'he hit'	[tu.ku.ni.ni]	'we planted'
[ban.ti.ki.di]	'begun'	[si.mi.ni]	'prohibited'
[tu.biŋ.gi.di]	'we hunted'	[fu.tu.mu.ki.ni]	'resuscitated (intr.)'

- Once more, several examples in the left column show that a coda [nasal] does not trigger assimilation, that is, the Kikongo rule of progressive nasal assimilation is "onset agreement" (14).
- The following diagram and examples illustrate that the perfective active suffix has a lateral onset even when preceded by a nasal coda.

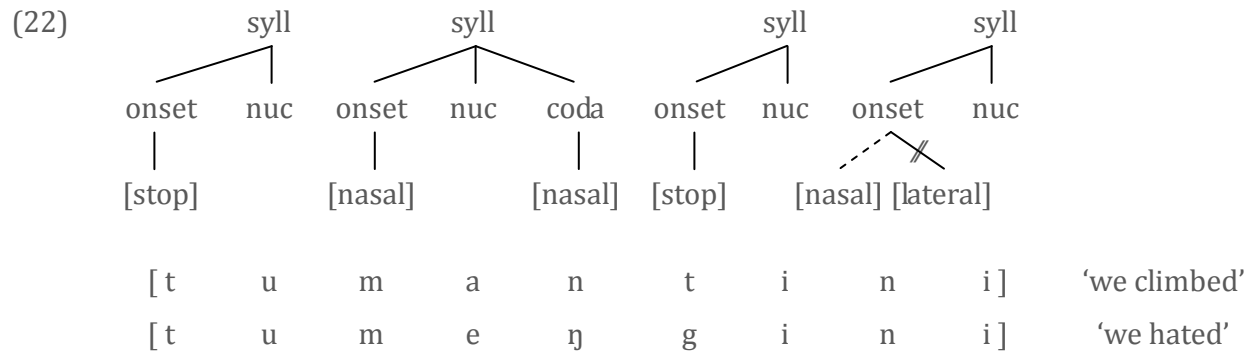


The following diagram and examples illustrate that even as [lateral] is changed to [stop] before [i], the suffix remains oral after a nasal coda.



NASAL $\stackrel{\text{def}}{=} \{[\text{NASAL}]\}$

- The following diagram and examples illustrate that the perfective active suffix acquires a nasal onset only when preceded by a nasal onset.



- Next, recall that Maxacalí (Gudschinsky et al. 1970; Wetzels 2009) is an indigenous Brazilian language with nasal vowels, but its nasal consonants are always derived by assimilation.

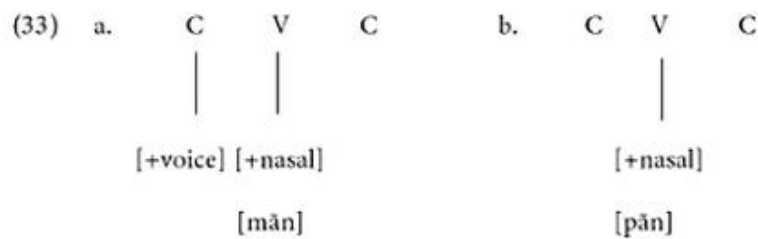
(23) *Some Maxacalí words borrowed from Brazilian Portuguese*

- | | | | |
|----|------------|---------------|-------------------|
| a. | [tʃã'mãm] | 'soap' | < BP [sa'bãũ] |
| | [pẽpõŋ] | 'beans' | < BP [fe'zũ] |
| b. | [bah'tet] | 'hammer' | < BP [mah'telɔ] |
| | [kuɗi'bet] | 'pocketknife' | < BP [kani'vetʃi] |
| c. | [tõ'mãn] | 'tomato' | < BP [tũ'matʃ] |
| | [kõ'mẽn] | 'shop' | < BP [kõ'mehs] |

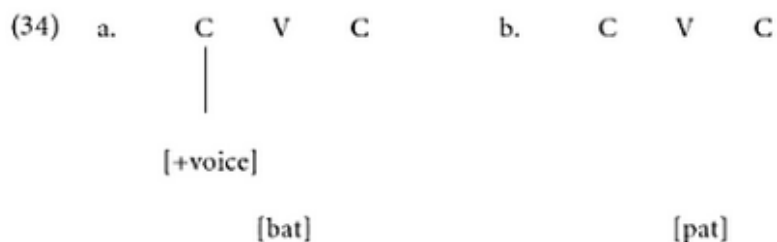
- Wetzels' (2009:263-4) own analysis is worth reading:

NASAL $\stackrel{\text{def}}{=} \{[\text{NASAL}]\}$

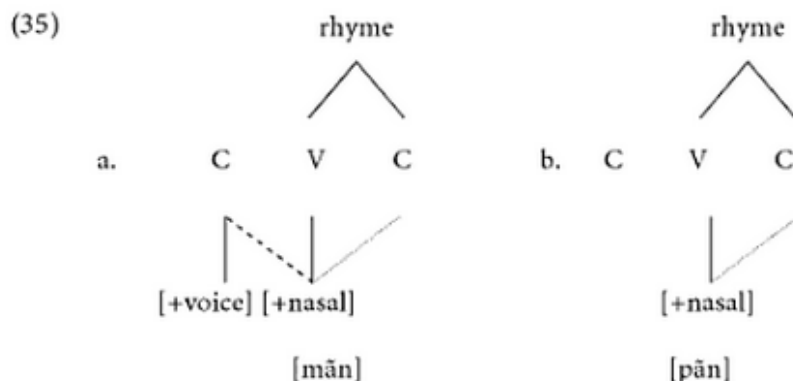
Dispensing with the unmarked and phonologically inactive features [–voice] and [–nasal], we can set up a lexical representation in which syllables that surface with a nasal vowel are lexically represented as either (33a) or (33b), and syllables that surface with an oral vowel as either (34a) or (34b), where C represents a [–vocoid] segment, V a [+vocoid] segment:



NASAL $\stackrel{\text{def}}{=} \{[\text{NASAL}]\}$



To derive the proper distribution of surface nasal consonants and vowels, we must posit two spreading mechanisms. One, indicated with a dotted association line in (35), spreads nasality from left to right and assures that syllable rhymes are always entirely oral or entirely nasal; and the other, indicated with a striped association line in (35a), iteratively spreads nasality from right to left predicting that possible targets to the left of a nasal vowel always surface as nasal.



The proposed analysis explains why words with a nasal syllable immediately preceded by an oral vowel, nasal syllables with a voiced non-nasal onset, and syllable rhymes that disagree in nasality do not occur. However, an explicit analysis of Maxacalí nasality must account for more. If nasal vowels really had a free distribution, we would expect to find, apart from words like #kacuṽp# ‘like this’, #muṽtik# ‘with’, or #māṽṽn# ‘sun’, words of the type #VC₁VC₂#, where C₁ is a voiceless consonant. The non-occurrence of such (non-derived) words shows that each morpheme contains only a single instance of the [+nasal] feature. It follows that morphemes containing more than a single nasal sound are the result of [+nasal]-spreading from a unique segmental source, a nasal vowel in the case of Maxacalí.³³

NASAL $\stackrel{\text{def}}{=} \{[\text{NASAL}]\}$

- Wetzels' treatment of nasality seems important for languages like Barasana (Tucanoan, Colombia and Brazil), in which words are largely either of completely oral or completely nasal, as illustrated in the two columns below (Pulleyblank 1998:107-8; see also: Gomez-Imbert & Kenstowicz 2000:422):

(24) *Some Barasana words*

[mãñõ]	'none'	[juka]	'vulture'
[mĩnĩ]	'bird'	[wati]	'going?'
[mãhãñĩ]	'eat'	[wesika]	'above'
[ɲãmõrõnĩ]	'ear'	[hikoro]	'tail'
[ẽõnõ]	'mirror'		

- This generalization —that words are entirely oral or entirely nasal— is best understood under these assumptions:
 - Nasal words are lexically marked by the inclusion of a [nasal] feature, while oral words lack such a specification.
 - All vowels in a word agree in terms of the [nasal] feature.
 - Consonants that can assimilate [nasal] from the vowels (mainly voiced ones) do so.

(25)	Underlying representations	b a d o	w a t i
		[nas]	
	Nasality assimilation		n/a
		[nas]	
	Surface representations	[mãñõ] 'none'	[wati] 'going?'

NASAL $\stackrel{\text{def}}{=} \{[\text{NASAL}]\}$

- A related language, Terena, offers a strong argument for the independence of the [nasal] feature. In this language, [nasal] is a morpheme; it indicates the first person singular, e.g.: aride ‘sickness’ vs. ãrĩnẽ ‘my sickness’ (Bendor-Samuel 1960).

(26) Underlying representations	a r i d e	a r i d e
		[nas]
Nasal assimilation	n/a	a r i n e
		[nas]
Surface representations	[aride] ‘sickness’	[ãrĩnẽ] ‘my sickness’

- Note that the [nasal] feature representing first person singular spreads in Terena words—a form of assimilation. This is the same as in Barasana words, which are generally composed either of completely oral sounds or completely nasal sounds.
- As Gomez-Imbert and Kenstowicz (2000:421-2) discuss:

“Nasality is not a phonemic but a morphemic feature. ... There is no segmental opposition between oral and nasal segments. The lexicon exhibits contrasts only between entirely oral (27a) and entirely nasal roots (27b). The nasal autosegment of the roots in (27b) nasalizes all the voiced segments—vowels, sonorants, and plosive consonants— of the root. The nasal allophones of the voiced plosives ... are: [m] for /b/, [n] for /d/, [ɲ] for /dʒ/ and [ŋ] for /g/ ... Voiceless plosives are transparent to nasal spreading.”

(27) a. Oral roots	b. [nasal] roots
/ba:-re/ [ba:re] ‘to swim’	/ba:-re/ [mã:řẽ] ‘to pour powder
	n with hands’
/bibi-re/ [bibire] ‘to blink’	/bibi-re/ [mĩmĩřẽ] ‘to suck’
	n

NASAL $\stackrel{\text{def}}{=} \{[\text{NASAL}]\}$

/tia-re/	[tiare]	‘to sew’	/tia-re/	[tĩãrẽ]	‘to stoke the fire’
			n		
/uka-re/	[ukare]	‘to draw/ write’	/baka-re/	[mākãrẽ]	‘to look for’
			n		

PRENASALIZED CONSONANTS?

- [nasal] can uniquely cooccur with [stop] in onsets in some languages.³⁰
 - Tamambo, a Southern Oceanic language of Vanuatu, admits the onsets: [mb, mbw, nd, ndʒ]

“In Tamambo, NC sequences are best analyzed as tautosyllabic prenasalized stops ... This means that every vowel followed by a nasal is in an open syllable, regardless of whether the nasal is intervocalic or part of an NC sequence.” (Riehl 2008:151)

E.g., [ta.mba] ‘to bump into’, [ta.ma] ‘father’; [ta.nda] ‘to look up’, [ta.no] ‘garden’

- Sinhala, an Indo-European language of Sri Lanka, apparently distinguishes the onset [nasal, stop] from the heterosyllabic sequence [nasal]+[stop] (Feinstein 1979; Cairns & Raimy 2009).

E.g., [ka.ndə] ‘trunk’ (sg. def.) versus [kan.də] ‘hill’ (sg. def.)

- Some languages also allow [nasal] to combine with [fricative]
 - The Bantu language Kinyarwanda allows the syllable onsets *mf, mv, ns, nz, nf, nʒ*, etc.

³⁰ [nasal] cooccurs with [stop] in English codas, e.g., *chandler* [tʃænd.ləɪ], *Umpqua*, OR [ʌmp.kwə], *linctus* [ˈlɪŋk.təs], *petuntse* [pə.tʊnt.sə], etc.

NASAL $\stackrel{\text{def}}{=} \{[\text{NASAL}]\}$

- [nasal] and [rhotic] cooccur as a prenasalized alveolar flap [nr] in the syllable onsets of Waffa (Trans-New Guinea, Papua New Guinea: Hotz & Stringer 1971; SIL-PNG 2011).³¹
 - For example: [nroonra] ‘big’, [nruuna] ‘throat’, [ɸainri] ‘dog’, [jeenra] ‘food’.
 - Waffa has no codas, so the syllabification is given as e.g. [i.pu.nra] ‘corner of a house’.
 - Waffa distinguishes the onset [rhotic, nasal] [nr] (written <nn>) from the simple [rhotic] onset [r] (a trill) and the simple [nasal] onset [n].

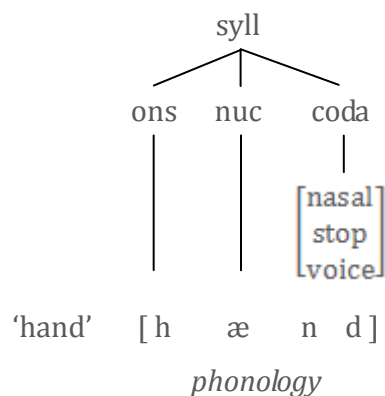
(28) *Waffa* (Hotz & Stringer 1971; SIL-PNG 2011)

[nr]	[nrau]	‘house’	[kwaanru]	‘type of cane’
[n]	[nau]	‘yesterday’	[kwaanuu]	‘spit’
[r]	[rinoo]	‘he is fighting’	[mβaraa]	‘belong’

ASSIMILATION

- Cohn (1990; 1993) points out that English vowels become nasalized before nasal consonants, which she ascribes to a *phonetic* process of regressive nasal assimilation.

(29)



The vowel is increasingly nasal near the nasal consonant
↓
[[æ̃nd̥]]³³
phonetics

“If ... nasalisation typically affects only a portion of the preceding vowel and is observed to occur in a gradient manner, it should be concluded that the nasalisation is the result of phonetic implementation rather than a phonological rule.” (Cohn 1993:59)³²

³¹ [nasal] cooccurs with [rhotic] in English codas, e.g., *lorgnette* [lo.ɪn.jɛt], *dirndl* [dɜ.ɪn.dəl], etc.

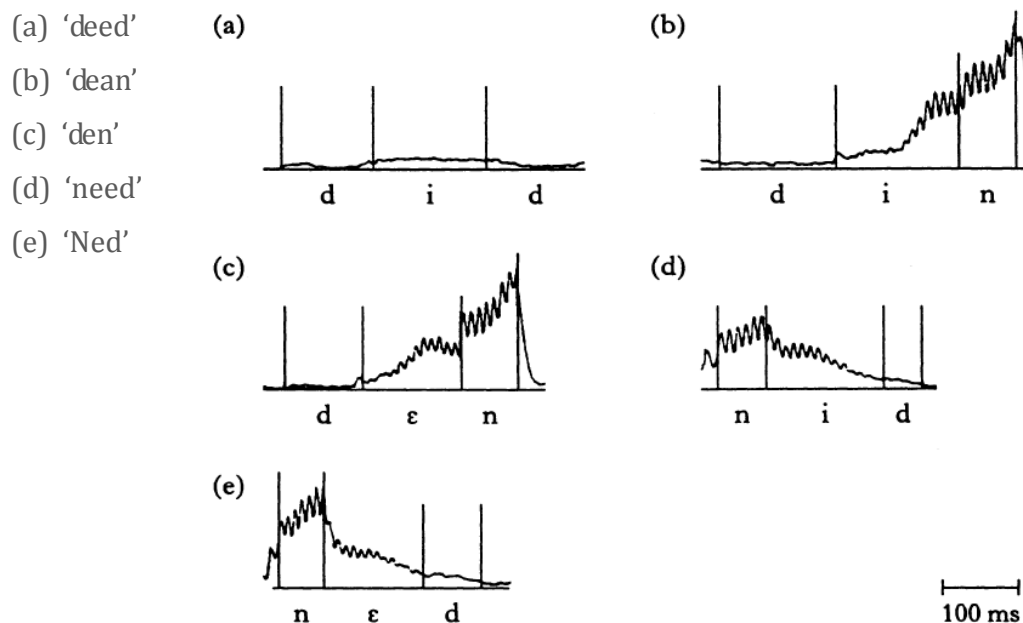
³² Compare Keating (1990:452): “Phonetic rules can thus, for example, assign a segment only a slight amount of some property, or assign an amount that changes over time during the segment.”

³³ Similarly, “vowel-like qualities of [h] are a result of phonetic implementation and not phonological assimilation” (Cohn 1993:45).

NASAL $\stackrel{\text{def}}{=} \{[\text{NASAL}]\}$

- “Identification of gradient behaviour is taken as evidence of phonetic, not phonological, rule application precisely because the mechanisms of phonology and phonetics are distinct: phonological rules manipulate discrete, timeless segments, whereas phonetic rules manipulate variables which are continuous in time and space. Gradient or CLINE-LINE behaviour is a result of phonetic implementation, while categorical output or a PLATEAU results from phonological rule application.” (Cohn 1993:45)

(30) Nasal airflow traces, an indirect measurement of velum position (Cohn 1993:60)



- The Indonesian language Sundanese (Robins 1957) is like English in that it does not make a lexical distinction between oral vowels and nasal vowels.

○ Cf. French, e.g. [lɛ] 'milk' versus [lɛ̃] 'linen'

- Cohn shows that Sundanese vowels also participate in nasal assimilation — vowels assimilate the nasality of an immediately preceding sound — but she argues that the process in question is *phonological*.

(31) *Progressive assimilation of [nasal] in Sundanese* (Anderson 1972; Cohn 1990; 1993:55)

[mã.ri.os] 'examine'

[ŋõ.bah] 'change'

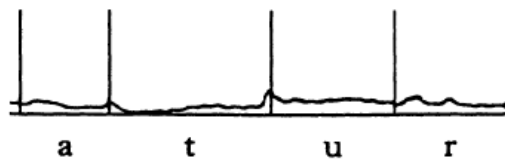
NASAL $\stackrel{\text{def}}{=} \{[\text{NASAL}]\}$

[o.mõŋ] 'say'	[nã.ãt.kin] 'dry'
[ka.nã] 'for the purpose'	[nĩ.ĩs] 'to take a holiday'
[mã.nẽh] 'you'	[nã.ũr] 'say'
[ŋã.wi.daŋ] 'to dry skins'	[pã.ĩ.ãn] 'wet'
[ŋĩ.sər] 'displace'	

(32) *Nasal airflow traces, an indirect measurement of velum position* (Cohn 1993:60)

(a) [a.tur] 'arrange'

(a)



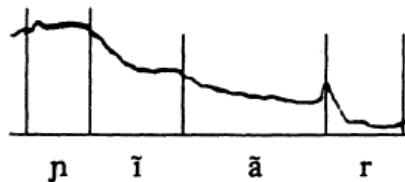
(b) [ŋã.tur] 'arrange'

(b)



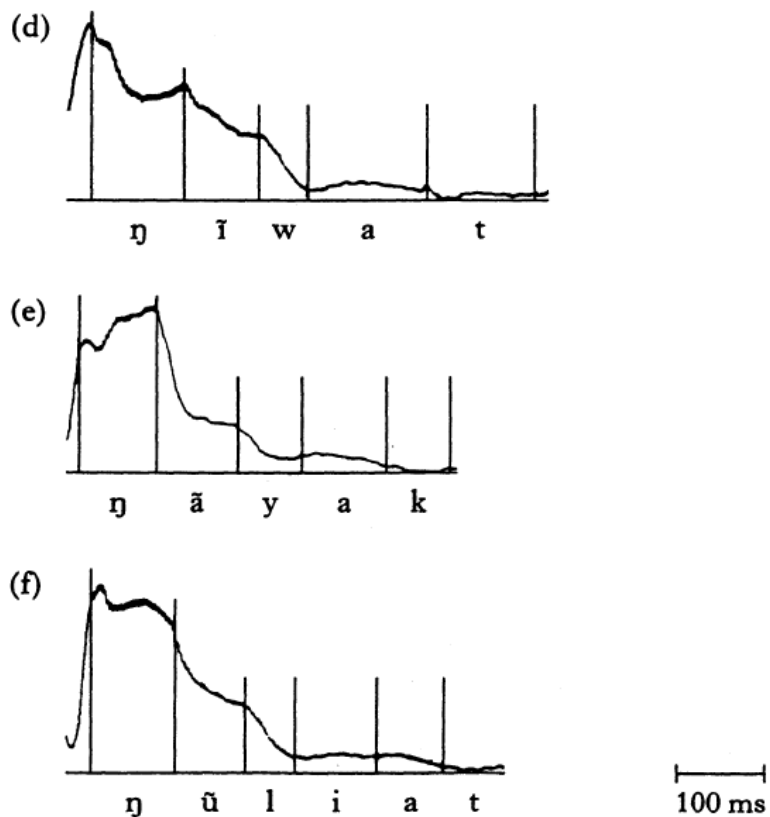
(c) [pĩ.ãr] 'seek'

(c)



NASAL $\stackrel{\text{def}}{=} \{[\text{NASAL}]\}$

- (d) [ŋĩ.wat] 'elope'
 (e) [ŋã.jak] 'sift'
 (f) [ŋũ.li.at] 'stretch'



- The examples below demonstrate vowel nasalization when a nasal affix (underlined) is added to a stem (Cohn 1990; Archangeli & Pulleyblank 2007:366):

(33)	[gə.de] 'big'	[gu. <u>m</u> ã.de] 'be conceited'
	[ra.sa] 'feel'	[ru. <u>m</u> ã.sa] 'admit to'
	[in.dit] 'leave'	[pa. <u>ŋ</u> ĩn.dit] 'reason for leaving'
	[o.mõŋ] 'say'	[pa. <u>ŋ</u> õ.mõŋ] 'reason for saying'
	[pi.asih] 'love'	[mĩ. <u>ã</u> sih] 'to love' (active)
	[saŋ.liŋ] 'to polish'	[si. <u>n</u> ãŋ.liŋ] 'to glitter'

- The following examples illustrate that the plural infix [-al- ~ -ar-] also undergoes nasalization.

(34)	<i>nasal spreading</i>	[-al-] ~ [-ar-]
	[ŋĩ.ãr] 'seek'	[ŋã.lĩ.ãr] 'seek' (pl.)

NASAL $\stackrel{\text{def}}{=} \{[\text{NASAL}]\}$

[nã.ũr]	‘say’	[nã.lã.ũr]	‘say’ (pl.)
[mĩ.ã.sih]	‘love’	[mã.ri.ã.sih]	‘love’ (pl.) ³⁴
[nã.ĩ.ãn]	‘wet’	[nã.ra.ĩ.ãn]	‘wet’

- The fact that vowels remain nasalized after the liquid suggests that the singular words in the left column are stored with nasalized vowels in the lexicon.

DISSIMILATION

- A first example is provided by Takelma, a Penutian language of Oregon, as described by Sapir (1912:45): “If a (generally) final *n* of a stem is immediately followed ... by a suffix containing a nasal, it dissimilates to *l*.”

(35) *Takelma nasal dissimilation* (Sapir 1912)

[g ^w ãn]	‘road’	[ha.g ^w a:l.am]	‘in the road’
[xãn]	‘urine’	[xa:l.am.tk]	‘my urine’
		[xa:l.a.xam.te]	‘I urinate’

* [nasal] ... [nasal] → [lateral] ... [nasal]

or: onset/coda ... onset/coda

[nasal] [lateral] [nasal]

- Another case of nasal dissimilation is found in Chukchi, a Chukotko-Kamchatkan language of Siberia (Bogoras 1922). When [ŋ] precedes a nasal, it turns into [ɣ].

(36) *Chukchi nasal dissimilation* (Krause 1980:20)

[ratʃ.wə.ŋək]	vs.	[mət.ratʃ.wəɣ.mək]	‘we competed’
[ta.ra.ŋək]	vs.	[nə.ta.raɣ.mo.re]	‘let’s build a place to live’
[e.naw.rə.ŋək]	vs.	[e.naw.rəɣ.nən]	‘he presented him’

³⁴ Cohn observes that vowels denasalize immediately after [r], but not after [l].

NASAL $\stackrel{\text{def}}{=} \{[\text{NASAL}]\}$

[pet.ʔiŋ] vs. [pet.ʔiy.ŋin.qej] ‘boy with a cold’

- Sporadic historical nasal dissimilations are also relatively common.
 - For example, Proto-Germanic **himin* ‘heaven’ evolved into **hibin* then *heaven* in English, and into *Himmel* in German. That is, dissimilation affected the first nasal in English, the second in German.
 - In dialectal English as well as in Child English one finds ‘chimney’ pronounced as ‘chimley’ or else ‘chimbley’, with epenthetic [b].
 - Analogous changes occurred in the history of Romance languages (Robert Murray, p.c.), e.g., Portuguese: *memorare* ‘to remember’ > *lembrar*; Spanish *homine* ‘man’ > *homne* > *homre* > *hombre*; *femina* ‘woman’ > *femna* > *femra* > *hembra*; cf. *anima* ‘soul’ > *anma* > *alma*.
 - The following examples are from Romanian (Rosetti 1965).

(37) *Historical nasal dissimilations in Romanian* (Rosetti 1965:27)

Regressive

inimă ‘heart’ > irimă
 fănină ‘flour’ > fărină
 venin ‘venom’ > verin
 cănunt ‘gray (hair)’ > cărunt
 genunchi ‘knee’ > gerunchi
 junincă ‘génisse’ > jurincă
 mănunt ‘menu’ > mărunt
 mănunchi ‘faisceau’ > mărunchi
 păninc ‘millet à l’épi noir’ > părinc
 rănunchi ‘rochon, rein’ > rărunchi
 amenința ‘to menace’ > amerința, amelința

Progressive

nimeni ‘person’ > nimeri
 pecingine ‘dartre’ > pecingire
 pîngăni ‘profaner’ > pîngări
 sîngena ‘saigner’ > sîngera
 grănunț ‘grain’ > grăunț

LIPS $\stackrel{\text{def}}{=} \{[\text{LABIAL}], [\text{ROUND}]\}$

$$\text{Lips} \stackrel{\text{def}}{=} \{[\text{labial}], [\text{round}]\}$$

[LABIAL]

- The feature [labial] characterizes speech sounds which are articulated primarily with the lips. These include:

- labial glides = [labial]

$$v, \tilde{v}, v_{\circ}, \underset{\circ}{v}, \beta, \underset{\circ}{\beta}, \text{etc.}$$

- labial nasals = [labial, nasal]

$$m, \underset{\circ}{m}, \underset{\sim}{m}, m^w, \underset{\circ}{m}^w, \underset{\sim}{m}^w, m^y, m^j, m^y, m^f, \text{etc.}$$

- labial trills = [labial, rhotic??]

$$\mathbf{B}, \mathbf{B}_0$$

- labial stops = [labial, stop]

p, mp, b, mb, p^h, p', b^h, ḅ, ɓ, ɓ̣, p^w, mp^w, b^w, mb^w, p^{wh}, p^w, b^{wh}, ḅ^w, ɓ^w, ɓ̣^w, p^j, mp^j, b^j, mb^j, p^{jh}, p^j, b^{jh}, ḅ^j, ɓ^j, ɓ̣^j, p^y, mp^y, b^y, mb^y, p̣^y, b^{yh}, ḅ^y, ɓ^y, ɓ̣^y, mp^ɕ, b^ɕ, mb^ɕ, p^ɕ, b^{ɕh}, b^ɕ, ɓ^ɕ, ɓ̣^ɕ, etc.

- labial affricates = [labial, stop, strident]

$$\widehat{\text{pf}}, {}^{\text{m}}\widehat{\text{pf}}, \widehat{\text{bv}}, {}^{\text{m}}\widehat{\text{bv}}, \widehat{\text{pf}}^{\text{h}}, \widehat{\text{pf}}', \widehat{\text{bv}}^{\text{h}}, \widehat{\text{bv}}, \text{etc.}$$

- labial fricatives = [labial, fricative]

$$\phi, \beta, \tilde{\beta}, f, v, \tilde{v}, f^h, f', f^w, v^w, \tilde{v}^w, f^{wh}, \dot{f}^w, f^j, v^j, \tilde{v}^j, f^{jh}, f^j, f^i, v^i, \tilde{v}^i, f^i, \text{etc.}$$

LIPS $\stackrel{\text{def}}{=} \{[\text{LABIAL}], [\text{ROUND}]\}$

- Some languages (e.g., in Iroquoian or Athabascan) ban the articulator feature [labial], such that they lack labial sounds entirely.
- However, most languages allow at least some labial sounds.
 - For example, Oowekyala has [labial] [p, b, p', m, m̥], as illustrated in the following words:

(38) *Oowekyala*

[ba.t̥a] 'to fathom, measure by using the extended arms or fingers'

[pa.t̥a] 'to flatten'

[p'a.t̥s] 'sth. strung out on the ground'

[ma.t̥a] 'to shake hands, take by the hand'

[m̥i.t̥a] 'to miss a shot, to dodge, avoid, or escape from sth., dislike contact'

- Observe that labial fricatives are absent. This gap in Oowekyala is not haphazard but rather reflects a markedness constraint on the feature combination [labial, fricative].

(1) * $\begin{bmatrix} \text{labial} \\ \text{fricative} \end{bmatrix}$ The features [labial] and [fricative] must not cooccur (in onset/coda)

- That the above constraint is markedness-based is evident typologically. For instance, consider the marking implication in (2), which Sherzer (1976:258) gives on the basis of a large survey of North American Indian languages.

(2) *A marking implicational* (Sherzer 1976:258, 1.3.1)

f, v, φ, β → p

- Here, $X \rightarrow Y$ signifies that "if a language has X, then that same language also has Y and that it is the case that X is marked with respect to Y" (Sherzer 1976:256).
- There is also acquisitional evidence that labial fricatives are relatively complex.

LIPS $\stackrel{\text{def}}{=} \{[\text{LABIAL}], [\text{ROUND}]\}$

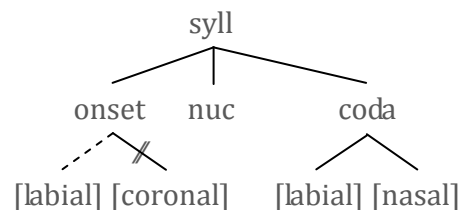
- For example, Beers (1996:36-7) reports that Dutch children acquire labial fricatives (f) 3 to 8 months later than they acquire coronal fricatives (s) and velar fricatives (x).
- To illustrate the effect of the above constraint in Oowekyala grammar, consider the adaptation of English labial fricatives into Oowekyala, as illustrated by the words in (3).³⁵

(3) *Loan adaptations of labial fricatives in Oowekyala*

<i>Oowekyala</i>	<i>English</i>	
pəlawas	flawə(ɫ)z	'flowers'
k ^w abi	kafi	'coffee'
sdup	stov	'stove'
bank ^w uba	væŋkuvə(ɫ)	'Vancouver'

- One of the most noticeable patterns of **[labial] assimilation** is one found exclusively in Child language, wherein a consonant assimilates to a following [labial] consonant, even across intervening vowels.
- For instance, the data in (4) from Dylan (4;6–5;0: Bernhardt & Stemberger 1998a) illustrate regressive [labial] assimilation from a nasal.

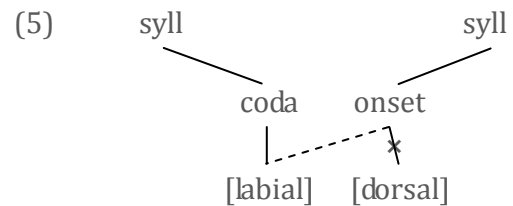
- (4) [pãĩm] 'time'
- [bẽm] 'thumb'
- [bẽmpajm] 'sometimes'
- [bãĩmbə]³⁶ 'numbers'



³⁵ It is a supposition that these English words were adapted directly into Oowekyala. In fact, some words might have been borrowed via Chinook Jargon. The general point remains valid nonetheless, as Chinook Jargon also lacked labial fricatives.

LIPS ^{def} {[LABIAL], [ROUND]}

- A case of progressive assimilation of [labial] is found in Hayu, a Himalayish language spoken in Nepal (Michailovsky 1988). As Hyman (2001:176, n. 10) reports: “In this language, a suffix-initial velar consonant will assimilate in oral place to a preceding labial-final root consonant, for example, /dip-ŋo/ ‘he pinned me (in wrestling)’ → [dipmo].”



assimilation as “spreading”

[ROUND]

- Chomsky and Halle (1968:309) define the feature [round] as follows: “Rounded sounds are produced with a narrowing of the lip orifice; nonrounded sounds are produced without such a narrowing.”
- As mentioned last week, languages which exclude [labial] include many Dene/Athabaskan and Iroquoian languages. Note that the grammatical constraint responsible for this exclusion, say *[labial], does not preclude the other Lips-feature [round] from being active in these languages.
 - For example, the Northern Iroquoian language Oneida lacks all [labial] sounds (*p, *b, *m, *f, etc.) but it has [round] sounds (w, o, ũ) (Pepper 1986).
 - Similarly, Wichita (Caddoan, Oklahoma) has [round] kw and w but no [labial] sounds such as p or m (Rood 1975:318).
- Moreover, as also mentioned last week, in Oowekyala (as in many other languages), [labial] may not cooccur with [fricative]. But nothing prevents [round] from cooccurring with

³⁶ The loss of [nasal] in the initial consonant of this form is unexpected, since “there were no obvious constraints against co-occurrence of [Labial] and [+nasal]” (Bernhardt & Stemberger 1998a:625, n. a). Perhaps there was dissimilation of [nasal], *[mVm]?

LIPS $\stackrel{\text{def}}{=} \{[\text{LABIAL}], [\text{ROUND}]\}$

[fricative], as in [dorsal] [xw, χw]. The latter sounds appear, along with other [round, dorsal, stop], in the following examples:

- (6)
- | | |
|--------------------|-----------------------------------|
| [qwx̣w] | ‘powder’ |
| [χw.t.kw] | ‘(sth.) cut with a knife’ |
| [kw.xwa] | ‘hot’ |
| [kwχ̣w.bis] | ‘noiseless fart, cushion creeper’ |
| [xwm̩.gwa.ts̩i] | ‘bee-hive’ |
| [gwi.qwx̣w.gwa.χa] | ‘to eat bread’ (pl) |

- Such facts —that languages without labials (*p, *m, *f, etc.) may nonetheless admit labialized sounds (e.g., gw, qw),³⁷ and that languages without labial fricatives (*f, *v, etc.) may otherwise allow labialized fricatives (e.g., xw, χw)— suggest that [labial] and [round] are relatively independent features.
- In the Chaha dialect of Sebat Bet Gurage, a Semitic language of Ethiopia, [round] can cooccur with [labial] (bw, mw, fw, ...) and with [dorsal] (gw, qw, xw, ...), but not with [coronal] (*tw, *dw, *sw, *nw...).
- Interestingly, the third masculine singular object in Chaha is indicated simply by labialization. As shown in (7), this [round] targets the rightmost labializable position, if any.

(7) *Perfective 3rd masc. sg. in Chaha* (McCarthy 1983:176, 179)

NO OBJECT			WITH OBJECT		
[qæ.næf]	[qæ.næfw]	‘knock down’	[næ.kæs]	[næ.kwæs]	‘bite’
[dæ.næg]	[dæ.nægw]	‘hit’	[sjæ.fær]	[sjæ.fwær]	‘cover’
[næ.dæf]	[næ.dæfw]	‘sting’	[qæ.ɬær]	[qwa.ɬær]	‘kill’
[næ.kæb]	[næ.kæbw]	‘find’	[mæ.sær]	[mwæ.sær]	‘seem’

³⁷ The reverse situation, in which labials are allowed but labialized sounds are banned (*u, *kw), is rare. According to Bernhardt and Stemberger (1998a), some child languages pattern this way, e.g. Morgan’s Child English allowed [labial] but not [round]: [bʊ:d] ‘food’, [bɒk] ‘book’, [ʔɒpən] ‘open’ (p. 359). Adult languages can also avoid [round] in vowels in this way, e.g., Wichita (Caddoan: Rood 1975).

LIPS _{def} {[LABIAL], [ROUND]}

[kæ.fæt]	[kæ.fwæt]	'open'	[mæ.kjær]	[mwæ.kjær]	'burn'
[bæ.kær]	[bæ.kwær]	'lack'	[sæ.dæd]	[sæ.dæd]	'chase'

- In Oowekeyala, a *phonotactic* constraint requires that velar and uvular obstruents be rounded after /u/.

(8) *Rounded velars and uvulars after /u/ in Oowekeyala*

[du.kwa]	(*[du.ka])	'to troll'
[ju.gwa]	(*ju.ga)	'to rain'
[tʰukw.pa]	(*[tʰuk.pa])	'to get spruce roots'
[bu.xwɫs]	(*[bu.xɫs])	'illegitimately pregnant'
[tsu.qwa]	(*[tsu.qa])	'to beg, to go and ask for something'
[hu.gwitʰ]	(*[hu.gitʰ])	'to run into the house (with a group of people)'
[lu.qwas]	(*[lu.q'as])	'Western or Lowland hemlock tree'
[lu.xwa]	(*[lu.xa])	'to roll (said of a round thing)'

< Ancient Greek *phōnē* 'sound' + *taktikós* 'having to do with arranging'
Phonology is responsible for all phonotactic generalizations.

- /u/ is Oowekeyala's only round vowel, and velars and uvulars (= [dorsal]) are its only labializable consonants, so the constraint may be stated informally as in (9).

(9) A vowel must share its feature [round] with a following ([dorsal]) consonant.

- That this is not simply a static fact holding of words, but a more general constraint in Oowekeyala, is apparent from *alternations*.

- For example, the initial velar of the inchoative suffix -x.ʔit becomes [round] after u-final stems.

Phonology is also responsible for the various outputs of morphologically related forms.

(Phonetics can also generate alternations.)

(10) -x.ʔit ~ -xw.ʔit 'to become, to start'

a.	[ʰx.ʔit]	'to become dead'	[ʰ]	'dead, paralysed'
	[p.qw'.ts'x.ʔit]	'to become sleepy'	[p.qw'.ts']	'sleepy'
	[pus.q'ax.ʔit]	'to become very hungry'	[pus.q'a]	'to feel very hungry'

LIPS ^{def} {[LABIAL], [ROUND]}

b.	[ʔxws.tuxw.ʔit]	‘to assume blood color’	[ʔxws.tu]	‘color of blood’
	[tʰʉ.xwa.la.suxw.ʔit]	‘to fall ill, to become sick’	[tʰʉ.xwa.la.su]	‘to be ill, sick’
	[tuxw.ʔit]	‘to start to walk’	[tə.wa]	‘to walk’ (< <i>tu-a</i>)
	[suxw.ʔit]	‘to take, grab, pick up, grasp with the hand’	[sə.wa]	‘to carry, get, take, (< <i>su-a</i>) hold in one's hand’

- Similarly, the initial velar of the suffix *-gila* ‘to make’ becomes rounded after *u*-final stems.

(11) *-gila* ~ *-gwila* ‘to make’

a.	[ʔə.nɲ.gi.lax.ʔit]	‘to make a sling’	[ʔə.nɲ]	‘sling’
	[gi.ɲi.gi.la]	‘to cook fish eggs’	[gi.ɲi]	‘salmon roe/eggs’
	[mə.ja.gi.la]	‘draw/carve a fish’	[mə.ja]	‘fish (esp. salmon)’
b.	[mu:.gwi.la]	‘to get four items’	[mu:.p’ə.nis.tə]	‘four round trips’
	[ʔa.mas.tu.gwi.la]	‘to make kindling’	[ʔa.mas.tu]	‘kindling’
	[tu.gwi.la]	‘term used for the second series of the Həmaća Dances’	[tə.wa]	‘to walk’ (< <i>tu-a</i>)

- The initial obstruent of the suffix *-k’ala* ‘noise, sound’ also becomes rounded after /u/.

(12) *-k’ala* ~ *-kw’ala* ‘noise, sound’

a.	[nan.k’a.la]	‘sound of a grizzly bear’	[nan]	‘grizzly bear’
	[wa.ka.k’a.la]	‘sound of barking’	[wa.ka]	‘to bark (dog), to woof’
	[nuł.k’ala]	‘sound of foolish talk’	[nu.la]	‘to behave crazy, or foolish’
b.	[tu.kw’a.la]	‘sound of footsteps’	[tə.wa]	‘to walk’ (< <i>tu-a</i>)
	(*[tu.k’a.la])			
	[lə.χwu.kw’a.la]	‘sound of coughing’	[lə.χwə.wa]	‘to cough’ (< <i>ləχwu-a</i>)
	(*[lə.χwu.k’a.la])			

- The following data illustrate that the initial uvular of the suffix *-gu* ‘together’ becomes rounded after /u/.

LIPS ^{def} {[LABIAL], [ROUND]}

(13) *-gu ~ -gwu* ‘together’

- | | | | | |
|----|-----------------|--|-----------------|-------------------------|
| a. | [bɲ.gut] | ‘to put things close together’ | [bə.ɲa] | ‘close to sth.’ |
| | [la:.gu] | ‘to go (fit) together’ | [la.but] | ‘go to the end of sth.’ |
| | [ʔak.gu] | ‘all together’ | [ʔak] | ‘all’ |
| b. | [mu:.gwə.wa.la] | ‘four people walking together’ (< <i>mu-gu-ala</i>) | [mu:.p’ə.na.χa] | ‘four times down’ |

- Likewise, the initial uvular of the suffix *-χs* ‘aboard’ becomes rounded after /u/.

(14) *-χs ~ -χws* ‘aboard’

- | | | | | |
|----|--------------|-----------------------|-----------------|---------------------------|
| a. | [wɲ.χs] | ‘to stow away’ | [wə.na] | ‘to hide, to sneak about’ |
| | [kw’a.χs] | ‘to sit in a boat’ | [kw’a.s] | ‘to sit outside’ |
| | [xw .tχs] | ‘fire on the boat’ | [xw .ta] | ‘to burn’ |
| b. | [mu:.χws] | ‘to be four aboard’ | [mu:.p’ə.na.χa] | ‘four times down’ |
| | [q’a.tu.χws] | ‘to meet on the boat’ | [q’a.tu] | ‘meeting’ |

- Finally, rounding also occurs across the prefix-root boundary.
 - The most common form of the plural in Oowekyala is a CV-shaped reduplicative prefix.
 - The data below show that a root initial obstruent becomes rounded when the copied vowel in the reduplicative prefix is /u/. (Note that syncope³⁸ applies within the base, such that /u/ deletes after being copied.)

(15) *Rounding in Oowekyala plural forms*

SINGULAR	PLURAL	
[ku.sa]	[kukw.sa]	‘to shave, scrape off with a knife (skin, fur, fish scales)’
[qu.ɬə.la]	[quqw.ɬə.la]	‘bend, crooked, warped’
[qu.χwa]	[quqw.χwa]	‘to scrape’

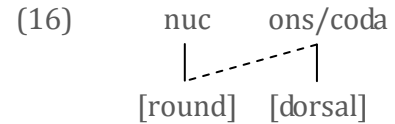
³⁸ *Syncope* refers to vowel deletion.

LIPS $\stackrel{\text{def}}{=} \{[\text{LABIAL}], [\text{ROUND}]\}$

[gu.las] [gu.gwə.las] 'salmonberry (*Rubus spectabilis*) bush'

[gu.ɲa] [gu.gwə.ɲa] 'paddle; propeller'

- In sum, one can observe that the feature [round] regularly spreads from the vowel /u/ onto a following consonant.



assimilation as "spreading"

- Oowekyala also displays a variable pattern of assimilation whereby a velar or uvular obstruent becomes labialized if it immediately follows a labiovelar or a labiouvular.
- For example, the initial sound of the suffix *-χ.dla* 'back' variably becomes rounded after rounded consonants.

(17) *-χ.dla* ~ *-χw.dla* 'back'

- a.
- | | |
|------------------|--|
| [q.k'χ.dla.la] | 'motor boat' |
| [q'ka] | 'to bite (mosquito)' |
| [ji.p'χ.dla.ʔiʔ] | 'the binding around the bottom edge of the basket' |
| [ji.pa] | 'to make a cedar bark mat (i.e. one with a special kind of weave)' |
- b.
- | | |
|--------------------------------------|---|
| [k'ɭ.qw'χw.dla ~ k'ɭ.qw'χ.dla] | 'incessantly urinating (said of a male)' |
| [k'ɭ.qwa] | 'to urinate (said of a male)' |
| [gwu.kw'χw.dla.la ~ gwu.kw'χ.dla.la] | 'boat with a cabin on the stern' |
| [gwukw] | 'to live in a place, reside, dwell, settle' |
| [bu.qw'χw.dla ~ bu.qw'χ.dla] | 'person who always farts' |
| [bu.qw'a.la] | 'to fart' |
| [du.qw'χw.dla ~ du.qw'χ.dla] | 'to look back' |
| [du.qwa] | 'to look for sth.' |

- Similarly, the initial sound of the inchoative suffix *-xʔit* variably becomes rounded after a labialized consonant.

LIPS $\stackrel{\text{def}}{=} \{[\text{LABIAL}], [\text{ROUND}]\}$

(18) $-x\dot{\eta}it \sim -xw\dot{\eta}it$ INCHOATIVE

- a. $[p'ax.\dot{\eta}it]$ 'begin to work' $[p'a:.la]$ 'working'
 $[\text{ɬ}x.\dot{\eta}it]$ 'to become dead' $[\text{ɬ}]$ 'dead, paralysed'
- b. $[dza.qw'xw.\dot{\eta}it \sim dza.qw'x.\dot{\eta}it]$ 'to begin to blow (said of the Dzaqw'ala wind)'
 $[dza.qw'a.la]$ 'north wind off the sea (also W, SW depending on location)'
 $[qa.kw'xw.\dot{\eta}it \sim qa.kw'x.\dot{\eta}it]$ 'to begin to lose in the game'
 $[qa.kw'a]$ 'to suffer a loss (as in a game)'

- Likewise, the initial uvular of the suffix $-\dot{\chi}u$ 'neck' variably becomes rounded after a labialized obstruent.

(19) $-\dot{\chi}u \sim -\dot{\chi}wu$ 'neck'

- a. $[t.q'\dot{\chi}u]$ 'itching throat, to have an...' $[t.q':\dot{\chi}a]$ 'to itch'
 $[g\dot{\chi}t'\dot{\chi}u]$ 'long neck, having a long neck' $[g\dot{\chi}t]$ 'long, tall'
- b. $[ts'.kw'\dot{\chi}wu \sim ts'.kw'\dot{\chi}u]$ 'short neck(ed)' $[ts'kw]$ 'short'
 $[qw\dot{\chi}.qw'\dot{\chi}wu \sim qw\dot{\chi}.qw'\dot{\chi}u]$ 'to sprain the neck' $[qw\dot{\chi}.qwa]$ 'to sprain, wrench'
 $[m\dot{\chi}.kw'\dot{\chi}wu \sim m\dot{\chi}.kw'\dot{\chi}u]$ 'to choke on sth. solid' $[m\dot{\chi}.kw-]$

- Here one can observe that the feature [round] variably spreads from a labialized consonant onto a following consonant in Oowekyala. Note that this process is different from the one seen above in which the feature [round] regularly spreads from the vowel /u/ onto a consonant.

(20)

ons/coda	ons/coda
[round]	[dorsal]

assimilation as "spreading"

- Rounding assimilation between consonants is *variable*, and there are some exceptions: it does not apply between obstruents across a reduplicative prefix boundary, e.g. (21).

LIPS $\stackrel{\text{def}}{=} \{[\text{LABIAL}], [\text{ROUND}]\}$

(21) *Some reduplications in Oowekyala*

- a. [k'ɭχw.k'ɭ.qwa] (*[k'ɭχw.k'wɭ.qwa]) 'refers to a man urinating repeatedly'
[k'ɭ.qwa] 'to urinate (said of a male)'
- b. [k'ixw.k'i.χwa] (*[k'ixw.kw'i.χwa]) 'run, stop, run (repeatedly)'
[k'i.χwa] 'to run away, escape, flee from'
- c. [Guχw.Gu.χwa] (*[Guχw.Gwu.χwa]) 'to scoop repeatedly'
[Gu.χwa] 'to scoop up loose things with one's hand'
- d. [q'tsɣw.q'ts.kwa] (*[q'tsɣw.qw'ts.kwa]) 'to eat meat'
[q'ts.kw] 'hair seal meat that has been cut up'

- Observe that rounding assimilation operates exclusively from left to right.
 - For example, the suffix *-gwuɬ* 'ago' does not cause rounding when it attaches to *ɲik* 'siphon': *ɲik'gwuɬ* (**ɲikw'gwuɬ*).
 - The nominalizer *-kw* also fails to induce rounding in a preceding (labializable) consonant, as exemplified here:

(22) *-kw* 'nominalizer'

- a. [t'ə.mak.kw] '(door) locked with a key'
[t'ə.ma.ka] 'to lock up with a key (door, trunk, etc.); to tie shoelaces'
- b. [ʔanq.kw] 'stripped from a branch with the fingers (as berries)'
[ʔan.qa] 'to strip berries off the branches with the fingers'
- c. [kiχ.kw] '(sth.) sawn, lumber, board'
[ki.χa] 'to use a saw'

- To understand the rightward bias of rounding assimilation in Oowekyala, it is surely significant that in terms of phonetic timing, rounding tends to be heavily skewed to the right edge of a consonant.

LIPS $\stackrel{\text{def}}{=} \{[\text{LABIAL}], [\text{ROUND}]\}$

- As Ladefoged and Maddieson (1996:357) describe, in consonants rounding “is typically concentrated on the release phase of the primary articulation that it accompanies.”
- Similarly, Watson (1999:298):³⁹
 In labialization, protrusion of the lips tends to occur on or after the hold phase of the primary articulation... As a result, the second formant of a vowel *following* a labialized consonant is lower than the second formant of a vowel *preceding* a labialized consonant.
- Turning now to long-distance assimilation of [round], consider the phenomenon of rounding harmony.
- For example, in Yowlumne (a California Penutian language), suffixes show alternations between [i] and [u], depending on whether the root has [u], e.g. (23)-(25). (Examples are from Archangeli 1984.)

(23) *-hin ~ -hun* ‘aorist’

[li.him.hin] ‘ran’

[ʔu.kun.hun] ‘drank’

(24) *-(ʔ)in̥in ~ -(ʔ)un̥un* ‘resident of’

[ʔaɭ.tʰi.n̥in] ‘resident of salt-grass’ (Poso Creek tribe)

[pa.ɭu.wu.n̥un] ‘resident of west; westerner’

(25) *-ijin ~ -ujun* ‘intensive possessor’

[piṭ.kʰi.jin] ‘one who is always excreting’

[tʰu.kʰu.jun] ‘one with large ears; jackrabbit’

³⁹ Cf. Gussenhoven and Jacobs (1998:197): “The two place nodes in a segment with secondary articulation are not sequenced in time. Although in the IPA symbols the superscripts indicating labialization, velarization, etc. conventionally appear to the right of the consonant symbol, the two components of a secondary articulation segment are phonologically simultaneous. That is, a side-view would show a straight line.”

LIPS $\stackrel{\text{def}}{=} \{[\text{LABIAL}], [\text{ROUND}]\}$

- Similarly, suffixes show alternations between [a] and [o] depending on whether the root has [o], e.g. (26-27).

(26) *-al ~ -ol* ‘dubitative’

[tʰiʔ.sal] ‘might make’

[hotʰ.nol] ‘might take the scent’

(27) *-hatin ~ -hotin* ‘desiderative’

[tʰaw.ha.tin.xoː.hin] ‘was trying to win’

[tʰos.ho.tin.xoː.hin] ‘was trying to sell’

- In other words, vowels of the same height —high vs. nonhigh— agree in terms of [round], even across intervening consonants. Height features are covered in a later section.

TONGUE FR. $\stackrel{\text{def}}{=} \{[\text{COR}], [\text{POSTERIOR}], [\text{LAMINAL}]\}$

Tongue fr. $\stackrel{\text{def}}{=} \{[\text{cor}], [\text{posterior}], [\text{laminal}]\}$

[CORONAL]

- “Coronal sounds are produced with the blade of the tongue raised from its neutral position; noncoronal sounds are produced with the blade in the neutral position” (Chomsky & Halle 1968:304).
- Consonants specified [coronal] are relatively numerous in most languages; they include:

- *dentals*

[illegible]

- *alveolars*

t, nt, d, nd, th, t̂, d̂h, d̂, d̂g, t̂w, nt̂w, d̂w, nd̂w, t̂wh, t̂w, d̂wh, d̂w, d̂ĝw, t̂j, nt̂j, d̂j, nd̂j, t̂jh, t̂j, d̂jh, d̂ĵ, d̂ĵ, t̂v, nt̂v, d̂v, nd̂v, t̂v, d̂vh, d̂v, d̂ĝv, t̂f, nt̂f, d̂f, nd̂f, t̂f, d̂fh, d̂f, d̂ĝf, ts, nt̂s, dz, nt̂dz, tŝh, tŝ, dẑh, dẑ, t̂t, nt̂t, d̂t̂g, nd̂t̂g, t̂t̂h, t̂t̂, d̂t̂ĝh, d̂t̂ĝ, s, ns, z, nz, ẑ, sĥ, ŝ, ŝw, ẑw, sĵ, zĵ, sf̂, zf̂, t̂, t̂g, t̂ĝ, tĥ, t̂, t̂f, t̂ĝf, t̂f, n, n̂g, n̂, n̂w, n̂ĝw, n̂w, nĵ, nv̂, nf̂, l̂, l̂, l̂, l̂w, t̂w, l̂ĝw, l̂w, l̂ĵ, l̂ĵ, l̂f̂, t̂, t̂ĝ, t̂, t̂w, t̂w, t̂ĝw, t̂w, l̂, l̂w, r̂, r̂, r̂w, r̂ĵ, rv̂, rf̂, r̂, r̂, r̂w, r̂ĵ, rv̂, rf̂, ɹ̂, ɹ̂w, r̂, r̂w, etc.

- *retroflexes*

t, $\mathfrak{t}$, d, $\mathfrak{d}$, t^h, $\mathfrak{t}$, d^h, $\mathfrak{d}$!, t^w, $\mathfrak{t}^w$, d^w, $\mathfrak{d}^w$, t^{wh}, $\mathfrak{t}^w$, d^{wh}, $\mathfrak{d}^w$, s, z, $\mathfrak{z}$, s^h, $\mathfrak{s}$, n, $\mathfrak{n}$, $\mathfrak{n}$, n^w, $\mathfrak{n}^w$, n^w, $\mathfrak{l}$, $\mathfrak{l}$, $\mathfrak{l}$, l^w, $\mathfrak{l}^w$, l^w, r, r^h, r^w, $\mathfrak{r}$, $\mathfrak{r}^w$, etc.

- *palatoalveolars*

$\mathfrak{f}, {}^n\mathfrak{f}, \mathfrak{d}, {}^n\mathfrak{d}, \mathfrak{f}^h, \mathfrak{f}, \mathfrak{d}^h, \mathfrak{d}^3, \widehat{\mathfrak{c}}, {}^n\widehat{\mathfrak{c}}, \widehat{\mathfrak{d}}, {}^n\widehat{\mathfrak{d}}, \widehat{\mathfrak{c}}^h, \widehat{\mathfrak{d}}^h, \mathfrak{d}^j, \mathfrak{f}, \mathfrak{z}, \widetilde{\mathfrak{f}}, \mathfrak{f}, \mathfrak{f}^w, \mathfrak{z}^w, \widetilde{\mathfrak{z}}^w, \mathfrak{f}^{wh}, \mathfrak{f}^w, \mathfrak{f}, \mathfrak{z}^j, \widetilde{\mathfrak{z}}^j, \mathfrak{f}^h, \mathfrak{f}, \mathfrak{f}, \mathfrak{z}^j, \widetilde{\mathfrak{z}}^j, \mathfrak{f}$, etc.

- *alveolopalatals*

$\mathfrak{c}, \mathfrak{z}, \tilde{\mathfrak{z}}, \mathfrak{c}^{\mathfrak{h}}, \mathfrak{c}', \mathfrak{tc}, {}^{\mathfrak{n}}\mathfrak{tc}, \mathfrak{dz}, {}^{\mathfrak{n}}\mathfrak{dz}, \mathfrak{tc}^{\mathfrak{h}}, \mathfrak{t}\mathfrak{c}', \mathfrak{dz}^{\mathfrak{h}}, \mathfrak{d}^{\mathfrak{z}}, \mathfrak{tc}^{\mathfrak{j}}, {}^{\mathfrak{n}}\mathfrak{tc}^{\mathfrak{j}}, \mathfrak{dz}^{\mathfrak{j}}, {}^{\mathfrak{n}}\mathfrak{dz}^{\mathfrak{j}}, \mathfrak{tc}^{\mathfrak{j}\mathfrak{h}}, \mathfrak{t}\mathfrak{c}'^{\mathfrak{j}}, \text{etc.}$

TONGUE FR. $\stackrel{\text{def}}{=} \{[\text{COR}], [\text{POSTERIOR}], [\text{LAMINAL}]\}$

- That such diverse sounds uniquely share a phonological feature is suggested by their class behavior in phonological patterns.
 - For example, Canadian (and American) English allows a variety of onsets before the nucleus [ju]:
 - [p] in 'puny', [b] in 'beauty', [f] in 'fume', [v] in 'view', [m] in 'muse', [k] in 'cube', [g] in 'legume', [h] in 'hue', etc.
 - But a large class of onsets is not permitted to occur before [ju]:
 - [θ, ð, t, d, s, z, n, l, ʃ, ʒ, tʃ, dʒ, ɹ]
 - Examination reveals that those consonants which are not allowed before [ju] in Canadian English are precisely those articulated with the tongue blade or tip.
 - This generalization is captured if they share an articulator feature: no [coronal] onset with the nucleus [ju].⁴⁰

North America	vs.	UK
<i>d[u]pe</i>		<i>d[ju]pe</i>
<i>l[u]rid</i>		<i>l[ju]rid</i>
<i>n[u]ws (news)</i>		<i>n[ju]ws</i>
<i>pre[zu]me</i> (<i>presume</i>)		<i>pre[zju]me</i>
<i>st[u]pid</i>		<i>st[ju]pid</i>
<i>s[u]t (suit)</i>		<i>s[ju]t</i>

TONGUE FR. $\stackrel{\text{def}}{=} \{[\text{COR}], [\text{POSTERIOR}], [\text{LAMINAL}]\}$

- Suggestive evidence that the distinctive feature [coronal] has independent status comes from speech errors
 - E.g., the articulator features [labial] and [coronal] are individually exchanged in the speech error *pedestrian* >^e *tebestrian* (Fromkin 1971).
- Further evidence that [coronal] is an independent feature comes from *mutation* patterns in Shona, a Southern Bantu language.
 - As LaCharité (1993) discusses, the causative suffix in Shona may be [-is-] or [-es-] when added to some stems, as illustrated in (a) below.
 - More typically, however, the causative morpheme is represented by just two features, [strident] and [coronal], which arguably survive from underlying [-s-].
 - These two features target the stem-final onset, resulting in various “mutations”: r > dz (b), t > ts (c), k > ts (d), ŋg > nz (e), b > dbzv (f), and β > zv (g).

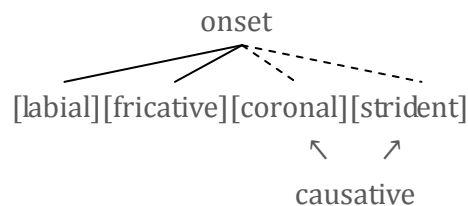
(1) Shona (LaCharité 1993)

a.	[...bi.ka] ‘cook’	[...bi.ki.sa] ‘make (someone) cook’
	[...e.nda] ‘go’	[...e.nde.sa] ‘make (someone) go’
	[...kwí.rá] ‘go up, climb’	[...kwí.rí.sá] ‘make (someone) climb’ or ‘lift up’
b.	[...kwí.rá] ‘go up, climb’	[...kwí.dzá] ‘make (someone) climb’ or ‘lift up’
	[...ri.ra] ‘make a sound’	[...ri.dza] ‘make (someone) make a sound’
c.	[...net...] ‘become tired’	[...ne.tsa] ‘make tired’
d.	[...seka] ‘laugh’	[...se.tsa] ‘make (someone) laugh’
e.	[...té.ŋgá] ‘buy’	[...té.nzá] ‘sell’
f.	[...re.βa] ‘be long’	[...redbzva] ‘lengthen’
g.	[...pó.ró.βá] ‘be moist, soft’	[...pó.ró.zvá] ‘moisten, soften’

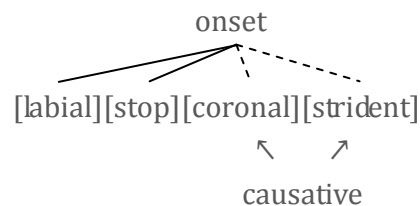
TONGUE FR. $\stackrel{\text{def}}{=} \{[\text{COR}], [\text{POSTERIOR}], [\text{LAMINAL}]\}$

- In the first two changes, $r > dz$ and $t > ts$, only [strident] is obviously added to the stem-final onsets (which are already [coronal]).⁴¹
- In the next two changes, $k > ts$ and $\eta g > nz$, both causative features —[coronal] and [strident]— are added to the stem-final velar consonants, resulting in the loss of the original velar articulation (see [dorsal] next week).
- Finally, in the last two changes, $b > dbzv$ and $\beta > zv$, both ‘causative’ features —[coronal] and [strident]— are added to the stem-final labial consonants, resulting in *complex* sounds:⁴²

(2) $\beta \rightarrow zv$



$b \rightarrow dbzv$



- In sum, causative formation in Shona provides a strong argument for the independent status of the articulator feature [coronal].

⁴¹ See LaCharité (1993) for a discussion of why [rhotic] changes into [stop] rather than [fricative] in Shona, i.e. $r \rightarrow dz$ rather than $r \rightarrow z$.

⁴² Such sounds are relatively rare. Only one language appears to have labial-coronal stops such as $/\hat{t}p, \hat{n}m/$ (cf. Maddieson 1983, who denies their existence; Yeletnye, Papuan: Ladefoged & Maddieson 1996:344).

TONGUE FR. $\stackrel{\text{def}}{=} \{[\text{COR}], [\text{POSTERIOR}], [\text{LAMINAL}]\}$

- In English, [lateral] can combine with [labial] or [dorsal] obstruents in syllable onsets, but not with [coronal] obstruents:⁴³

$\left[\begin{array}{c} \{ \text{labial} \} \\ \{ \text{dorsal} \} \\ \{ \text{fricative} \} \\ \text{stop} \\ \text{lateral} \end{array} \right]_{\text{onset}}$	<i>fly, play,</i> <i>blow, clue,</i> <i>glow, etc.</i>	vs.	$* \left[\begin{array}{c} \text{coronal} \\ \{ \text{fricative} \} \\ \text{stop} \\ \text{lateral} \end{array} \right]_{\text{onset}}$	<i>*thly, *tlay,</i> <i>*dlow, *chlue,</i> <i>*jlow, etc.</i>
--	--	-----	--	---

- When they encounter *tl* onsets, English speakers usually substitute [dorsal] for [coronal], e.g.:
 - Tlingit* ['klɪŋ.gɪt] (Indigenous people of BC and AK)
 - Tlaxcala* [ˌklas.'ka.lə] (Mexican state and city)
 - Tlemcen* [ˌklɛm.'sɛn] (Algerian city)
- 'Another universal bites the dust: Northwest Mekeo lacks coronal phonemes' (Blevins 2009)
 - Northwest Mekeo (Oceanic, Papua New Guinea) lacks codas, has these onsets:

p β ~ b ~ v m w ~ o j ~ ɛ k g ~ dzj ŋ ~ n

- "In all varieties of Mekeo, the velar nasal /ŋ/ is pronounced as [n], a coronal nasal, when adjacent to a preceding or following /i/" (p. 267).
- "Northwest Mekeo ... shows regular /ŋ/ → n / __i, except when another velar occurs within the word, in which case the assimilation is inhibited, as in /gunji/ 'push', Northwest Mekeo *gunji*, but *guni* in all other dialects." (p. 267, fn. 5)

⁴³ The feature cluster [strident, fricative, coronal] appears to combine with [lateral] in onsets in e.g. *sleep*, *Schlepp*. [s] and [ʃ] are exceptional in this regard and may be "appended" more generally. For instance, they are the only consonants with nasals, e.g., *snow*, *small*, *schnapps*, *schmuck*. Note that words that begin in *ʃC*, where *C* ≠ ɹ, derive from Yiddish and are recognized by speakers as being unusual.

TONGUE FR. $\stackrel{\text{def}}{=} \{[\text{COR}], [\text{POSTERIOR}], [\text{LAMINAL}]\}$

(3) $\eta \rightarrow n \% _i$ in Northwest Mekeo

$\% _i$ means
/ $_i$ or / $i_$

(= “mirror
image rule”)

PROTO-M.	NW M.		Alternation: $-\eta a \sim -na$ ‘his’
*[i.ɲa]	> [i.na]	‘mother’	[i.na.ɲa] ‘his mother’
*[a.ɲi]	> [a.ni]	‘seed’	[a.ni.na] ‘his seed’
*[a.i.ɲa]	> [a.i.na]	‘ear’	
cf. *[a.ɲo]	> [a.ɲo]	‘earth’	

- “/g/ voiced velar stop; the main (conditioned) allophone is [dzʲ] before /i/.” (p. 266)
 - Evidently a form of assibilation, involving not only [coronal] but also [strident].

(4) $g \rightarrow dz^j / _i$ in Northwest Mekeo

[gi.na] → [dzʲi.na] ‘sun, day’ [a.gi] → [a.dzʲi] ‘younger same sex sibling’

- “Before this massive influence [from English], the absence of /t/, /s/, and /n/ in Mekeo resulted in English words with coronals being shifted to velars. For example, English *tea* was borrowed as /ki/, *soap* was borrowed as /kopu/, and *towel* was borrowed as /kauli/. In more recent times, the influence of English results in nonaltered loans like [tʰi] ‘tea’, [tʰopu] ‘soap’, [tauli] ‘towel’, [tʰili] ‘chili pepper’, [tʰiuka] ‘sugar’, [milika] ‘milk’, [tʰiati] ‘shirt’, [tʰokis] ‘socks’, and so on... In the Northwest Mekeo text published in Jones (1998:581-82), the author’s name, *Alan Jones*, and the English word *family* /famili/ are both pronounced with coronal consonants. Northwest Mekeo also has words with surface [l] that are borrowings from other Mekeo dialects, or other neighboring languages: for the meaning ‘good’, compare Northwest Mekeo *lobiana* ‘with Iafia, Lapeka *lobiana*, Kuni *yobiana*...’ (Blevins 2009:269)

Exercise: List then discuss all the codas which may appear after [aw] in English, with an example of each, e.g.: [t] *shout*. (Halle & Clements 1983)

TONGUE FR. $\stackrel{\text{def}}{=} \{[\text{COR}], [\text{POSTERIOR}], [\text{LAMINAL}]\}$

Apparent exceptions in child language and some dialects:

[[sewf]] 'south', [[mewf]] 'mouth', [[ma'wvŷ]] 'mouthe' (also 'foulmouthed'), etc.



TH fronting is a merger that occurs (historically independently) in Cockney, Newfoundland English, African American Vernacular English, and Liberian English (though the details differ among those accents), by which Early Modern English [θ, ð] merge with [f, v]. ... Apparently, no accents with the merger completely merge the phonemes, because virtually all speakers such accents know which words "should" have which sound; moreover, in many accents the two sounds appear in free variation. Where TH fronting is applied, pairs such as three/free, slither/sliver, and oath/oaf are homophonous. (Wells 1982:328-330)

Assimilation

- An example of [coronal] assimilation occurs in the Sri Lankan Portuguese Creole (Smith 1978; Hume & Tserdanelis 1999; de Lacy 2002:326; 2002).
- In this language, [labial, nasal] becomes [coronal] preceding a [coronal] consonant, as shown in (5a), and similarly, [dorsal, nasal] assimilates to a following [coronal] consonant, as shown in (5b). The reverse is not true: [coronal, nasal] does not change to [labial]

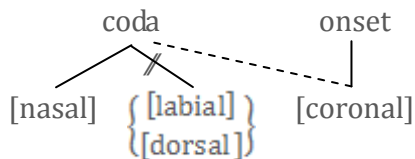
TONGUE FR. $\stackrel{\text{def}}{=} \{[\text{COR}], [\text{POSTERIOR}], [\text{LAMINAL}]\}$

preceding a [labial] consonant, nor to [dorsal] preceding a [dorsal] consonant, as shown in (5c).

(5) *Sri Lankan Portuguese Creole*

a.	[ma:m]	vs.	[ma:n.su]	'hand' (genitive)
	[pə.rim]		[pə.rin.tə.su.wa:]	'I am sweating'
	[re.za:m]		[re.za:n.ləj]	'reasonably'
b.	[mi:.tiŋ]		[mi:.tin.su]	'meeting' (gen.)
	[uŋ]		[un.di:.jə.pə]	'for one day'
c.	[kə.klu:n]		[kə.klu:n.pə]	'turkey' (dative sg.)
	[si:n]		[si:n.ki]	'bell' (verbal noun)

(6) *Regressive [coronal] assimilation as "spreading"*



- Another example is provided by nasal place assimilation in Chukchi (Chukotko-Kamchatkan, Siberia: Bogoras 1922; Kenstowicz 1980; 1986). As the following paradigm illustrates, an underlying /ŋ/ converts to [n] before coronals.⁴⁴

(7) *Place assimilation in Chukchi* (Bogoras 1922:653-7; Kenstowicz 1980:90-1)

[te.ŋəʔ.ʔən]	'good'	[tan.ʔan]	'good house'
[tan.leut]	'good head'	[tan.ʔʔa.ʔə]	'good breastband'
[tan.ʔəm.ŋəʔ]	'good story'	[tan.tʃot.tʃot]	'good pillow'
[ten.jəʔ.qe.tək]	'sleep well'	[tan.tʃai]	'good tea'

⁴⁴ [a] ~ [e] alternations are due to vowel harmony (see p. 152ff. below). Bogoras' and Kenstowicz's *r* is written *ʎ*, after its description in Spencer (1999:2.1) as "retroflex glide (like Standard British English)". (7b) is from Spencer (1999:9.4.1.12).

TONGUE FR. $\stackrel{\text{def}}{=} \{[\text{COR}], [\text{POSTERIOR}], [\text{LAMINAL}]\}$

Dissimilation

- As an example of [coronal] dissimilation, consider first the case of reduplication in Dakota, a Siouan language (Shaw 1980). In general a CVC-shaped portion of the word is faithfully copied in reduplication, as shown in (8a). However, when both C's of the copied syllable are [coronal], one is realized as [k] in reduplication, as shown in (8b). This change in Dakota reduplication is an instance of [coronal] dissimilation.

(8) *Dakota reduplication*

a.	[ʃa.pa]	[ʃap.ʃá.pa]	'be dirty'
	[zú.ka]	[zuk.zú.ka]	'hang in mucuous strings'
	[tʃé.ka]	[tʃek.tʃé.ka]	'be staggering'
b.	[su.tá]	[suk.sú.ta]	'be hard, firm'
	[ʃé.tʃa]	[ʃek.ʃé.tʃa]	'be dry and dead'
	[ʒĩ.tʃa]	[ʒĩk.ʒĩ.tʃa]	'to sniffle'
	[tí.tǎ]	[tik.ti.tǎ]	'to have force exerted'

- In Chukchi (cf. (7) above) [coronal] *j* changes to [dorsal] *y* when followed by a coronal consonant (Kenstowicz 1980; Odden 1987; Rice 1996:521):⁴⁵

[T]he change of [j] to the velar spirant [ɣ] before coronals ... is a quite regular rule, as evidenced by the behavior of Russian loanwords such as *tʃaj* 'tea': cf. *tʃaj-te* (plural), but *tʃaj-paw-ək* 'to drink tea', *tʃaj-kojŋ-ən* 'tea cup'. (Kenstowicz 1986:87)

[POSTERIOR]

- As we saw in the preceding section, a wide variety of sounds are specified with the articulator feature [coronal].

⁴⁵ The change may actually be to [k], as in Dakota, since [k] regularly lenites to [ɣ] preconsonantly (Kenstowicz 1986a:80).

TONGUE FR. $\stackrel{\text{def}}{=} \{[\text{COR}], [\text{POSTERIOR}], [\text{LAMINAL}]\}$

- A first subgroup, which is produced behind the alveolar ridge, is specified [posterior]:
 - *retroflexes*: $\mathfrak{s}, \mathfrak{z}, \mathfrak{t}, \mathfrak{d}, \mathfrak{t}^h, \mathfrak{d}^h, \mathfrak{d}, \mathfrak{t}^w, \mathfrak{d}^w, \mathfrak{n}, \mathfrak{l}, \mathfrak{r}, \mathfrak{l}, \mathfrak{l}^w$, etc.
 - *palatoalveolars*: $\mathfrak{ʃ}, \mathfrak{ʃ}^w, \mathfrak{ʒ}, \mathfrak{ʒ}^w, \mathfrak{tʃ}, \mathfrak{dʒ}, \mathfrak{tʃ}^h, \mathfrak{tʃ}^w$, etc.
 - *alveolopalatals*: $\mathfrak{ɕ}, \mathfrak{ʝ}, \mathfrak{tɕ}, \mathfrak{dɕ}, \mathfrak{tɕ}^h, \mathfrak{tɕ}^w$, etc.
 - *palatals*: $\mathfrak{ç}, \mathfrak{j}, \mathfrak{c}, \mathfrak{ɟ}, \mathfrak{c}^h, \mathfrak{c}^w, \mathfrak{f}, \mathfrak{ɸ}, \mathfrak{ɰ}, \mathfrak{j}, \mathfrak{ɥ}$, etc.
- The complement of [posterior] is termed *anterior*: “Anterior sounds are produced with an obstruction that is located in front of the palato-alveolar region of the mouth” (Chomsky & Halle 1968:304).⁴⁶
 - *dentals*: $\mathfrak{θ}, \mathfrak{ð}, \mathfrak{θ}^f, \mathfrak{s}, \mathfrak{z}, \mathfrak{t}, \mathfrak{d}, \mathfrak{n}, \mathfrak{d}, \mathfrak{t}^h, \mathfrak{t}^w, \mathfrak{d}, \mathfrak{t}^h, \mathfrak{d}^h, \mathfrak{t}^h, \mathfrak{d}^h, \mathfrak{t}^h, \mathfrak{d}^h, \mathfrak{n}, \mathfrak{n}^w, \mathfrak{l}$, etc.
 - *alveolars*: $\mathfrak{s}, \mathfrak{z}, \mathfrak{s}^w, \mathfrak{s}^j, \mathfrak{s}^f, \mathfrak{t}, \mathfrak{d}, \mathfrak{n}, \mathfrak{d}, \mathfrak{t}^h, \mathfrak{t}^w, \mathfrak{d}^h, \mathfrak{t}^w, \mathfrak{t}^j, \mathfrak{t}^f, \mathfrak{ts}, \mathfrak{dz}, \mathfrak{t}, \mathfrak{ʒ}, \mathfrak{tʃ}, \mathfrak{dʒ}, \mathfrak{tʃ}^h, \mathfrak{tʃ}^w, \mathfrak{n}, \mathfrak{n}^w, \mathfrak{n}^j, \mathfrak{n}^v, \mathfrak{l}, \mathfrak{l}^w, \mathfrak{l}^j, \mathfrak{l}^f, \mathfrak{t}, \mathfrak{d}, \mathfrak{r}, \mathfrak{r}^w$, etc.
- The English rhotic [ɹ] is listed as alveolar in the IPA chart but it behaves as [posterior]:⁴⁷
 - The ‘foreign’ syllable onset [sɹ] is nativized as [ʃɹ], as in ‘sri’ (frequently written <shree>), e.g. *Sri Lanka*, *Sri Chinmoy*, etc.
 - Cf. *shrink*, *shred*, *shrub*, *shrill*, *shrapnel*, *shrewd*, *shrimp*, *shroud*, *shrine*, etc.
 - Many speakers also pronounce the onset [tɹ] as [tʃɹ], and [dɹ] as [dʒɹ].

⁴⁶ Chomsky & Halle’s definition does not mention the front of the tongue because they also considered labial sounds to be anterior. This view was abandoned as phonological phenomena very rarely group labials with anterior coronals.

⁴⁷ English [ɹ] is a postalveolar approximant which varies phonetically between retroflex [ɻ] and “bunched” [ɻ̥] (Laver’s (1994:302) [ɻ̥]). The latter variant is favored in combination with [t, d] (Guenther et al. 1999); see below.

TONGUE FR. $\stackrel{\text{def}}{=} \{[\text{COR}], [\text{POSTERIOR}], [\text{LAMINAL}]\}$

- This causes some children to write <tr> as <chr>, e.g. <chrie> ‘try’ (Read 2009:265). Read (1975:79-104) gives more examples, including <chree> ‘tree’ and <jru> ‘Drew’.
- “at early stages of development, what a learner writes is not merely an imperfectly remembered standard spelling. In fact, a learner may never have even seen the standard spelling of a word that she wishes to write. Rather, the spellings that learners produce are in many instances the result of an active effort, based on the sound of the word, including its syllabic structure, and a partial knowledge of the principles of standard spelling, including letter-names, sound-spelling correspondences, and spelling patterns, as well as, later in development, whatever the learner knows (or supposes) about the history and morphology of the word. We now know that spelling is like reading in that while focusing on the message, the learner attempts to integrate multiple kinds of information.” (Read 2009:268-9)
- As usual, syllable constituents are crucial in understanding this phenomenon. Speakers may apply this process in *sri*, *entrée* and *address*, where the participating features belong to the same syllable, but not in *disregard*, *outrage* or *headrest*, where the features in question belong to separate syllables.

Enhancement

Phonetic enhancement

- “Enhancement” (Stevens et al. 1986 et seq.) is the notion that weak feature contrasts may be strengthened by supplemental subfeatural gestures.⁴⁸ A good example is the superimposition of lip protrusion on the defining tongue blade gesture for [posterior] in, say, /ʃ/. This enhances the perceptual saliency of that distinctive feature, as Stevens and Keyser (2010:16) explain:

This rounding tends to lower the natural frequency of the anterior portion of the vocal tract, so that the frequency of the lowest major spectrum prominence in the

⁴⁸ The principle is closely related, if “independently developed” (Diehl 2008:974), to the auditory enhancement hypothesis (Diehl & Kluender 1989a; b; Diehl et al. 1990; Kingston & Diehl 1994).

TONGUE FR. $\stackrel{\text{def}}{=} \{[\text{COR}], [\text{POSTERIOR}], [\text{LAMINAL}]\}$

fricative spectrum is in the F3 range, well below the F4 or F5 range for the lowest spectrum prominence for the contrasting fricative consonant /s/.

- Stevens and Keyser observe that enhancing gestures gain importance as the gestures which are more obviously associated with distinctive features reduce:
 - “Enhancing acoustic cues usually preserve evidence for the distinctive feature, even though the defining acoustic cue is weakened or even obliterated” (ib.:18).
 - In fact, Perkell et al. (1998) report that upper lip protrusion *trades off* with tongue blade retraction from token to token in American English [ʃ].
 - Kingston (2007) interprets this “effort to keep resonator length constant ... as evidence that the speaker is trying to produce a particular acoustic or auditory effect” (p. 405). Manifestly, the effect in question is a strong spectrum prominence in the F3 range.

Phonological enhancement

- Though enhancement properly belongs to the phonetic component of grammar, it is recognized that “enhancement gestures can become phonologized” (Keyser & Stevens 2006:61).
- In fact, most phonologizations derive from enhancement gestures (Hyman 2008).
- One example (among many) from Flynn (2011): Miotti (2002) reports that in central Friulian, the fricatives /ʃ, ʒ/ are variably realized as “post-alveolar” [ʃ̠, ʒ̠] or as “labialized alveolar” [ʃ̠ʷ, ʒ̠ʷ] (p. 241). (The former realization is conservative, the latter innovative.)

(18) Variable alveolarization and labialization in non-(sub)urban central Friulian

/ʃ/ [ʃ ~ ʃ̠ʷ]	/meʃe'da/	‘to mix, stir’	cf. /s/ [s]	/'mase/	‘too much’
	/pa'i:ʃ/	‘villages’		/pa'i:s/	‘village’
	/'vo:ʃ/	‘voice’		/'vo:s/	‘voices’
/ʒ/ [ʒ ~ ʒ̠ʷ]	/al'bruʒe/	‘it burns’	cf. /z/ [z]	/'muze/	‘face’
	/a'ʒe:t/	‘vinegar’		/'caze/	‘house’
	/'ʒave/	‘toad’		/zar'din/	‘garden’

TONGUE FR. $\stackrel{\text{def}}{=} \{[\text{COR}], [\text{POSTERIOR}], [\text{LAMINAL}]\}$

- That [round] should figure categorically precisely where [posterior] disappears indicates that central Friulian has phonologized the above-described acoustically/auditorily-based trade-off relation between tongue-blade retraction (the feature-defining gesture) and lip protrusion (the enhancement gesture).
- Another example re: [tɪ] → [tʃɪ] and [dɪ] → [dʒɪ] discussed above. Note that [strident] is also added. This is because the specification [stop, posterior] is “enhanced” by [strident] in English phonology.

As Clements (2009:50) explains: “[±strident] can be understood as a feature that enhances the acoustic properties of ... posterior sounds (such as palatoalveolars), in the sense of Stevens, Keyser & Kawasaki (1986). It enhances ... posterior obstruents by making their characteristic lower frequency noise component in the region of the third formant more audible. ... The addition of [+strident] to a posterior stop increases its auditory distance from a nonstrident anterior stop such as /t/. In this case, the increase is not along a uniform auditory dimension, but along a different one. This is because /tʃ/ differs from /t/ not only in terms of its lower burst and transition frequencies, which depend on the feature value [+posterior], but also in terms of the presence of high-pitched, high-amplitude turbulence noise following the burst, which depends on [+strident]. [More exactly, in [+posterior] obstruents the lowest spectral prominence is associated with F3 of neighboring vowels, while in [−posterior] obstruents this prominence is associated with F4 or F5 of neighboring vowels ... As for [±strident], the high-frequency spectral energy of [+strident] sounds exceeds that of neighboring vowels, while the spectral energy of [−strident] sounds is lower than that of neighboring vowels at all frequencies ...] It is not always clear whether a given enhancing property is due to a feature operating at the phonological level or to a gesture introduced at the phonetic level. In the case of English /tʃ/, /dʒ/, however, the enhancement is clearly due to the feature [+strident], for three reasons. First, the stridency following the release of /tʃ/, /dʒ/ is not variable or gradient, but appears to be similar in duration, prominence and consistency to the distinctive stridency of affricates in languages in which they contrast minimally with nonstrident stops. Second, though this feature is redundant in the stops /tʃ/, /dʒ/ in English, it is distinctive in the fricatives /s/, /z/, which are minimally distinguished from /θ/, /ð/ by their stridency. The redundancy rule introducing [+strident] in the stops thus introduces a feature which is already distinctive in the system. Third, redundant values of [+strident] function in exactly the same way as distinctive values of [+strident] in English phonology. For example, both trigger an epenthetic vowel [ɪ] before the plural marker /-z/; compare

TONGUE FR. $\stackrel{\text{def}}{=} \{[\text{COR}], [\text{POSTERIOR}], [\text{LAMINAL}]\}$

nouns such as *matches* [...tʃɪz], with redundant [+strident], and *places* [...sɪz], with distinctive [+strident].”

Markedness

- [posterior] is especially marked in combination with [fricative], suggesting a constraint *[posterior, fricative].
 - As Clements (2009) concluded in his survey of phonological inventories, “[+posterior] is disfavored with [+continuant] obstruents” (p. 28).
 - Note: [+continuant] $\approx$ [fricative].
 - For example, Spanish admits [posterior, stop] /tʃ, dʒ/ but avoids [posterior, fricative] /ʃ, ʒ/.
 - Similarly, we saw above that in innovative Friulian, [posterior] is variably absented from /ʃ, ʒ/ (and it is replaced by [round]).
 - French *magie* [mazi] ‘magic’ was borrowed into the Bantu language Lingala as [mazi] because Lingala lacks /ʒ/. As Paradis and LaCharité (2001:259) explain, “there is a prohibition against the non-anterior coronal fricatives /ʃ ʒ/ in ... Lingala.”
- Some languages avoid not only [posterior, fricative] but also [posterior, stop].
 - For example, Oowekyala has [s, z, ts, dz, tʂ] but not *[ʃ, ʒ, tʃ, dʒ, tʃʰ].
 - This can be seen in the loanword adaptation of English words, e.g.:

(9) English loanwords in Oowekyala

[tsi.lis]	‘cherries’	[dzam]	‘jam’
[wats]	‘watch’	[dzu:s]	‘juice’
[dzi.gɪns]	‘chicken’	[su.gwa]	‘sugar’
[ma.dzis]	‘matches’		

TONGUE FR. $\stackrel{\text{def}}{=} \{[\text{COR}], [\text{POSTERIOR}], [\text{LAMINAL}]\}$

- That [posterior] sounds are relatively complex is also apparent in language acquisition. Berhardt and Stemberger (1998a:299-300) observe that it is common for children under nine to rid coronal obstruents of [posterior] in their speech, e.g. *ship* as [sɪp], *chip* as [tɪp].
 - The opposite pattern, in which all anterior alveolars are replaced by [posterior] palatoalveolars, is rare and attested only in individuals with oral mechanism challenges such as cleft palates (ibid.).
- In child-directed Persian, [s, z, ts, dz] substitute for [ʃ, ʒ, tʃ, dʒ].
- Relatedly, in Luiseño, a Uto-Aztecan language from the San Diego area of California, [ʃ] changes to [s] in diminutive forms. As Kroeber and Grace (1960:23) describe, “[ʃ] in a noun stem becomes [s] when the diminutive suffix, *-mal* is added, irrespective of whether the [ʃ] occurs one or two syllables before the suffix or of its position in the syllable.”

(10) *Diminutive in Luiseño* (Kroeber & Grace 1960:23)

[ʃu:.kat]	‘deer’	vs.	[suk.mal]	‘fawn’
[ʃo.ká:.wot]	‘tree squirrel’		[so.káw.mal]	‘small tree squirrel’
[to:.ʃe.xet]	‘cottontail’		[to:.sex.mal]	‘young cottontail’
[maʃ.la]	‘large brake fern’		[mas.mal]	‘small fern’
[qa:.ʃil]	‘white sage’		[qa:.si.mal]	‘blue sage’
[ʃo:.wut]	‘black rattlesnake’		[so.mal]	‘small species’

- Notwithstanding markedness, many languages do contrast [posterior] sounds with anterior ones.
 - For example, the West African language Hausa contrasts [rhotic] /r/ (or /ɾ/) with [rhotic, posterior] /ɽ/, e.g., *bára:* ~ *bárá:* ‘servant’ vs. *báɽà* ‘begging’ (Ladefoged & Maddieson 1996:237).
 - The California language Karok contrasts [strident] /ʂ/ with [strident, posterior] /ʂ̚/, e.g., *ʂú:f* ‘creek’ vs. *ʂ̚ú:f* ‘backbone’.

TONGUE FR. $\stackrel{\text{def}}{=} \{[\text{COR}], [\text{POSTERIOR}], [\text{LAMINAL}]\}$

- Similarly, in Luiseño: *šúkat* ‘deer’ vs. *šúkmal* ‘fawn’ (ibid., p. 146).
- Here are some (near) minimal pairs involving [posterior] from the South Wakashan language Nuuchahnulth (Sapir & Swadesh 1939):

(11) *Nuuchahnulth*

[su:p]	‘soap’ or ‘soup’ < Eng	[fu:.wis]	‘shoes’ < Eng
[tsa.ka:]	‘to get spilled’	[tʃa.ʔak]	‘island’
[ts’a.ʔak]	‘river’	[tʃ’a.ʔak]	‘water’

Assimilation

- A case of long-distance assimilation occurs in Barbareño, a Chumashan language spoken in the vicinity of Santa Barbara, California (Mithun 2001). This language has the sibilants in (12). Pairs such as *slow* ‘eagle’ vs. *flow* ‘goal line’ show that [posterior] is contrastive.

(12) *Sibilants in Barbareño Chumash*

			[posterior]
[stop]	ts		tʃ
	ts ^h		tʃ ^h
	ts’		tʃ’
[fricative]	s		ʃ
	s ^h		ʃ ^h

- Barbareño has a process of “sibilant harmony” whereby sibilants must agree in posteriority within a word, e.g.:

(13) *Barbareño Chumash sibilant harmony in stems*

			[posterior]
[sqojis]	‘kelp’	[fofo]	‘flying squirrel’
[ts’axs]	‘scum’	[tʃ ^h umaʃ]	‘Santa Cruz Islander’
[swoʔs]	‘feather ornament’	[tʃ’imujaʃ]	‘escurpe’ (a fish)

- That this is not simply a static fact holding of words but an active process in the language, is apparent from alternations in morphologically-complex words. Thus the prefixes in (14) alternate in terms of [posterior] in words with the suffixes in (15), as illustrated in (16).

(14) *Barbareño prefixes with sibilants*

TONGUE FR. $\stackrel{\text{def}}{=} \{[\text{COR}], [\text{POSTERIOR}], [\text{LAMINAL}]\}$

	[posterior]
[s-] '3 rd person subj.'	[if-] 'dual subject'
[saʔ-] 'future'	[itʃ-] 'associative'
[su-] 'causative'	[uʃ-] 'with the hand'
[sili-] 'desiderative'	

(15) Barbareño suffixes with sibilants

	[posterior]
[-us] '3 rd sg. benefactive'	[-ʃi]/[-ʃa] 'reflective/reciprocal'
	[-Vtʃ] 'affected by'
	[-Vʃ] 'resultative'
	[-ʃ] 'imperfective'
	[(i)-waʃ] 'past'

(16) Barbareño regressive sibilant harmony

		[posterior]
a.	/s-i.ni.we/ [si.ni.we]	/s-iniwe-ʃi/ [ʃin.we.ʃi]
	3-kill 'he killed (it)'	3-kill-reflex. 'he killed himself'
b.	/k-saʔ-ti.wo.liʔ.laj/ [ksaʔ.ti.wo.liʔ.laj]	/k-saʔ-ti.wo.liʔ.la.ji-n-ʃ/ [kʃaʔ.ti.wo.liʔ.la.jitʃ]
	1-future-flute 'I'll play the flute'	1-fut.-flute-verb-imp. 'I'll play the flute'
c.	/k-saʔ-su.kuj/ [ksaʔ.su.kuj]	/s-su.kuj-aʃ/ [ʃu.ju.jaʃ]
	1-future-caus.-boil 'I will boil it'	3-caus.-boil-result. 'boiled islay'

- Specifically, then, Barbareño has a process of "consonant harmony" in which a sibilant assimilates to the [posterior] specification of a following sibilant.
- Additional data illustrating sibilant harmony with the affixes in (14)-(15) are provided in (17) (from Shaw 1991). As shown, [s] assimilates [posterior] from [ʃ] or [tʃ] in (17a,b,c); and [ʃ] assimilates anterior from [s] in (17d).

(17)	a.	/k-su.non-ʃ/ [kʃu.nonʃ]	'I am obedient'
	cf.	/k-su.non-us/ [ksu.no.nus]	'I obey him'
	b.	/sax.tun-itʃ/ [ʃax.tu.nitʃ]	'to be paid'
	cf.	/sax.tun/ [sax.tun]	'to pay'

TONGUE FR. $\stackrel{\text{def}}{=} \{[\text{COR}], [\text{POSTERIOR}], [\text{LAMINAL}]\}$

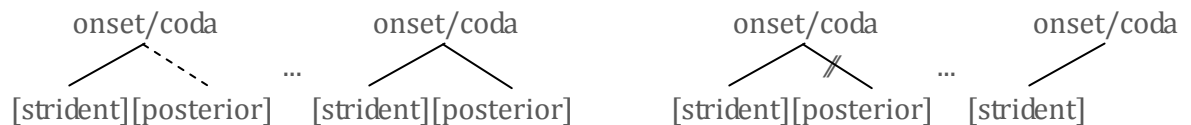
- c. /s-i.lakʃ/ [ʃi.lakʃ] ‘it is soft’
 /s-am-motʃ/ [ʃam.motʃ] ‘they paint it’
 /s-ku.ti-waʃ/ [ʃku.ti.waʃ] ‘he saw’
 cf. /s-i.xut/ [si.xut] ‘it burns’
 /s-a.qu.ni.mak/ [sa.qu.ni.mak] ‘he hides’
- d. /s-iʃ-ti.ʃi-jep-us/ [sis.ti.si.je.pus] ‘they two show him’
 cf. /p-iʃ-al-naŋ/ [pi.ʃa.naŋ] ‘don’t you two go’

The forms in (18) show that the nonsibilant coronals [t, n, l] do not trigger (18a), do not undergo (18b) and do not block (18c) the assimilation of [posterior]. (There are several examples of these facts also in (16) and (17) above.)

- (18) a. [ʃ-a.pi-tʃo-it] ‘I have good luck’
 [s-a.pi-tso-us] ‘he has good luck’
- b. [k-ʃu.non-ʃ] ‘I am obedient’
 [k-su.nos-us] ‘I obey him’
- c. [ha-ʃ-xin.ti.la-waʃ] ‘his former Indian name’
 [ha-s-xin.ti.la] ‘his Indian name’

- To explain the first two facts —that anterior [t, n, l] neither trigger nor undergo sibilant harmony— we might consider adding a restriction on the process: that the source and the target be both specified [strident].

(19) *Long-distance regressive [posterior] assimilation among sibilants in Chumash*



TONGUE FR. $\stackrel{\text{def}}{=} \{[\text{COR}], [\text{POSTERIOR}], [\text{LAMINAL}]\}$

[LAMINAL]

- Chomsky and Halle (1968:312) proposed the feature $[\pm\text{distributed}]$ primarily to distinguish coronals produced with the blade of the tongue —*laminal*— from those produced with the tip of the tongue —*apical*.
- We'll use the more descriptive feature [laminal] (Arsenault 2009; Arsenault & Kochetov 2009).
- The European isolate Basque makes the apical versus laminal distinction in anterior sibilants:

(20) *Anterior sibilants in Basque* (Hualde et al. 2010)

			[laminal]	
[fricative]	[ʃa.ré]	‘net’	[ʃa.kúr]	‘dog’
	[u.ʃái]	‘smell’	[a.ʃá]	‘cabbage’
	[ʃósʃ]	‘money’	[a.pèʃ]	‘priest’
[stop]	[án.tʃi]	‘anxiety’	[tʃi.tʃí]	‘gut, fat’
	[a.tʃó]	‘old woman’	[a.tʃó]	‘yesterday’
	[a.métʃ]	‘dream’	[ítʃ]	‘word’

- Upper Kuskokwim, a Dene language of western Alaska, makes the apical versus laminal distinction in posterior sibilants (Collins 1973).

(21) *Posterior sibilants in Upper Kuskokwim*

		[laminal]		
	[ʃaŋ]	‘summer’	[si.ti.laʃɪ]	‘adze’
	[ʃiʃɪ]	‘bear’	[ʃɪh]	‘hook’
[mi.tsi]	‘caribou’		[ʃɪuh]	‘robin’
	[ʔo]	‘showshoes’	[tʃe.ʔa]	‘camp robber’
	[tʃi.zis]	‘hide, skin’	[tɪaŋ]	‘day’
	[su.tʃe]	‘marten’	[tɪ'ə]	‘wind’
	[tʃuh]	‘quill’	[ʃiʃɪ]	‘bear’
	[ti.ne.tʃe]	‘moose’	[k ^h a. tɪ ^h ə]	‘moccasin’

TONGUE FR. $\stackrel{\text{def}}{=} \{[\text{COR}], [\text{POSTERIOR}], [\text{LAMINAL}]\}$

[ti.tʃiŋ]	'stick'	[do.tʃiŋ]	'raven'
[tʃiʃ]	'cooking stick'	[fʃ'e]	'boat'
[tʃe.tʃ'a]	'dog'	[dʃi.o.de.ja]	'sheep'
[ts'otʃ]	'plate'		
[tʃʰon]	'rain'		
[tʃʰela]	'boy(s)'		
[la.tutʃ]	'headscarf'		
[tʃi.tʃa]	'berries'		

- Among [posterior] coronals, retroflex coronals are considered apical (because the tip of the tongue is curled upwards in their production) whereas palatoalveolars are considered [laminal].
- For example, the Indo-Aryan language Hindi has just one series of anterior coronal stops, but it has two series of [posterior] coronal stops: apical retroflexes and [laminal] palatoalveolars (Ladefoged & Maddieson 1996:58).
- Among anterior coronals, dentals are typically [laminal] (except when they are produced with the tip of the tongue) while alveolars are typically apical (except when they are produced with the blade of the tongue).
- As Ladefoged and Maddieson (1996:20) report:

In the languages we have investigated, dental stops are usually laminal rather than apical, with contact on both the teeth and the front part of the alveolar ridge, whereas the alveolar stops are often apical, with contact usually on the center of the alveolar ridge.

- They thus report the following generalization (p. 23): “languages that contrast dental and alveolar stops have laminal dentals and apical alveolars.” In featural terms, [coronal, stop] is usually interpreted as alveolar, whereas [coronal, laminal, stop] is usually interpreted as dental. For example, the following words from Toda, a Dravidian language, illustrate [laminal] dental stops, alveolar stops, and [posterior] retroflex stops in syllable-final position (ib., p. 21):

TONGUE FR. $\stackrel{\text{def}}{=} \{[\text{COR}], [\text{POSTERIOR}], [\text{LAMINAL}]\}$

(22) *Toda*

	Voiceless		Voiced	
dental	poɽ	'ten'	moɽ	'churning stick'
alveolar	pa:t	'cockroach'	mod	'village with dairy'
retroflex	ɽaɽ	'churning vessel'	maɽ	'head'

- As another example, most Athabascan languages have just one series of [posterior] coronal obstruents (palatoalveolars), but they have at least two series of anterior coronal stops: [laminal] dentals and apical alveolars. This three-way contrast can be illustrated with Dëne Sų́líné affricates (ib., p. 91):

(23) Dëne Sų́líné

t̪ʰéθ	'hide'	tsêke	'rubbers'	t̪ʰiɛ	'berries'
t̪ʰhe	'pipe'	tsʰapa	'money'	t̪ʰhεθ	'duck'
t̪ʰ'ái	'dish'	ts'i	'canoe'	t̪ʰoɣ	'quill'

Assimilation

- The feature [laminal] often patterns with the other Tongue Blade feature, [posterior], in phonological processes.
- For example, Sanskrit has a rule that spreads [posterior] and [laminal] to a preceding alveolar consonant, as illustrated in the following data (Hall 1997:80):

(24)	a.	/ta:n-dimbʰa:n/	[ta:ɳdimbʰa:n]	'those infants'
	b.	/ta:n-dʒana:n/	[ta:ɳdʒana:n]	'those people'
	c.	/etat-t̪ʰattram/	[etat̪ʰt̪ʰattram]	'this umbrella'
	d.	/tat-daukate/	[tat̪daukate]	'it approaches'
	e.	/tatas-t̪ʰa/	[tata̠t̪ʰa]	'and then'
	f.	/pa:tas-t̪alati/	[pa:ta̠st̪alati]	'the foot is disturbed'

TONGUE FR. $\stackrel{\text{def}}{=} \{[\text{COR}], [\text{POSTERIOR}], [\text{LAMINAL}]\}$

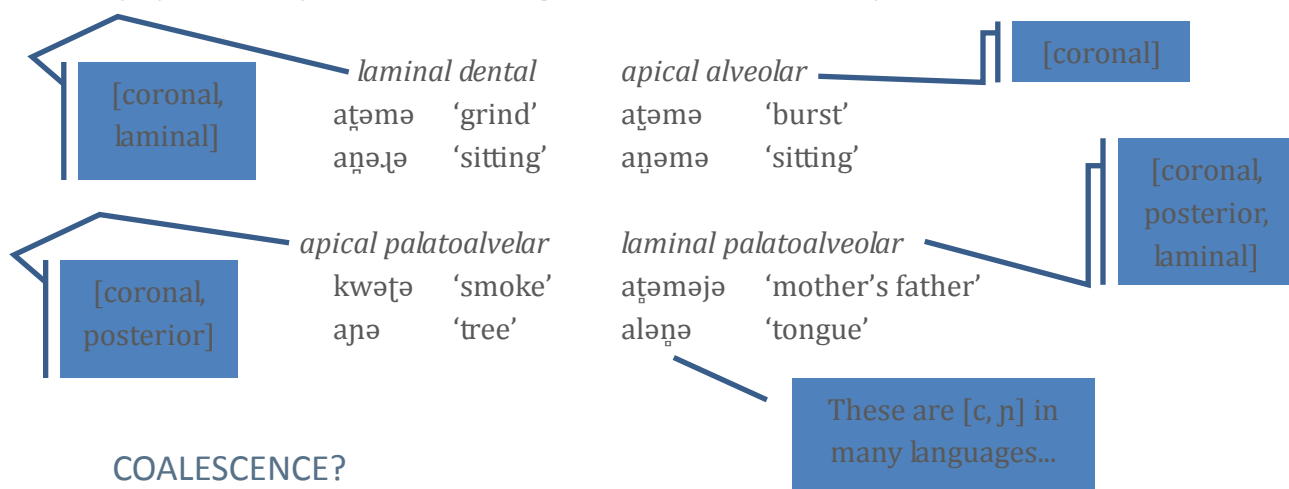
	[coronal]	$\begin{bmatrix} \text{coronal} \\ \text{posterior} \end{bmatrix}$	$\begin{bmatrix} \text{coronal} \\ \text{posterior} \\ \text{laminal} \end{bmatrix}$
[stop]	t	ʈ	tʃ
[fricative]	s	ʂ	ʃ
[nasal]	n	ɳ	ɲ
[rhotic]		ɽ	
	alveolar	retroflex	palatal

- The following additional data show that /n/ does not assimilate to a following velar or labial consonant in Sanskrit. This confirms that the relevant process is *coronal assimilation*: only the tongue-front features [posterior] and [laminal] are assimilated.

- (25)
- | | | | |
|----|-------------------------------|------------------------------|---------------|
| a. | /maha:n-kavih/ | [maha:nkavih] | ‘great poet’ |
| b. | /maha:n-b ^h a:gah/ | [maha:nb ^h a:gah] | ‘illustrious’ |

- The two features [posterior] and [laminal] predict a four-way phonological contrast among [coronal] sounds.

(26) *Arrernte* (Australian: Ladefoged & Maddieson 1996:28)



- “The merging of two or more phonological segments into one.”

TONGUE FR. $\stackrel{\text{def}}{=} \{[\text{COR}], [\text{POSTERIOR}], [\text{LAMINAL}]\}$

- Non-segmental alternative: the distinctive features of separate onsets/nuclei/codas are combined into a single onset/nucleus/coda.
- In the Ethiopian language Amharic, the instrumental suffix is *-(i)ja* when added to stems ending in [labial] or [dorsal].

(27) *Instrumental in Amharic* (Leslau 1995:15, 413)

[gal.læ.bæ]	'gallop'	[mæ.ga.læ.bi.ja]	'means for galloping'
[ʃa.fæ]	'write'	[mæ.ʃa.fi.ja]	'writing material'
[at.tæ.mæ]	'print'	[mat.tæ.mi.ja]	'printing shop/press'
[læq.qæ.mæ]	'pick up'	[mæl.qæ.mi.ja]	'object for picking up things'
[mar.ræ.kæ]	'take prisoners'	[mæ.ma.ræ.ki.ja]	'means/place to take prisoners'
[dæb.bæ.qæ]	'hide'	[mæ.dæb.bæ.qi.ja]	'hiding place'
[tær.ræ.gæ]	'sweep'	[mæt.ræ.gi.ja] ~ [mæt.ræg.ja]	'broom'

- When added to stem ending in [coronal], however, “*-(i)ya* causes palatalization of the preceding dental, sibilant, *l*, and *n* ... with the absorption of the *(i)y*.” (p. 413)

(28) *Instrumental in Amharic* (Leslau 1995:15, 413)

[he.dæ]	'go'	[mæ.he.dʒa]	'means for going somewhere'
[kæf.fæ.tæ]	'open'	[mæk.fæ.tʃa]	'key'
[wæt.tʃa]	'go out'	[mæw.tʃa]	'exit'
[wæg.gæ.zæ]	'excommunicate'	[mæ.wæg.gæ.ʒa]	'means to excommunicate'
[gæz.za]	'buy'	[mæg.ʒa]	'means of buying'
[dær.ræ.sæ]	'arrive'	[mæd.ræ.ʃa]	'arrival, time or place of arrival'
[ar.ræ.sæ]	'plow'	[ma.ræ.ʃa]	'plough'
[tæb.bæ.sæ]	'fry'	[mæt.bæ.ʃa]	'frying pan'
[kæd.dæ.næ]	'cover'	[mæk.dæp.ja]	'lid'
[næq.qæ.læ]	'pull out'	[mæn.qæ.ja]	'instrument for pulling things out'
[tæ.kæ.læk.kæ.læ]	'defend'	[mæk.kæ.læk.kæ.jæ]	'means of defense'

TONGUE FR. $\stackrel{\text{def}}{=} \{[\text{COR}], [\text{POSTERIOR}], [\text{LAMINAL}]\}$

- English
 - Usher: <http://www.youtube.com/watch?v=jUe8uoKdHao>
 - Shania: <http://www.youtube.com/watch?v=tiBGWfT6G-I>

(29) Yod in English

a.	<i>annual</i>	[ˈæn.ju.əl]	vs.	<i>annuity</i>	[əˈnuː.ə.ti]
	<i>continuance</i>	[kənˈtɪn.juəns]		<i>continuity</i>	[ˌkən.təˈnuː.ə.ti] (~ [ˌkən.tənˈjuː.ə.ti])
	<i>aluminium</i>	[ˌæl.jʊˈmɪ.ni.əm]		<i>aluminium</i>	[əˈluː.mə.nəm]
	<i>aleurone</i>	[ˈæl.jə.ɪoːn]		<i>aleurone</i>	[əˈlu.ɪoːn]
b.	<i>perpetual</i>	[pə.ɪ.ˈpɛ.tʃu.əl]		<i>perpetuity</i>	[ˌpə.ɪ.pə.ˈtuː.ə.ti]
	<i>fatuous</i>	[ˈfæ.tʃu.əs]		<i>fatuity</i>	[fəˈtuː.ə.ti]
	<i>assiduous</i>	[əˈsɪ.dʒu.əs]		<i>assiduity</i>	[æ.səˈduː.ə.ti]
	<i>gradual</i>	[ˈɡɹæ.dʒu.əl]		<i>grade</i>	[ˈɡɹæːd]
	<i>racial</i>	[ˈɹeː.ʃəl]		<i>race</i>	[ˈɹeːs]

- Some dialects (notably Australian, Cockney and Newfoundland English) merge [tj] and [dj] in stressed syllables.
 - E.g. *dew* [dʒuː], *tune* [tʃuːn], etc.

TONGUE BK/RT $\stackrel{\text{def}}{=} \{[\text{DOR}], [\text{FR}], [\text{HI}], [\text{LO}], [\text{RTR}]\}$

Tongue bk/rt $\stackrel{\text{def}}{=} \{[\text{dor}], [\text{fr}], [\text{hi}], [\text{lo}], [\text{rtr}]\}$

[DORSAL]

- Vs. [lateral]
 - Chomsky and Halle (1968:317) believed that “[t]his feature [±lateral] is restricted to coronal consonantal sounds.”
 - This belief is perpetuated in, e.g., Levin (1987), McCarthy (1988), Blevins (1994), MacKay (1994), and Grijzenhout (1995).
 - However, the feature [lateral] must be considered “articulator-free” because laterals can be produced with articulators other than the front of the tongue.
 - For instance, languages have been reported in West Africa (e.g., Kotoko) and in Papua New Guinea (e.g., Melpa) in which laterals are executed not only with the tongue blade but also with the tongue body (Ladefoged & Maddieson 1996:190).

(1) *Words illustrating laterals in Mid-Waghi* (Papuan: Ladefoged & Maddieson 1996:190)

<i>Laminal dental</i>	<i>Apical alveolar</i>	<i>(Dorsal) Velar</i>
[a.ḷa a.ḷa]	[a.la.la]	[a.la.le]
‘again and again’	‘speak incorrectly’	‘dizzy’

- Vs. [rhotic]
 - [rhotic, coronal] vs. [rhotic, dorsal]
 - According to Laver (1994:220): “Alveolar and uvular trills were said by Coustenoble, a colleague of Daniel Jones, to be in contrast in the Arles accent of Modern Provençal (Coustenoble 1945), in word pairs such as [‘sero] ‘evening’ versus [‘sero] ‘a saw’, and [a’ri] ‘to cure’ versus [a’ri] ‘oak’.

TONGUE BK/RT $\stackrel{\text{def}}{=} \{[\text{DOR}], [\text{FR}], [\text{HI}], [\text{LO}], [\text{RTR}]\}$

It is not clear that the contrast between alveolar and uvular trills is still maintained in the Provençal spoken today."

- [rhotic, dorsal] in French

(2) *Théo* 2;05-4;00 (Rose 2000:237)

<i>Target</i>	<i>Child</i>	
[dʊol]	[gʊol]	'funny'
[dʊa.gɔ̃]	[kʏɔ.gɔ̃]	'dragon'
[tʏɛ̃]	[kʏɛ]	'train'
[tʏo]	[kʏo]	'too much'
[si.tʏʊj]	[kʏœj]	'pumpkin'

- [dorsal] in same onset (or coda) as [labial]:

(3) **Complex sounds**, e.g., $w, \tilde{w}, \mathfrak{w}, \mathfrak{w}, w^f, \tilde{w}, \widehat{kp}, \mathfrak{w}^m \widehat{kp}, \mathfrak{w} \widehat{kp}, \widehat{gb}, \mathfrak{w}^m \widehat{gb}, \mathfrak{w} \widehat{gb}, \widehat{kp}^h, \widehat{kp}', \widehat{gb}^h, \widehat{gb}, \widehat{kb}, \widehat{kp}^w, \widehat{gb}^w, \widehat{qp}, \widehat{qb}$, etc.

Clicks, e.g., $k\odot$, $g\odot$, $k\odot^h$, $k\odot'$, $k\odot^?$, $q\odot$, $g\odot$, $q\odot^h$, $q\odot'$, $q\odot^?$, $\eta\odot$, $\eta\odot$, $^?\eta\odot$, $\eta\odot^h$, etc.

- [dorsal] in same onset (or coda) as [coronal]:

(4) **Clicks**, e.g., kl , gl , kl^h , kl' , $kl^?$, $k!$, $g!$, $k!^h$, $k!'$, $k!^?$, kll , gll , kll^h , kll' , $kll^?$, $k\ddot{t}$, $g\ddot{t}$, $k\ddot{t}^h$, $k\ddot{t}'$, $k\ddot{t}^?$, kl^x , $k!^x$, kll^x , $k\ddot{t}^x$, ql , gl , ql^h , ql' , $ql^?$, $q!$, $g!$, ql^h , ql' , $ql^?$, qll , gll , qll^h , qll' , $qll^?$, $q\ddot{t}$, $g\ddot{t}$, $q\ddot{t}^h$, $q\ddot{t}'$, $q\ddot{t}^?$, ηl , $\eta l'$, $^?\eta l$, ηl^h , $\eta l'$, $\eta l^?$, $^?\eta l$, ηl^h , $\eta l'$, $\eta l^?$, $^?\eta l$, ηll , $^?\eta ll$, ηll^h , $\eta\ddot{t}$, $\eta\ddot{t}'$, $^?\eta\ddot{t}$, $\eta\ddot{t}^h$, etc.

Assimilation

- This assimilation is perhaps most dramatically illustrated by “velar harmony” in child phonology, e.g. (5).
 - In most cases, this process of [dorsal]-spread targets coronals, and it is usually regressive.

TONGUE BK/RT $\stackrel{\text{def}}{=} \{[\text{DOR}], [\text{FR}], [\text{HI}], [\text{LO}], [\text{RTR}]\}$

- As Bernhardt and Stemberger (1998a:558) observe, “there is often velar harmony in *take* (/tejk/ [k^hejk]) but not in *Kate* (/kejt/ [k^hejt]).” This process can therefore be represented as in (5b).

(5) *Velar harmony* (Bernhardt & Stemberger 1998a)

/tɪkɫ/	[gɪgʊ]	‘tickle’
/dʌk/	[gʌk]	‘duck’
/nɪk/	[ŋɪk]	‘Nick’

- We saw that a nasal assimilates to a following [labial] consonant in many languages; compare *in-destructible* vs. *im-possible*.
 - In English, a nasal does not always assimilate to a following [dorsal] consonant, e.g., *in-competent*, but velar assimilation is indeed obligatory within morphemes, e.g., *bu[ŋk]er*, *hu[ŋg]er*.⁴⁹
- Other languages with velar assimilation include Gã (Padgett 1995). In this Kwa language of Ghana, the first person is [ŋ] before velars (6a) and labiovelars (6b,c). That is, [dorsal] seems to spread from a velar consonant or a labiovelar consonant to a preceding nasal consonant. (Compare: *n-taoɔ* ‘I want’.)

⁴⁹ More generally, velar assimilation is responsible for the sound *ŋ* in English, as Sapir (1925:45) remarks:

In spite of what phoneticians tell us about this sound (*b:m* as *d:n* as *g:ŋ*), no naïve English-speaking person can be made to feel in his bones that it belongs to a single series with *m* and *n*. Psychologically it cannot be grouped with them because, unlike them, it is not a freely movable consonant (there are no words beginning with *ŋ*). It still *feels* like *ŋg*, however little it sounds like it. The relation *ant:and* = *sink-sing* is psychologically as well as historically correct. Orthography is by no means solely responsible for the “*ng* feeling” of *ŋ*. Cases like *-ŋg-* in *finger* and *anger* do not disprove the reality of this feeling, for there is in English a pattern equivalence of *-ŋg:-ŋ* and *-nd:-nd*. What cases like *singer* with *-ŋ-* indicate is not so much a pattern difference *-ŋg:-ŋ-*, which is not to be construed as analogous to *-nd:-n-* (e.g., *window:winnow*), as an analogical treatment of medial elements in terms of their final form (*singer:sing* like *cutter:cut*). ... [S]uch a form as *singer* betrays an unconscious analysis into a word of absolute significance *sing* and a semi-independent agentive element *-er* ... *-er*, for instance, might almost be construed as a “word” which occurs only as the second element of a compound, cf. *-man* in words like *longshoreman*. ... the agentive *-er* contrasts with the comparative *-er*, which allows the adjective to keep its radical form in *-ŋg-* (e.g., *long* with *-ŋ-*: *longer* with *-ŋg-*).

- (6)
- | | |
|-------------|-------------|
| [ŋ.klɛ.mpe] | ‘my basin’ |
| [ŋ.gbe.ke] | ‘my child’ |
| [ŋ.kpai] | ‘my cheeks’ |

- An example of progressive [dorsal] assimilation is reported by Hyman (2001:145) in Noni, a Bantoid language spoken in Cameroon. According to Hyman’s description:

The forms in [(7a)] show that /-te/ is realized without change after a root-final /m/. ... It is the examples in [(7b)] that interest us here: the input sequence /ŋ+t/ is realized [ŋk]. The /t/ has assimilated to the velar place of the preceding [ŋ].⁵⁰

- (7)
- | | | | | | |
|-------------|----|--------|-----------|-----------|----------------|
| <i>Noni</i> | a. | [cím] | ‘dig’ | [cim.tè] | ‘be digging’ |
| | | [dvum] | ‘groan’ | [dvùm.tè] | ‘be groaning’ |
| | b. | [cín] | ‘tremble’ | [ci:ŋ.kè] | ‘be trembling’ |
| | | [kán] | ‘fry’ | [ka:ŋ.kè] | ‘be frying’ |

[dorsal] codas

- The velarization of nasals in syllable-final position is remarkably common across languages.⁵¹

⁵⁰ Hyman (ib., p. 147) adds:

He [Ohalá] criticizes feature geometry for its ability to express the disfavored left-to-right place assimilation process ... as easily as the favored right-to-left ... However, this is exactly what is needed: the Noni example shows that an input sequence /ŋ+t/ may undergo place assimilation in either direction. ... The reason why the [t] of the progressive suffix /-te/ assimilates to a preceding velar is that it is a suffix. Besides phonetic principles, phonology is subject to (possibly conflicting) grammatical ones. The relevant principle here is the paradigmatic one: languages frequently preserve base features over affixal ones.

⁵¹ Examples abound in Austronesian (e.g., Aronoff et al. 1987; Goldsmith 1990:131), Bantu (e.g., Hyman 1975a:168), Niger-Congo (e.g., Creissels 1989:93-6; Olawsky 2002:206-11), West Germanic (e.g., Kuepper 1992; Hoeksema 1999; van Oostendorp 1999 et seq.), Romance (e.g., Lipski 1975; Resnick 1975:29; Porto Dapena 1976; Guitart 1981; Harris 1983; Anderson 1986; Durand 1988; Bullock 1995; Van Deyck 1996), Papuan (e.g., Wurm 1982), Cariban (e.g., Jackson 1972:47; Peasgood 1972:39; Edwards 1978:226; Abbott 1991), Totonacan (e.g., MacKay 1994:380), Sino-Tibetan (e.g., Chen 1973; Chen 1981; Rutgers 1998),

- This process targets a specific syllable-final nasal in some instances, for example, the palatal nasal in Canadian French.
 - “When /ɲ/ occurs preconsonantly or in word-final position, that is to say at the end of a syllable, a productive process causes it to be realized as the velar [ŋ]” (Walker 1984:115), e.g. (8).⁵²
 - This change is unconditioned by the height or frontness of the preceding vowel.

(8) *Nasal velarization in Canadian French* (Walker 1982:76, my transcriptions)

a. Onset position	b. Word-finally	c. Preconsonantly
gaɲe ‘won’	gaŋ ‘win!’	gaɲpɛ ‘job’ (win-bread)
ãseɲe ‘taught’	ãseŋ ‘teach!’	ãseŋmã ‘teaching’
peɲe ‘combed’	peŋ ‘comb!’	peŋwaɾ ‘peignoir’
liɲe ‘lined’	liŋ ‘line’	ãliŋmã ‘alignment’

- All syllable-final nasals are targeted in other languages, such as Ligurian (Romance: Ghini 1995) which distinguishes /m, n, ɲ, ŋ/ (e.g., *ramu* ‘branch’, *raɲu* ‘spider’, *pena* ‘pen’, *peɲa* ‘pain’), but which permits only [ŋ] in syllable-final position: word-finally (9a) and even before heterorganic⁵³ consonants (9b,c). Again, the quality of the vowel preceding the nasal seems immaterial to the change; the resultant nasal is always high and non-front.

(9) *Nasal velarization in Ligurian* (Ghini 1995:58-9)

a. Word-finally	b. Before labials	c. Before coronals
[viŋ] ‘wine’	[puŋ.pa] ‘pump’	[tʃaŋ.ta:] ‘plant (v.)’
[tʃaŋ] ‘even’	[riŋ.bur.su] ‘refund’	[veŋ.de] ‘sell’
[noŋ] ‘not’	[ruŋ.fu] ‘I snore’	[fiŋ.ze] ‘pretend’
[feŋ] ‘fine’	[kaŋ.paŋ.ɲa] ‘bell’	[iŋ.ʃa:] ‘blow up’

Japanese (e.g., Trigo 1988; Yip 1991), Mongolian (Poppe 1970:55), and elsewhere. Coda nasals also velarize in child language (e.g., Hua & Dodd 2000:27).

⁵² Carrier (Athabaskan: Cook 1985) also velarizes syllable-final /ɲ/.

⁵³ Heterorganic means ‘at a different place of articulation’.

TONGUE BK/RT $\stackrel{\text{def}}{=} \{[\text{DOR}], [\text{FR}], [\text{HI}], [\text{LO}], [\text{RTR}]\}$

- As another example, Sinhala (Indo-Aryan: Fairbanks et al. 1968; Reynolds 1980; Stonham 1995:25) has an exceptionally large inventory of nasal sounds (/m, n, ŋ, ɲ, ŋ̃, ^mb, ⁿd/) which are all neutralized to [ŋ] word-finally, as seen in the plurals of (10a,b).

(10) Nasal velarization in Sinhala (Feinstein 1979:247)

a. sg. def.	plur.	b. sg. def.	plur.	cf. sg. def.	plur.
bim-ə	biŋ 'ground'	a ^m b-ə	aŋ 'mango'	mal-ə	mal 'flower'
gam-ə	gaŋ 'village'	li ⁿ d-ə	liŋ 'well'	pot-ə	pot 'book'
kan-ə	kaŋ 'ear'	ka ⁿ d-ə	kaŋ 'trunk'	gas-ə	gas 'tree'

- The velarization of obstruent codas is less common across languages but is attested.
 - One historical case presented last class: the parallel participation of nasals and obstruents in velarization in the development of Fuzhou Chinese (Chen 1973; Norman 1988:228-39), where coda velarization affected not only nasals (11a) but also stops (11b).

(11) Coda velarization: Middle Chinese (MC) > Fuzhou (Norman 1988:229ff.)

a. śjəm	> t ^s ʰiŋ	'deep'	b. diep	> t ^h ak	'stack up'
duân	> touŋ	'break off'	ngjwet	> ŋuok	'moon'
dung	> tɕiŋ	'copper'	ńźjiuk	> nyk	'meat'

- Akin changes have occurred in several Chinese dialects of Hong Kong (Zee 1999:161-2). For instance, the Xiamen words *ts^hit* 'seven' and *sin* 'new' are pronounced with final [k, ŋ] in adjacent Chaozhou (cf. Xiamen/Chaozhou: *pak* 'north', *taŋ* 'winter') (Norman 1988:236-7). As Chen (1973:44) remarks: "In the Chaozhou case the nasal and the stop endings have followed parallel and synchronous paths of development."
- Similarly, in Cuban Spanish, for instance, "all nasals are realized as velar before other consonants and in word-final position" (Guitart 1976:49). Crucially, Guitart finds that in colloquial Cuban Spanish coda velarization extends to nonfinal obstruents such that, for example, *apto* 'fit' and *acto* 'act' are homophonous as ['akto] (ib., p. 77). Several other examples are given in (12). (The resultant velar obstruents spirantize occasionally.)

(12) *Obstruent velarization in colloquial Cuban Spanish* (Guitart 1976: 23, 48, 77)

conce[k]to	'concept'	cf.	conce[β]ir	'to conceive'
rece[y]tor	'receptor'		reci[β]ir	'to receive'
su[k]desarrollado	'underdeveloped'		su[β]arrendado	'subleased'
ecli[y]sar	'to eclipse'			
é[g]nico	'ethnic'			
a[y]mitir	'to admit'			

- Guitart (1982) reports the same pattern in the Spanish spoken in Maracaibo, Venezuela, e.g., *obsequio* [oksekio] 'gift', *este* [exte] 'this' (see also Trigo 1988; de Lacy 2006:352).
- As with nasal and liquid velarization, the height and frontness of the preceding vowel appear insignificant to this pattern, while syllable structure plays a critical role. Compare *s[uk.li]ngual* 'sublingual' vs. *s[u.βli]mar* 'to sublimate' (Guitart 1976:48).
- A similar pattern occurs synchronically in Tlachichilco Tepehua: "the coda can be filled with any consonant with one condition: if the consonant is a noncontinuant (i.e. a stop or a nasal), it must be nonanterior [i.e. dorsal]" (Watters 1988:494).
- The effect of this constraint is productive velarization, as shown for /t, p, k/ in (13). The forms in (13b) illustrate a small complication: "if [+labial] is present within the delinked place node, it is relinked directly to another position of the root tier, forming a complex consonant." (ib.) (Relatedly, coda /m/ velarizes as [w̃], e.g. *ta[w̃]* 'one'.)

(13) *Stop velarization in Tlachichilco Tepehua* (Watters 1988)

a.	qasmat- → qas'mak̥i	'X heard Y'	cf.	qas'mat'a	'X hears Y'
	q'ut → ʔoq-t̥i	'X drank it'	cf.	ʔot'a	'X drinks it'
	tsq'ut- → 'ts'oq̥i	'he wrote it'		'ts'ot'a	'X writes Y'
	huq'ak- → hoʔakna	'men'		'hoʔati	'man'
	tʃankat- → tʃan'kakna	'sugarcanes'		'tʃankati	'sugarcane'
	ta-litsukut- → tali:tsu'kukna	'animals'		tali:tsukuti	'animal'
	ʃtaq'a:t- → ʃtaʔa:kna	'petate pl'		ʃtaʔa:ti	'petate'
b.	nip- → niʷk̥fi ~ nik̥fi	'squash'		nipfi	(Huehuetla, Tecomojapa)
	ʃap- → ʃaʷk̥i	'X panted'	cf.	ʃap'a	'X pants'
	kap- → 'kaʷk̥i	'he forgot it'		'kap'a	'he forgets it'

TONGUE BK/RT $\stackrel{\text{def}}{=} \{[\text{DOR}], [\text{FR}], [\text{HI}], [\text{LO}], [\text{RTR}]\}$

c. pa:stak- → pa:stak-nan ‘X thinks’ cf. pa:stak-’a ‘X thinks of Y’

- The synchronic “rule of ‘consonant backing’” (ib.:495) extends to loanwords as shown here:

(14) *Stop velarization in loanwords* (Watters 1980)

- a. *Huayacocotla* (Aztec place name) → wajako'kokla
Huehuetla (Aztec place name) → we'wekla
 - b. *capsula* ‘capsule’ → 'kawksula *reptil* ‘reptile’ → 'rekitil
septiembre ‘September’ → sekti'jembre *pepsi* ‘Pepsi’ → 'peksi
- A comparable neutralization of obstruents occurred in Ecuador Quichua (Orr 1962). In this language, [k, g] are the only obstruent stops permitted in coda position, e.g., *l'ak.ta* ‘village’, *pu.sak* ‘eight’, *tfig.ni.na* ‘to hate’, *ug.fa* ‘grass’; “/p/ and /t/ [and /b, d/] are not found in syllable-final position” (Orr 1962:61).
 - That stop velarization is at least partially responsible for this state of affairs is suggested by loan adaptations, e.g., Spanish *Pedro* ‘Peter’ is adapted as [pig.ru] in Quichua (ib., p. 65, 73). Orr (p. 61-2) notes that this distribution of obstruents parallels /h, n/, which are realized as velar [x, ŋ], respectively, in coda position.
 - Obstruent velarization is also one of several strategies adopted in Dschang (Bamileke) to avoid final coronals in English loans, as Bird (2003:14) describes: “Alveolars are not licensed in the syllable coda. In [meta] *mat*, a vowel is inserted, making the *t* into the initial segment of the next syllable. For [dæɪk] *debt*, the place of articulation of the *t* is changed to velar, making it a legal syllable-final consonant. For [aplɛŋgɛ] *blanket*, the final *t* is deleted.”
 - In Arekuna Carib, too, obstruent velarization is presumably responsible for the fact that [k] is the only obstruent permitted in coda position, e.g., [ek.ma] ‘road’, [wɪ.rik] ‘girl’, [ˈwɔk.rɪ] ‘marudi (bird)’.
 - “All Arekuna consonants can appear syllable-initially and word-initially, but only [k], [ŋ], [m], and [n] are permissible in syllable-final positions. Word-finally only [k] and [ŋ] are possible” (Edwards 1978:227).

TONGUE BK/RT $\stackrel{\text{def}}{=} \{[\text{DOR}], [\text{FR}], [\text{HI}], [\text{LO}], [\text{RTR}]\}$

- [m, n] occur syllable-finally only in Place-assimilation to a following consonant, e.g., [i.'pan.ta] 'branch'.)
- There is additional evidence of obstruent velarization in Carib (Hoff 1968:59-61, 86-92; 2003:261). Like other members of the Cariban family, this language of Guyana habitually drops stem-final vowels before suffixes (Gildea 1995). When such syncope brings together a stop and an obstruent, the first neutralizes to a velar fricative, as exemplified in (15). (Pre-obstruent spirantization is here considered a separate process.)

(15) *Stop velarization in Carib of Surinam* (Hoff 1968)

enapi+taŋ ^j → enaxtaŋ ^j	'he'll eat'	cf.	enapi	'to eat' (p. 60)
wi:to+sa → wixsa	'I go' (p. 66)		wi:to	'to go' (p. 168)
s+eka:riti+to → seka:rixto	'I told it then cont.'		eka:riti	'to tell' (p. 172)
woni:ki+poro → (w)onixporo	'to sleep'		woni:ki	(p. 157, fn. 38)

- Obstruent velarization similarly occurred historically in Blackfoot (Proulx 1989). As the following data illustrate, Proto-Algonquian consonants have shifted to [x] in (non-final) coda position. This velarization and spirantization affected stops (16a,b), fricatives (16c,d), nasals (16e) and even laryngeals (16f-h).⁵⁴

(16) *Historical velarization in Blackfoot* (Proulx 1989, my revised Blackfoot data)

	<i>Proto-Algonquian</i>	<i>Blackfoot</i>	
a.	*-tpikaji	(m)oxpikís	'rib'
b.	*-tka:tʃi	(m)oxkát(s)-	'leg'
c.	*-welkani	oxkin	'bone'
d.	*ka:ʃkantamwa	ikaxkennima:	'bite it off'/'cut off branch'
e.	*-to:ntani	(m)o:toxtón	'heel'
f.	*nehk-	inixka(t)	'name'
j.	*-hpani	(m)oxpín	'lung'
h.	*-aʔte:	-ixtsi:-	'be located'

- Finally, consider stop velarization in Western Apache (Athabaskan: Hill 1963):

⁵⁴ Proulx (1989:50) also documents *x*-epenthesis in Blackfoot: “*s → xs noninitially” [i.e., postvocally], e.g. PA *-so:wi > Blackfoot (m)oxsojís ‘tail of quadruped’.

TONGUE BK/RT $\stackrel{\text{def}}{=} \{[\text{DOR}], [\text{FR}], [\text{HI}], [\text{LO}], [\text{RTR}]\}$

- In the San Carlos dialect (SC), /t, k/ are distinguished word-finally (/p/ is rare and never final) but in the White Mountain dialect (WM) final coronals have shifted to velars; compare the following cognates:⁵⁵

(17) *Apache stem-final stops: San Carlos vs. White Mountain* (Hill 1963:150-2)

	SC	WM		SC	WM		
a.	-tʃát	-tʃák	‘leg’	b.	-tʰak	-tʰak	‘cry’
	-lit	-lik	‘burn’		-tak	-tak	‘count’
	-zit	-zik	‘spit’		-tok	-tok	‘be warm’
	-zi:t	-zi:k	‘work’		-tʰak	-tʰak	‘hear’
	-tsit	-tsik	‘fear’		-tsok	-tsok	‘be yellow’

- Additional data from Hill (1963:150-2) and Greenfeld (1978:152) reveal that coronals resist velarization in syllables that contain a velar consonant (18). As Greenfeld (1978:152) remarks: "There also seems to be a tendency among all speakers to want to pronounce stems which begin in a velar with a final alveolar. Thus one can elicit [ʃikok] 'my knee', but most speakers seem to prefer [ʃikot]." This is an instance of [dorsal] dissimilation.

(18) *White Mountain Apache*

-kʰé:t	'ask for it'
-ké:t	'dig'
-kot	'knee'
-yot	'strength'
-xot	'be lame'

On the sequencing of [dorsal]

- In the Papuan language Awara (Wantoat: Quigley 2003), the 2s genitive suffix is [dorsal]-initial after vowels (19a) and after velars (19b), but it is [coronal]-initial after labials (19c) and after alveolars (19d).⁵⁶

(19) *2s genitive allomorphy in Awara* (Quigley 2003:183)

a.	<i>ɾɿje-ka</i>	'your SS.sib'	c.	<i>mom-da</i>	'your aunt'
	<i>kaji-ka</i>	'your eye'		<i>pajip-da</i>	'your machete'
	<i>jagɿ-ka</i>	'your water'		<i>ap-da</i>	'your husband'

⁵⁵ This change occurred identically in the Southern Min dialect of Chinese (Chen 1973).

⁵⁶ Stops regularly (if strangely) devoice after vowels in Arawa (Quigley 2003:69).

TONGUE BK/RT $\stackrel{\text{def}}{=} \{[\text{DOR}], [\text{FR}], [\text{HI}], [\text{LO}], [\text{RTR}]\}$

- b. *miŋ-ga* 'your mother'
 ok-ga 'your uncle'
 kakɿluk-ga 'your chicken'
- d. *sadun-da* 'your axe'
 hiput-da 'your stick'
 jot-da 'your home'
- Quigley (2003:70) suggests that the suffix is /-ga/ underlyingly, and that it becomes [-da] after labials and coronals due a rule rule which converts velars to coronals after [-dorsal] consonants.⁵⁷
 - How can we formalize this rule without reference to “minus dorsal”?

Metathesis

- Metathesis of [labial] and [dorsal] is a regular process in Kui, a Dravidian language of India (Hume 1999).
 - It can be observed in the second conjugation of verbs where the present participle and infinitive is typically formed by the addition of the suffixes /-pi/ and /-pa/, respectively.
 - However, when the stem ends in a velar stop, the suffix-initial labial stop occurs to the left of the stem-final consonant. A similar situation holds in the fourth conjugation, although in this instance the stem-final consonant involved in metathesis is [g], while the prefixal consonant surfaces as [b]. Examples from the second conjugation are shown.

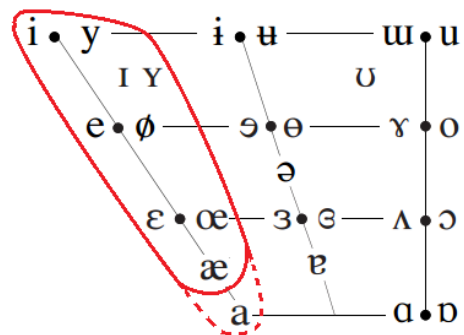
<i>Verb Stem</i>	<i>Future</i>	<i>Past</i>	<i>Present Participle</i>	<i>Infinitive</i>	<i>Gloss</i>
bluk-	bluki	blukte	blupki	blupka	'to break down'
kok-	koki	kokte	kopki	kopka	'to sit down'
mlik-	mliki	mlikte	mlipki	mlipka	'to turn over'

⁵⁷ Quigley calls this rule “coronal assimilation” but is well aware of its awkwardness: “Though the alternation between coronal and dorsal is a natural process in Awara, it is impossible to specify a single rule that defines a voiced consonant as coronal after labials and coronals and dorsal after dorsals. This is problematic for both Distinctive Feature theory and Feature Geometry” (ib., n. 45).

TONGUE BK/RT $\stackrel{\text{def}}{=} \{[\text{DOR}], [\text{FR}], [\text{HI}], [\text{LO}], [\text{RTR}]\}$

lek-	leki	lekte	lepki	lepka	'to break'
<i>cf.</i>					
gas-	gasi	gaste	gaspi	gaspa	'to hang oneself'
mil-	mili	milte	milpi	milpa	'to turn over'

[FRONT]



- The feature [front] characterizes sounds in which the tongue body is moved forward in the mouth, as in front vowels:
- Among consonants, the feature [front] is used to characterize *palatalization*.
- For example, Japanese has a series of palatalized consonants, that is, sounds produced by raising the tongue body toward the hard palate when certain consonants are pronounced.
- The superscript [ʲ] is used to represent palatalized consonants. Examples in Japanese include *sanbyaku* [sambʲaku] 'three hundred', *ryokan* [rʲokan] 'inn', *myaku* [mʲaku] 'pulse', and *kyaku* [kʲaku] 'guest' (Tsujimura 1996:16).
- Because these sounds are produced with tongue body fronting, they are traditionally treated as having a [front] feature, in addition to their primary articulator feature ([labial], [coronal], or [dorsal]).
- Just as [round] can occur on a consonant that lacks [labial], so too can [front] remain on a consonant that lacks [dorsal].

TONGUE BK/RT $\stackrel{\text{def}}{=} \{[\text{DOR}], [\text{FR}], [\text{HI}], [\text{LO}], [\text{RTR}]\}$

- A clear example is offered by the Guddiri dialect of Hausa, where onset glottalized dorsals have lost their [dorsal] feature, as can be seen in a comparison with the Kano dialect (20) (Bagari 1982:244-6; Fallon 2002:148).

(20) *Loss of [dorsal] in Guddiri Hausa*

	<i>Kano</i>	<i>Guddiri</i>	
a.	k'eetaa	ʔeetaa	'wickedness'
	k'aunaa	ʔaunaa	'love'
	k'uunaa	ʔuunaa	'to burn'
b.	k ^w 'aala	ʔ ^w aala	'to suffer'
	k ^w 'alloo	ʔ ^w alloo	'ball'
c.	k ^j 'allee	ʔ ^j allee	'cloth'
	k ^j 'afaa	ʔ ^j afaa	'a kind of bird'
	k ^j 'ujaa	ʔ ^j ujaa	'laziness'

- Crucially, the consonants' other Oral Place features such as [round] and [front] remain, since they are independent of the lost [dorsal] feature.
- The palatalization feature, which is assumed to be [front], can also act as a "floating" feature.

- For instance, in Zoque, spoken in Chiapas, Mexico, [front] represents the third person possessive (Akinlabi 1996). It targets word-initial consonants, as illustrated in (21):

(21) *Zoque* (Wonderly 1965)

pata	'mat'	p ^j ata	'his mat'
buru	'burro'	b ^j uru	'his burro'
faha	'belt'	f ^j aha	'his belt'
mula	'mule'	m ^j ula	'his mule'
wakas	'cow'	w ^j akas	'his cow'
kama	'cornfield'	k ^j ama	'his cornfield'
gaju	'rooster'	g ^j aju	'his rooster'
hajah	'husband'	h ^j ajah	'his husband'
ʔatsi	'older brother'	ʔ ^j atsi	'his older brother'

- Russian, too, has suffixes which appear to carry a [front] feature which docks onto stem-final consonants, e.g. (from Blumenfeld 2002:6):

TONGUE BK/RT $\stackrel{\text{def}}{=} \{[\text{DOR}], [\text{FR}], [\text{HI}], [\text{LO}], [\text{RTR}]\}$

- (22) -^jonok DIM, /ut-/ ‘duck’ vs. /ut^j-onok/ ‘duck-DIM’
 -^jonok DIM, /or^jol-/ ‘eagle’ vs. /orl^j-onok/ ‘eagle-DIM’
 -^juga PEJOR, /vor-/ ‘thief’ vs. /vor^j-uga/ ‘thief-PEJOR’
 -^jsk ADJ, /general-/ ‘general’ vs. /general^j-skij/ ‘of a general’ (ADJ)
 -^jba ?, /sud-/ ‘judge’ vs. /sud^j-ba/ ‘fate’

- More alleged examples of floating [front] features come from German (Roca & Johnson 2000; Wiese 2000).
 - The adjectival suffix *-lich* and the adverbial suffix *-ig*, both translatable as ‘-ly’ in English, each appear to carry a floating [front].
 - To see this, first consider the changes in (23): when *-lich* or *-ig* are added to a root, its back vowels (e.g., /o, u, ɔ/) become fronted (/ø, y, œ/, respectively).

- (23)
- | | | | |
|----------|-----------|---------------|-------------|
| T[o]d | ‘death’ | t[ø]d+lich | ‘deadly’ |
| Br[u]der | ‘brother’ | br[y]der+lich | ‘brotherly’ |
| v[ɔ]ll | ‘full’ | v[œ]ll+ig | ‘fully’ |

- Other suffixes, even those which appear to be very similar on the surface, do not trigger such fronting:

- (24)
- | | | | |
|--------|-----------|------------|-----------------|
| M[o]de | ‘fashion’ | m[o]d+isch | ‘fashionable’ |
| R[u]he | ‘silence’ | r[u]h+ig | ‘quiet’ |
| d[ɔ]rt | ‘there’ | d[ɔ]rt+ig | ‘of that place’ |

- Roca and Johnson (2000:161-3) suggest that what is special about the suffixes *-lich* and *-ig* in (23) is that they carry a floating [front] feature, as represented here for *tödlich* ‘deadly’:

- (25)
- | | | | |
|---------|----------|---|----------------|
| [front] | [front] | | [front][front] |
| | | → | |
| t[o]d | + l[i]ch | | t[ø]d + l[i]ch |

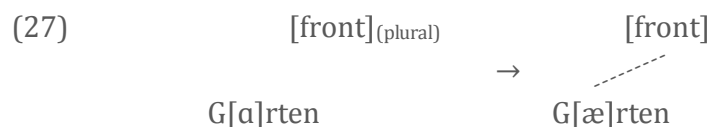
- Vowel fronting is also used to indicate the plural form of many nouns in German, e.g. (26). The umlaut diacritic (¨) indicates fronting ([front]) in a vowel in German orthography.

TONGUE BK/RT $\stackrel{\text{def}}{=} \{[\text{DOR}], [\text{FR}], [\text{HI}], [\text{LO}], [\text{RTR}]\}$

(26)

<i>Singular</i>	<i>Plural</i>	
Garten	Gärten	'garden(s)'
Vogel	Vögel	'bird(s)'
Vater	Väter	'father(s)'
Mutter	Mütter	'mother(s)'
Bruder	Brüder	'brother(s)'
Tochter	Töchter	'daughter(s)'
Kloster	Klöster	'cloister(s)'

- Here, too, it is suggested that a floating [front] feature, which represents the plural, is added to the specification of noun vowels (Roca & Johnson 2000; Wiese 2000).



- Finally, vowel fronting is also used to indicate the subjunctive form of many verbs, e.g.:

(28)

Past Indic.	Past Subj.	
h[ɑ]tte	h[æ]tte	'have'
br[ɑ]chte	br[æ]chte	'bring'
w[u]βte	w[y]βte	'know'

- Roca and Johnson (2000:164-5) go so far as to analyse English irregular plural forms such as *geese* and *teeth* in the same way: a floating [front] plural marker is added to the specification of the vowels in *goose* and *tooth*, respectively. (Note that the [round] specification of these vowels is assumed to be lost simultaneously, since English disallows the combination [front, round] in vowels, i.e. *[y].)

Assimilation

- The feature [front] can spread regressively. This happens in Polish, where [front] spreads from [i] onto a preceding consonant which consequently becomes palatalized.

(29) *Polish* (Rubach 1984; Gussmann 2002)

pisk	[p ⁱ isk]	‘scream’
ring	[r ⁱ ink]	‘ring’
kino	[k ⁱ ino]	‘cinema’
brat i siostra	[brat ⁱ ɕɔstra]	‘brother and sister’
chłop idzie	[xwɔp ⁱ idze]	‘the farmer walks’

- A similar but more complex assimilation occurs in Acadian French (Hume 1994).
- The consonants affected in this case are /k, g/. As illustrated in (35), [kⁱ, gⁱ] and [tʃ, dʒ] are found only before front vowels and glides, whereas [k, g] are found elsewhere: at the end of words (e.g., [sark] ‘circle’), before consonants (e.g., [griʃe] ‘ruffled’), and before (nonfront) vowels (e.g., [kut] ‘cost’).
- The change from /k, g/ to [kⁱ, gⁱ] is the same as palatalization in Polish.
- The variable change to [tʃ, dʒ] (*coronalization*) is really a change from [dorsal, front] to [coronal, posterior, laminal, strident], a switch which is rather common across languages.

(30) *Acadian French*

a.	[kø] ~ [k ⁱ ø] ~ [tʃø]	‘tail’	b.	[ka]	‘case’
	[kɥir] ~ [k ⁱ ɥir] ~ [tʃɥir]	‘leather/to cook’		[kut]	‘cost’
	[okɛ̃] ~ [ok ⁱ ɛ̃] ~ [otʃɛ̃]	‘no, not any’		[kote]	‘side’
	[ki] ~ [k ⁱ i] ~ [tʃi]	‘who’		[gar]	‘station’
	[kɛ] ~ [k ⁱ ɛ] ~ [tʃɛ]	‘quay’		[gut]	‘drop (N.)’
	[kœr] ~ [k ⁱ œr] ~ [tʃœr]	‘heart’			
	[sarkœj] ~ [sark ⁱ œj] ~ [sartʃœj]	‘coffin’			
	[gɛte] ~ [g ⁱ ɛte] ~ [dʒɛte]	‘to watch for’			
	[gœl] ~ [g ⁱ œl] ~ [dʒœl]	‘mouth’			

- Vaux (1999) reports a pattern of consonant harmony involving [front] in Karaim, a Turkic language spoken in Lithuania. [front] spreads from consonants in the stem to consonants in affixes, such that all consonants in the word become palatalized.

TONGUE BK/RT $\stackrel{\text{def}}{=} \{[\text{DOR}], [\text{FR}], [\text{HI}], [\text{LO}], [\text{RTR}]\}$

- For example, the plural suffix is $[\text{l}^{\text{i}}\text{ar}^{\text{i}}]$ after stems with palatalized consonants, and $[\text{lar}]$ otherwise; the ablative suffix is $[\text{d}^{\text{i}}\text{an}^{\text{i}}]$ after stems with palatalized consonants, and $[\text{dan}]$ otherwise. Compare $\text{ku}\eta\text{-lar-dan}$ ‘servant-PL-ABL’ vs. $\text{k}^{\text{i}}\text{un}^{\text{i}}\text{-l}^{\text{i}}\text{ar}^{\text{i}}\text{-d}^{\text{i}}\text{an}^{\text{i}}$ ‘day-PL-ABL’.

(31)	<i>stem</i>	<i>ablative</i>	
a.	suv	suv-dan	‘water’
	taf	$\text{ta}\text{f-tan}$	‘stone’
b.	$\text{k}^{\text{i}}\text{un}^{\text{i}}$	$\text{k}^{\text{i}}\text{un}^{\text{i}}\text{-d}^{\text{i}}\text{an}^{\text{i}}$	‘day’
	$\text{m}^{\text{i}}\text{en}^{\text{i}}$	$\text{m}^{\text{i}}\text{en}^{\text{i}}\text{-d}^{\text{i}}\text{an}^{\text{i}}$	‘I’
	$\text{k}^{\text{i}}\text{op}^{\text{i}}$	$\text{k}^{\text{i}}\text{op}^{\text{i}}\text{-t}^{\text{i}}\text{an}^{\text{i}}$	‘very’

- This pattern is peculiar because $[\text{front}]$ spreads across intervening non- $[\text{front}]$ vowels, yet these remain unaffected by the harmony process. A full analysis of this pattern is now available in Nevins and Vaux (2003).
- In contrast to consonant harmony, vowel harmony with $[\text{front}]$ is common. Vowels in classical Mongolian words are all $[\text{front}]$, e.g. (32a), or all non- $[\text{front}]$, e.g. (32b) (Poppe 1970; Steriade 1979; Goldsmith 1985; Svantesson 1985).

(32) a. $[\text{k} \ \emptyset \ \text{t} \ \text{e} \ \text{l} \ \text{b} \ \text{y} \ \text{r} \ \text{i}]$ ‘instruction’ b. $[\text{u} \ \text{y} \ \text{u} \ \text{t} \ \text{a}]$ ‘bag’

- The distinction between central and back vowels is important in phonetics but not in phonology, e.g. $[\text{i}]$ and $[\text{u}]$ have the same phonological features, and so do, say, $[\text{e}]$ and $[\text{o}]$.
- Note that the IPA classifies $[\text{a}]$ as a front vowel, which can contrast with nonfront $[\text{ɑ}]$. For example:
 - Canadian English (Clarke et al. 1995; Boberg 2004; 2010)
 - $[\text{kat}]$ ‘cat’ vs. $[\text{kat}]$ ‘cot’
 - $[\text{sak}]$ ‘sack’ vs. $[\text{sak}]$ ‘sock’
 - $[\text{pap}]$ ‘pap’ vs. $[\text{pap}]$ ‘pop’
 - etc.
 - Canadian French (Walker 1984)

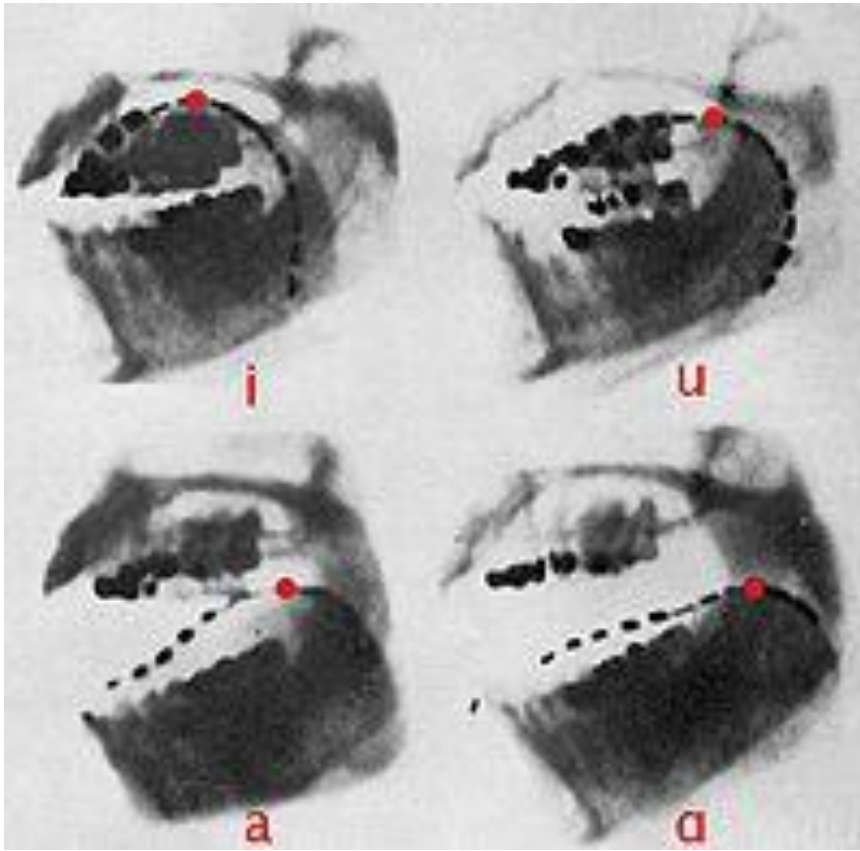
TONGUE BK/RT $\stackrel{\text{def}}{=} \{[\text{DOR}], [\text{FR}], [\text{HI}], [\text{LO}], [\text{RTR}]\}$

- [pat] ‘paw’ vs. [pat] ‘pasta’
- [taʃ] ‘spot’ vs. [taʃ] ‘task’
- [mal] ‘box’ vs. [mal] ‘male’
- [la] ‘the’ (fem.) vs. [la] ‘there’
- etc.
- Persian (Rohany Rahbar 2009)
 - [zar] ‘gold’ vs. [zar] ‘deplorable’
 - [sar] ‘head’ vs. [sar] ‘starling’
 - [ʃar] ‘evil’ vs. [ʃar] ‘flux’
 - [far] ‘magnificence’ vs. [far] ‘lighthouse’
 - [kar] ‘deaf’ vs. [kar] ‘work’
- Tsuut’ina (Starlight & Donovan 2010)
 - [mītà] ‘its horns’ vs. [mītà] ‘its end/top’
 - [sī.tʰá] ‘my stomach’ vs. [sī.tʰá] ‘my rain’
 - [más] ‘knife’ vs. [màs] ‘gambling’
 - etc.
- But [a] can also be nonfront.
 - In many Northern cities of the U.S., including Syracuse, Rochester, Buffalo, Detroit, and Chicago, front [ɛ̃] is opposed to nonfront [a] (Labov et al. 2006).
 - E.g., [kɛ̃t] ‘cat’ vs. [kat] ‘cot’; [sɛ̃k] ‘sack’ vs. [sak] ‘sock’; [pɛ̃p] ‘pap’ vs. [pap] ‘pop’, etc. (Compare Canadian English above.)
 - Latvian, too, distinguishes front [æ, æ:] from nonfront [a, a:] in stressed positions (Bond 1994).

X-ray evidence for ambiguity of [front]/[nonfront] feature with /a/:

(Wikipedia)

TONGUE BK/RT $\stackrel{\text{def}}{=} \{[\text{DOR}], [\text{FR}], [\text{HI}], [\text{LO}], [\text{RTR}]\}$



- The ambiguity of [a] is evident from [front] dissimilation in Ainu, an almost-extinct linguistic isolate of northern Japan (Ito 1984; Archangeli & Pulleyblank 1994).

- The transitivizing suffix is [-i] after back vowels, and [-u] after [front] vowels.

(33) *Transitivizing suffix in Ainu: -i ~ -u*

-i	[hu.mi]	'to chop up'	[mu.si]	'to choke'
	[po.ki]	'to lower'	[ho.pi]	'to leave behind'
	[u.si]	'to attach sth. to sth.'		
-u	[pi.ru]	'to wipe'	[ki.ru]	'to alter/turn sth.'
	[ke.tu]	'to rub'	[re.ku]	'to ring'
	[pe.tu]	'to cut/tear sth. finely'		

- This is an instance of [front] dissimilation.

TONGUE BK/RT $\stackrel{\text{def}}{=} \{[\text{DOR}], [\text{FR}], [\text{HI}], [\text{LO}], [\text{RTR}]\}$

- Interestingly, in some roots, [a] patterns as a [front] vowel, taking -u, while in other roots [a] patterns as nonfront, taking -i.

(34) Transitivity suffix in Ainu: -i ~ -u

-u	[ra.mu]	'to think'	[ra.pu]	'to flutter'
	[sat.sa.tu]	'to dry sth. well' (red.)	[ja.ku]	'to crush'
	[ka.mu]	'to cover'	[sa.nu]	'to put it out'
-i	[ka.ri]	'to rotate'	[sa.ri]	'to look back'
	[a.si]	'to stand up' (tr.)	[tsa.ri]	'to scatter sth.'

- [a] also patterns as nonfront in changes affecting [k, g] in Acadian French (Hume 1994).
 - [kⁱ, gⁱ] and [tʃ, dʒ] are found only before front vowels and glides, whereas [k, g] are found elsewhere: at the end of words (e.g., [sark] 'circle'), before consonants (e.g., [grife] 'ruffled'), and before (nonfront) vowels (e.g., [kut] 'cost').

(35) Acadian French

a.	[kø] ~ [k ⁱ ø] ~ [tʃø]	'tail'	b.	[ka]	'case'
	[kʷir] ~ [k ⁱ ʷir] ~ [tʃʷir]	'leather/to cook'		[kut]	'cost'
	[okɛ̃] ~ [ok ⁱ ɛ̃] ~ [otʃɛ̃]	'no, not any'		[kote]	'side'
	[ki] ~ [k ⁱ i] ~ [tʃi]	'who'		[gar]	'station'
	[kɛ] ~ [k ⁱ ɛ] ~ [tʃɛ]	'quay'		[gut]	'drop (N.)'
	[kœr] ~ [k ⁱ œr] ~ [tʃœr]	'heart'			
	[sarkœj] ~ [sark ⁱ œj] ~ [sartʃœj]	'coffin'			
	[gɛte] ~ [g ⁱ ɛte] ~ [dʒɛte]	'to watch for'			
	[gœl] ~ [g ⁱ œl] ~ [dʒœl]	'mouth'			

- The variable change to [tʃ, dʒ] (*coronalization*) is really a change from [dorsal, front] to [coronal, posterior, laminal, strident], a form of *assibilation* which is rather common across languages.
- Crucially, [a] behaves as nonfront—it does not cause palatalization [kⁱ, gⁱ] or coronalization/assibilation [tʃ, dʒ].

TONGUE BK/RT $\stackrel{\text{def}}{=} \{[\text{DOR}], [\text{FR}], [\text{HI}], [\text{LO}], [\text{RTR}]\}$

- In contrast: “Palatalisation of the velars /k, g/ in Gallo-Romance applied not just before the usual front vowels /i, e, ε/ but also, famously, before the low vowel /a/.” (Buckley 2009:31)
 - In the late 5th or early 6th century, Gallo-Romance [k, g] changed to Old French [tʃ, dʒ] when followed by [i, e, ε], e.g.
 - *skerpa* > [ɛs.tʃɛr.pə] ‘scarf’ (*écharpe*)
 - *skîna* > [ɛs.tʃi.nə] ‘spine’ (*échine*)
 - *kip(f)e* > [tʃi.pə] ‘rag’ (*chiffe*)
 - *rekînan* > [rə.tʃiŋ.jær] ‘to grimace, balk’ (*rechigner*)
 - *meskin* > [mɛs.tʃiŋ] ‘a youth’ (*meschin*)
 - *sakkettu* > [sa.tʃɛt] ‘small bag’ (*sachet*)
 - Crucially, Gallo-Romance [k, g] changed to Old French [tʃ, dʒ] also preceding [a], e.g.:
 - CÁR.RU > [tʃar] ‘cart, wagon’
 - CÂM.PU > [tʃamp] ‘field’
 - CAR.BÓ.NE > [tʃar.bɔn] ‘coal’
 - CAN.TÁ.RE > [tʃan.tær] ‘to sing’
 - GÂM.BA > [dʒam.bə] ‘leg’
 - GÁL.BI.NU > [dʒal.nə] ‘yellow’
 - CA.BÁL.LU > [tʃa.val] > [tʃə.val] ‘horse’
 - CA.NÚ.RA > [tʃa.nu.rə] > [tʃə.nu.rə] ‘gray hair’
 - GAL.LÍ.NA > [dʒa.li.nə] > [dʒə.li.nə] ‘hen’
 - VÁC.CA > [va.tʃa] > [va.tʃə] ‘cow’
 - BÚC.CA > [bo.tʃa] > [bo.tʃə] ‘mouth’
 - LÁR.GA > [lar.dʒa] > [lar.dʒə] ‘broad (f.)’

Assimilation

- Vaux (1999) reports a pattern of consonant harmony involving [front] in Karaim, a Turkic language spoken in Lithuania. [front] spreads from consonants in the stem to consonants in affixes, such that all consonants in the word become palatalized.

TONGUE BK/RT $\stackrel{\text{def}}{=} \{[\text{DOR}], [\text{FR}], [\text{HI}], [\text{LO}], [\text{RTR}]\}$

- For example, the plural suffix is [l^jar^j] after stems with palatalized consonants, and [lar] otherwise; the ablative suffix is [d^jan^j] after stems with palatalized consonants, and [dan] otherwise.
- Compare kuŋ-lar-dan ‘servant-PL-ABL’ vs. k^jun^j-l^jar^j-d^jan^j ‘day-PL-ABL’.

(36)

	stem	ablative	
a.	suv	suv-dan	‘water’
	taʃ	taʃ-tan	‘stone’
b.	k ^j un ^j	k ^j un ^j -d ^j an ^j	‘day’
	m ^j en ^j	m ^j en ^j -d ^j an ^j	‘I’
	k ^j op ^j	k ^j op ^j -t ^j an ^j	‘very’

- This pattern is peculiar because [front] spreads across intervening nonfront vowels, yet these remain unaffected by the harmony process.

(37) *Progressive assimilation of [front] in Karaim*



- Irish, which also abounds in palatalized consonants, demonstrates that [dorsal] can assimilate separately from [front] (de Bhaldraithe 1945:§260; Ní Chiosáin 1994:95-6):
 - a coda [coronal, nasal] optionally assimilates to the [dorsal] specification of following onset, regardless of whether either the source or the target of assimilation is palatalized or not:⁵⁸

(38) *Irish* (Ní Chiosáin & Padgett 1993:7)

a.	[d ^j ek ^j .h ^j in ^j]	‘I would see’
	[d ^j ek ^j .h ^j iŋ ^j gan e:]	‘I would see without it’
b.	[d ^j i:.lən]	‘a diary’
	[d ^j i:.lən g ^j i:v ^j .r ^j i]	‘a winter’s diary’

⁵⁸ Non-palatalized consonants are phonetically velarized in Irish, particularly when adjacent to front vowels (Ní Chiosáin & Padgett 2001).

TONGUE BK/RT $\stackrel{\text{def}}{=} \{[\text{DOR}], [\text{FR}], [\text{HI}], [\text{LO}], [\text{RTR}]\}$

- Here the articulator feature [dorsal] spreads from a consonant to a preceding [coronal, nasal], independently of the specification for [front] in either the source or the target (Halle et al. 2000:421-3, 434-9).
- In classical Mongolian, a word's vowels are all [front] or all nonfront (Poppe 1970; Steriade 1979; Goldsmith 1985; Svantesson 1985).

(39) [front]: [k ø t e l b y r i] nonfront: [u y u t a]
 ‘instruction’ ‘bag’

- In Turkish, not all stem vowels agree in [front], but suffix vowels alternate in [front] depending on the [front] specification of the stem vowels (Lees 1961; Ringen 1980; Yavaş 1980; Kardestuncer 1983; Roca & Johnson 2000).

(40) *Turkish* (Goldsmith 1990:304)

	<i>Nom. sg.</i>	<i>Gen. sg.</i>	<i>Nom. pl.</i>	<i>Gen. pl.</i>
'rope'	ip	ip-in	ip-ler	ip-ler-in
'hand'	el	el-in	el-ler	el-ler-in
'girl'	kiz	kiz-in	kiz-lar	kiz-lar-in
'stalk'	sap	sap-in	sap-lar	sap-lar-in
'container'	kap	kap-in	kap-lar	kap-lar-in

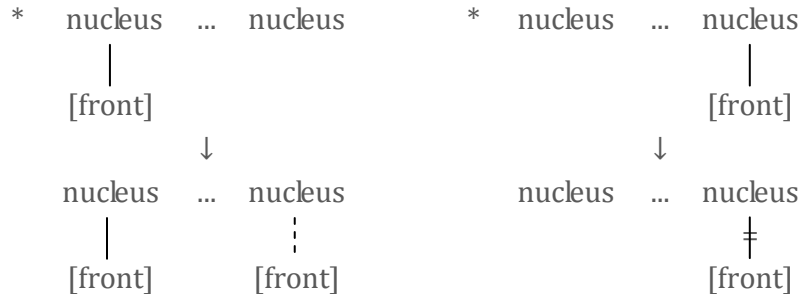
- Similarly in Hungarian, suffix vowels generally agree with the [front] specification of root vowels (Ringen 1988; Ringen & Kontra 1989; Ringen & Vago 1998).

(41) *Hungarian*

<i>rian</i>		'to'	'from'
ørøm	'joy'	ørøm-næk	ørøm-tø:l
idø:	'time'	idø:-næk	idø:-tø:l
tømeg	'crowd'	tømeg-næk	tømeg-tø:l
vi:z	'water'	vi:z-næk	vi:z-tø:l
ke:f	'knife'	ke:f-næk	ke:f-tø:l
ha:z	'house'	ha:z-nak	ha:z-to:l
varos	'city'	varos-nak	varos-to:l
mo:kus	'squirrel'	mo:kus-nak	mo:kus-to:l

TONGUE BK/RT $\stackrel{\text{def}}{=} \{[\text{DOR}], [\text{FR}], [\text{HI}], [\text{LO}], [\text{RTR}]\}$

(42) *Progressive assimilation/harmony of [front] in Turkish and Hungarian*



MRI of tongue movement <http://www.youtube.com/watch?v=uTOhDqhCKQs&feature=fvwrrel>

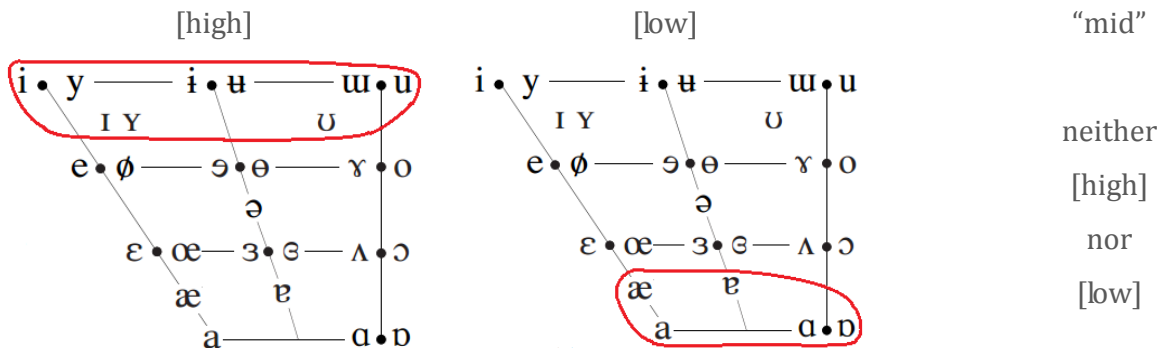
[HIGH] & [LOW]

- Chomsky and Halle (1968:304-5) define [high] and [low] as follows:

High sounds are produced by raising the body of the tongue above the level that it occupies in the neutral position; nonhigh sounds are produced without such a raising of the tongue body. ...

Low sounds are produced by lowering the body of the tongue below the level that it occupies in the neutral position; nonlow sounds are produced without such a lowering of the body of the tongue.

- These features make a three-way height distinction in vowels (syllable nuclei):



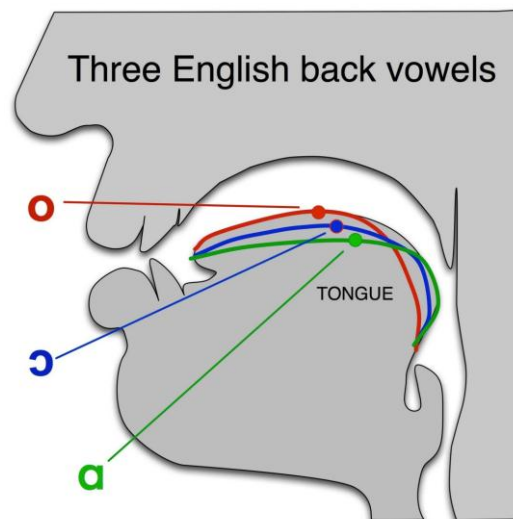
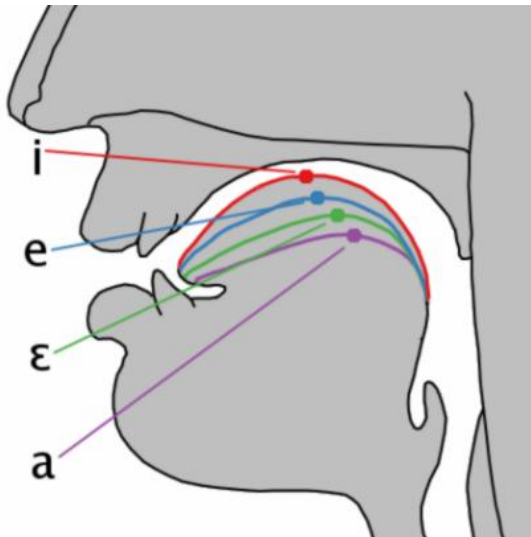
TONGUE BK/RT $\stackrel{\text{def}}{=} \{[\text{DOR}], [\text{FR}], [\text{HI}], [\text{LO}], [\text{RTR}]\}$

TowerofBabelFish.com tutorial on vowels:

<http://www.youtube.com/watch?NR=1&v=eeaghqkLRi8&feature=endscreen>

Tongue height in vowel production:

(Wikipedia)



- In Latvian the accusative singular marker appears to be just the feature [high].
 - At the end of singular accusative forms, a nonhigh vowel is raised to its high counterpart, e.g., nonhigh front [e] is raised to high front [i], and nonhigh nonfront [a] is raised to high nonfront [u], e.g. (43a).
 - Naturally, when the stem-final vowel is already high, no raising is observed in the singular accusative, e.g. (43b).

(43) *Latvian* (Archangeli 1984)

	<i>sg. loc.</i>	<i>sg. dat.</i>	<i>sg. acc.</i>	
a.	ma:te:	ma:te-j	ma:ti	‘mother’ (fem.)
	ma:sa:	ma:sa-j	ma:su	‘sister’ (fem.)
	zirga:	zirga-m	zirgu	‘horse’ (masc.)
b.	zivi:	zivi-j	zivi	‘fish’ (fem.)
	gulbi:	gulbi-m	gulbi	‘swan’ (masc.)
	tirgu:	tirgu-m	tirgu	‘market’ (masc.)

- In **consonant sounds**, [high] distinguishes between two types of [dorsal] sounds: **velars** versus **uvulars** (Chomsky & Halle 1968:304-5; Li 1996:286ff., 306ff.; Zetterstrand 1998; Vaux 1999b; Halle et al 2000:426-7).

[dorsal, high] **Velars**, e.g., k, ^hk, g, ^hg, k^h, k̰, g^h, g̰, d̰, k^w, ^hk^w, g^w, ^hg^w, k^{wh}, k̰^w, g^{wh}, g̰^w, d̰^w, k^{wɪ}, ^hk^{wɪ}, g^{wɪ}, ^hg^{wɪ}, k̰^{wɪ}, g̰^{wɪ}, d̰^{wɪ}, k^j, ^hk^j, g^j, ^hg^j, k^{jʰ}, k̰^j, g^{jʰ}, g̰^j, d̰^j, k^ɕ, ^hk^ɕ, g^ɕ, ^hg^ɕ, k^{ɕʰ}, g^{ɕʰ}, d̰^ɕ, k^x, g^ɣ, k^{xh}, k̰^x, k^{ɔx}, k̰^ɔ, ^hk̰^ɔ, g̰^ɔ, k̰^{ɔʰ}, k̰^{ɔʷ}, g̰^{ɔʰ}, g̰^{ɔʷ}, k̰^{ɔʷ}, ^hk̰^{ɔʷ}, g̰^{ɔʷ}, ^hg̰^{ɔʷ}, k̰^{ɔʷh}, k̰^{ɔʷʷ}, g̰^{ɔʷh}, g̰^{ɔʷʷ}, k̰^{ɔʷʷ}, ^hk̰^{ɔʷʷ}, g̰^{ɔʷʷ}, ^hg̰^{ɔʷʷ}, k̰^{ɔʷʷh}, k̰^{ɔʷʷʷ}, g̰^{ɔʷʷh}, g̰^{ɔʷʷʷ}, k̰^{ɔʷʷʷ}, ^hk̰^{ɔʷʷʷ}, g̰^{ɔʷʷʷ}, ^hg̰^{ɔʷʷʷ}, k̰^{ɔʷʷʷh}, k̰^{ɔʷʷʷʷ}, g̰^{ɔʷʷʷh}, g̰^{ɔʷʷʷʷ}, k̰^{ɔʷʷʷʷ}, ^hk̰^{ɔʷʷʷʷ}, g̰^{ɔʷʷʷʷ}, ^hg̰^{ɔʷʷʷʷ}, k̰^{ɔʷʷʷʷh}, k̰^{ɔʷʷʷʷʷ}, g̰^{ɔʷʷʷʷh}, g̰^{ɔʷʷʷʷʷ}, k̰^{ɔʷʷʷʷʷ}, ^hk̰^{ɔʷʷʷʷʷ}, g̰^{ɔʷʷʷʷʷ}, ^hg̰^{ɔʷʷʷʷʷ}, k̰^{ɔʷʷʷʷʷh}, k̰^{ɔʷʷʷʷʷʷ}, g̰^{ɔʷʷʷʷʷh}, g̰^{ɔʷʷʷʷʷʷ}, k̰^{ɔʷʷʷʷʷʷ}, ^hk̰^{ɔʷʷʷʷʷʷ}, g̰^{ɔʷʷʷʷʷʷ}, ^hg̰^{ɔʷʷʷʷʷʷ}, k̰^{ɔʷʷʷʷʷʷh}, k̰^{ɔʷʷʷʷʷʷʷ}, g̰^{ɔʷʷʷʷʷʷh}, g̰^{ɔʷʷʷʷʷʷʷ}, k̰^{ɔʷʷʷʷʷʷʷ}, ^hk̰^{ɔʷʷʷʷʷʷʷ}, g̰^{ɔʷʷʷʷʷʷʷ}, ^hg̰^{ɔʷʷʷʷʷʷʷ}, k̰^{ɔʷʷʷʷʷʷʷh}, k̰^{ɔʷʷʷʷʷʷʷʷ}, g̰^{ɔʷʷʷʷʷʷʷh}, g̰^{ɔʷʷʷʷʷʷʷʷ}, k̰^{ɔʷʷʷʷʷʷʷʷ}, ^hk̰^{ɔʷʷʷʷʷʷʷʷ}, g̰^{ɔʷʷʷʷʷʷʷʷ}, ^hg̰^{ɔʷʷʷʷʷʷʷʷ}, k̰^{ɔʷʷʷʷʷʷʷʷh}, k̰^{ɔʷʷʷʷʷʷʷʷʷ}, g̰^{ɔʷʷʷʷʷʷʷʷh}, g̰^{ɔʷʷʷʷʷʷʷʷʷ}, k̰^{ɔʷʷʷʷʷʷʷʷʷ}, ^hk̰^{ɔʷʷʷʷʷʷʷʷʷ}, g̰^{ɔʷʷʷʷʷʷʷʷʷ}, ^hg̰^{ɔʷʷʷʷʷʷʷʷʷ}, k̰^{ɔʷʷʷʷʷʷʷʷʷh}, k̰^{ɔʷʷʷʷʷʷʷʷʷʷ}, g̰^{ɔʷʷʷʷʷʷʷʷʷh}, g̰^{ɔʷʷʷʷʷʷʷʷʷʷ}, k̰^{ɔʷʷʷʷʷʷʷʷʷʷ}, ^hk̰^{ɔʷʷʷʷʷʷʷʷʷʷ}, g̰^{ɔʷʷʷʷʷʷʷʷʷʷ}, ^hg̰^{ɔʷʷʷʷʷʷʷʷʷʷ}, k̰^{ɔʷʷʷʷʷʷʷʷʷʷh}, k̰^{ɔʷʷʷʷʷʷʷʷʷʷʷ}, g̰^{ɔʷʷʷʷʷʷʷʷʷʷh}, g̰^{ɔʷʷʷʷʷʷʷʷʷʷʷ}, k̰^{ɔʷʷʷʷʷʷʷʷʷʷʷ}, ^hk̰^{ɔʷʷʷʷʷʷʷʷʷʷʷ}, g̰^{ɔʷʷʷʷʷʷʷʷʷʷʷ}, ^hg̰^{ɔʷʷʷʷʷʷʷʷʷʷʷ}, k̰^{ɔʷʷʷʷʷʷʷʷʷʷʷh}, k̰^{ɔʷʷʷʷʷʷʷʷʷʷʷʷ}, g̰^{ɔʷʷʷʷʷʷʷʷʷʷʷh}, g̰^{ɔʷʷʷʷʷʷʷʷʷʷʷʷ}, k̰^{ɔʷʷʷʷʷʷʷʷʷʷʷʷ}, ^hk̰^{ɔʷʷʷʷʷʷʷʷʷʷʷʷ}, g̰^{ɔʷʷʷʷʷʷʷʷʷʷʷʷ}, ^hg̰^{ɔʷʷʷʷʷʷʷʷʷʷʷʷ}, k̰^{ɔʷʷʷʷʷʷʷʷʷʷʷʷh}, k̰^{ɔʷʷʷʷʷʷʷʷʷʷʷʷʷ}, g̰^{ɔʷʷʷʷʷʷʷʷʷʷʷʷh}, g̰^{ɔʷʷʷʷʷʷʷʷʷʷʷʷʷ}, k̰^{ɔʷʷʷʷʷʷʷʷʷʷʷʷʷ}, ^hk̰^{ɔʷʷʷʷʷʷʷʷʷʷʷʷʷ}, g̰^{ɔʷʷʷʷʷʷʷʷʷʷʷʷʷ}, ^hg̰^{ɔʷʷʷʷʷʷʷʷʷʷʷʷʷ}, k̰^{ɔʷʷʷʷʷʷʷʷʷʷʷʷʷh}, k̰^{ɔʷʷʷʷʷʷʷʷʷʷʷʷʷʷ}, g̰^{ɔʷʷʷʷʷʷʷʷʷʷʷʷʷh}, g̰^{ɔʷʷʷʷʷʷʷʷʷʷʷʷʷʷ}, k̰^{ɔʷʷʷʷʷʷʷʷʷʷʷʷʷʷ}, ^hk̰^{ɔʷʷʷʷʷʷʷʷʷʷʷʷʷʷ}, g̰^{ɔʷʷʷʷʷʷʷʷʷʷʷʷʷʷ}, ^hg̰^{ɔʷʷʷʷʷʷʷʷʷʷʷʷʷʷ}, k̰^{ɔʷʷʷʷʷʷʷʷʷʷʷʷʷʷh}, k̰^{ɔʷʷʷʷʷʷʷʷʷʷʷʷʷʷʷ}, g̰^{ɔʷʷʷʷʷʷʷʷʷʷʷʷʷʷh}, g̰^{ɔʷʷʷʷʷʷʷʷʷʷʷʷʷʷʷ}, k̰^{ɔʷʷʷʷʷʷʷʷʷʷʷʷʷʷʷ}, ^hk̰^{ɔʷʷʷʷʷʷʷʷʷʷʷʷʷʷʷ}, g̰^{ɔʷʷʷʷʷʷʷʷʷʷʷʷʷʷʷ}, ^hg̰^{ɔʷʷʷʷʷʷʷʷʷʷʷʷʷʷʷ}, k̰^{ɔʷʷʷʷʷʷʷʷʷʷʷʷʷʷʷh}, k̰^{ɔʷʷʷʷʷʷʷʷʷʷʷʷʷʷʷʷ}, g̰^{ɔʷʷʷʷʷʷʷʷʷʷʷʷʷʷʷh}, g̰^{ɔʷʷʷʷʷʷʷʷʷʷʷʷʷʷʷʷ}, k̰^{ɔʷʷʷʷʷʷʷʷʷʷʷʷʷ}

[dorsal] **Uvulars**, e.g., q, ⁿq, ɢ, ⁿɢ, q^h, ɖ, ɢ^h, ɠ, ɢ, q^w, ⁿq^w, ɢ^w, ⁿɢ^w, q^{wh}, ɖ^w, ɢ^{w^h}, ɠ^w, ɢ^w,
χ, ɣ, ʁ, χ^h, ɣ^w, ɣ^w, ʁ^w, χ^{wh}, ɣ^w, ɴ, ɴ_ɔ, ɴ, ɴ^w, ɴ_ɔ^w, ɴ^w, ʀ, ʀ^w, ʁ, ʁ^w, etc.

- This distinction is illustrated in the following Oowekyala (Howe 2000) minimal pairs:⁵⁹

⁵⁹ Closely-related Heiltsuk provides a nice minimal pair: [k'ə.ját] 'poor' vs. [q'ə.ját] 'rich' (Rath 1981).

(44) *Oowekyala velars vs. uvulars*

- a. [ka.pə.la] 'lifting a lid, blanket, etc.'
[qa.pə.la] 'rising and coming towards one (said of steam, haze, smell), steam, smell, air'
- b. [ki.χa] 'to use a saw'
[qi.χa] 'to fade (color)'
- c. [gə.na.la] 'getting more (money), adding to what one already has'
[ɢə.na.la] 'carrying on the arm; tug-of-war played on fourth night of the Dləw'əχa Dances'
- d. [k'.la] 'to move (brush, sweep, shake) particles from a surface'
[q'.la] 'to lift, pick up, hold, carry a person (esp. a baby)'

- A revealing pattern of assimilation is found in Sibe (Li 1996:286ff., 306ff.; Vaux 1999a).
 - This Tungusic language distinguishes [high] /i, y, ɨ, u/ from nonhigh /ɛ, ø, ɑ, ɔ/.
 - Velar onsets [k, x] change to uvular [q, χ] (respectively) when preceded *anywhere in the word* by a nonhigh vowel, as the following suffixal alternations illustrate. (These examples also illustrate [round] harmony.)

(45) *Sibe* (Li 1996; Vaux 1999a)

a. *Diminutive suffix*

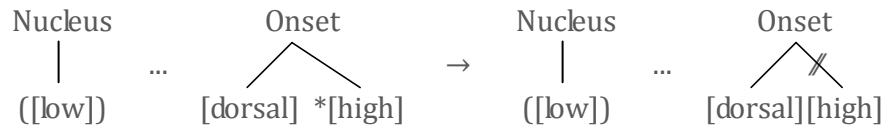
[ɨl.dɨ(n).kin]	'bright'	vs.	[su.la.qɨn]	'loose'
[u.lu.kun]	'soft'		[ɕɑ.lu.qun]	'full'
[mu.xu.li(n).kin]			[ɑ.ɕi(g).qɨn]	'small'
			[gø.lmi(n).qɨn]	'long'

b. *Non-self perceived past tense*

[i.ɕi.xi]	'to be enough'	vs.	[fɔn.ɕi.χɨ]	'to ask'
[ti.xi]	'to sit'		[ty.kɛ.χɨ]	'to watch'
[ty.ry.xu]	'to rent'		[ø.mi.χɨ]	'to drink'
			[bɔ.du.χu]	'to consider'
			[lav.du.χu]	'to become more'

TONGUE BK/RT $\stackrel{\text{def}}{=} \{[\text{DOR}], [\text{FR}], [\text{HI}], [\text{LO}], [\text{RTR}]\}$

- In other words, Sibe avoids a [high] onset after a non-high nucleus:



- In many other languages, it is uvular consonants which cause lowering in high vowels.
 - For instance, in Ayacucho Quechua “/u/ and /i/ are replaced by /o/ and /e/ respectively before /q/” (Parker 1969:20).
 - In other words, [high] nuclei are avoided before nonhigh $[\chi]$:⁶⁰



Pharyngeals

- [low] plays no obvious role in consonant sounds. However, Rood (1975:329-33) suggests that pharyngeals $[\text{h}], [\text{ʕ}]$ are uniquely distinguished (especially from laryngeals $[\text{h}], [\text{ʔ}]$) by this feature.
 - This proposal sits well with a common assumption that the low vowels and pharyngeal approximants are in a vowel-to-consonant relationship (see, e.g., Gardiner 1969 on Ancient Egyptian; Lowenstamm & Prunet 1986 on Tigrinya; Ladefoged & Maddieson 1996:323; Pulleyblank 1996 on Old Chinese).

$$\text{○ } [\text{a}]:[\text{ʕ}]:: \left\{ \begin{array}{l} [\text{i}]:[\text{j}] \\ [\text{u}]:[\text{w}] \\ [\text{y}]:[\text{ɥ}] \\ [\text{ɯ}]:[\text{ʉ}] \end{array} \right\}$$

⁶⁰ $[\chi]$ is used rather than $[\text{q}]$, except after $[\text{n}]$, where it is optionally realized as $[\text{q}]$ (Parker 1969:19).

TONGUE BK/RT $\stackrel{\text{def}}{=} \{[\text{DOR}], [\text{FR}], [\text{HI}], [\text{LO}], [\text{RTR}]\}$

- Pharyngeals may be fricatives [ħ, ʕ] (e.g., Ladefoged & Maddieson 1996) or else glides/approximants [ɰ, ʁ] (e.g., Laufer 1996; Halle et al. 2000).
- Pharyngeals are famously found in the Middle East and North Africa (e.g., Semitic,⁶¹ Berber, Cushitic), but also in other areas, such as Caucasia (e.g., North Caucasian) and the North American Northwest (e.g., Interior Salish, South Wakashan, Haida).
- Pharyngeals are illustrated in the following words from Stoney (a.k.a. ȩyāhé Nakoda; Siouan), as spoken in Morley, near Calgary (Convery 1997:47):

(46)	[bó.ʃǎ]	'blow'	[ħo.ʃǎ]	'fish'
	[ʃi]	'brown'	[ga.ħní.ʃa]	'choose'
	[ǎ.ʃán]	'on top'	[ħno]	'growling'
	[na.ʃé]	'stomach'	[ĩ.já.ħe]	'mountain'

- Stoney [ħ, ʕ] developed historically from velar fricatives [x, ɣ] (Shaw 1980:21):
 - [fricative, dorsal, high] > [fricative, low]
- “[T]here is a common sound change of uvulars to pharyngeals” (Blevins 2004:198), as seen
 - “in every branch of Semitic” (ibid.)
 - in Haida (Eastman & Aoki 1978)
 - in South Wakashan (Jacobsen 1969):

Uvular fricatives [χ, χ^w] have changed to a voiceless pharyngeal [ħ] in Nootka-Nuuchahnulth (47a), and the glottalized uvulars [q', q^w'] have changed to a pharyngealized epiglottal stop [ʕ̤] in both Nootka-Nuuchahnulth and Ditidaht (47b), but not in Makah.

⁶¹ E.g., Hebrew: <http://www.phonetics.ucla.edu/appendix/languages/hebrew/hebrew.html>

TONGUE BK/RT $\stackrel{\text{def}}{=} \{[\text{DOR}], [\text{FR}], [\text{HI}], [\text{LO}], [\text{RTR}]\}$

(47) *Uvular-to-pharyngeal changes in South Wakashan* (Jacobsen 1969)

	<i>Proto-South Wakashan</i>	<i>Nootka- Nuuchahnulth</i>	<i>Ditidaht</i>	<i>Makah</i>	
a.	[χa.mup]	[ħa.mup]	[χa.bup]	[χa.bup]	'knowing'
	[χupt-]	[ħup.ta:]	[χu:.bi.t'ad]	[χu:.bi.t'ad]	'snoring'
	[tʃ'i.χ ^w at-]	[tʃ'i.ħa.ta]	[tʃ'i.χ ^w atʃ.tʃ]	[tʃ'i.χ ^w a.tʃitʃ]	'to be scared'
b.	[q'a.pa:k]	[ḥa.pa:k]	[ḥa.pa:k]	[q'.pa:k]	'willing'
	[q ^w i.tʃa:k]	[ḥi.tʃa:k]	[ḥi.tʃa:k]	[q ^w i.tʃa:k]	'rotten'
	[mi.q'a:t]	[mi.ḥa:t]	[bi.ḥa:t]	[bi.q'a:t]	'sockeye salmon'
	[q'i.χak]	[ḥi.ħak]	[ḥi.χak]	[q'i.χak]	'to cry, howl'

- Nuuchahnulth: [fricative, dorsal] > [fricative, low]
- Nuuchahnulth, Ditidaht: [stop, dorsal, glottalized] > [stop, low, glottalized]⁶²
- Videos of the voiceless pharyngeal and pharyngealized epiglottal stop of Nuuchahnulth:
http://web.uvic.ca/ling/research/phonetics/ICPhS/epiglottal_stop/pages/page10.htm

- On Rood's (1975:329ff.) proposal that pharyngeals are [low], the great rarity of these sounds is explained by the great markedness of [low] in the margin of a syllable, as opposed to the unmarked use of this feature in a vowel, in syllable peak position.

Vowel harmony

- Many Bantu languages show a type of vowel harmony which involves [high]. The examples in (48)–(51) are from Shona, a Southern Bantu language (Beckman 1998).
 - As shown, a suffix vowel which is otherwise [high] *i* (see (a) examples) becomes nonhigh *e* when it is preceded by a non-[high] non-[low] vowel in the stem (see (b) examples).

⁶² Plain uvular stops /q, q^w/ have remained intact. Compare, e.g., North Wakashan Oowekyala *naq*- 'drink' and South Wakashan Nootka-Nuuchahnulth *naq*- 'ibid.'

(48) 'Applicative' *-ira* ~ *-era*

a.	<i>fat-a</i>	'hold'	<i>fat-ir-a</i>	'hold for'
	<i>vav-a</i>	'itch'	<i>vav-ir-a</i>	'itch at'
	<i>pofomadz-a</i>	'blind'	<i>pofomadz-ir-a</i>	'blind for'
	<i>ip-a</i>	'be evil'	<i>ip-ir-a</i>	'be evil for'
	<i>svetuk-a</i>	'jump'	<i>svetuk-ir-a</i>	'jump in'
b.	<i>per-a</i>	'end'	<i>per-er-a</i>	'end in'
	<i>tsvet-a</i>	'stick'	<i>tsvet-er-a</i>	'stick to'
	<i>son-a</i>	'sew'	<i>son-er-a</i>	'sew for'
	<i>pon-a</i>	'give birth'	<i>pon-er-a</i>	'give birth at'

(49) 'Neuter' suffix *-ik-* ~ *-ek-*

a.	<i>taris-a</i>	'look at'	<i>taris-ik-a</i>	'easy to look at'
	<i>kwir-a</i>	'climb'	<i>kwir-ik-a</i>	'easy to climb'
	<i>bvis-a</i>	'remove'	<i>bvis-ik-a</i>	'be easily removed'
b.	<i>gon-a</i>	'be able'	<i>gon-ek-a</i>	'be feasible'
	<i>vereng-a</i>	'count'	<i>vereng-ek-a</i>	'be numerable'
	<i>tʃenget-a</i>	'keep'	<i>tʃenget-ek-a</i>	'get kept'

(50) 'Perfective' suffix *-irir-* ~ *-erer-*

a.	<i>pind-a</i>	'pass'	<i>pind-irir-a</i>	'to pass right through'
	<i>bud-a</i>	'come out'	<i>bud-irir-a</i>	'to come out well'
b.	<i>pot-a</i>	'go round'	<i>pot-erer-a</i>	'go right round'
	<i>tʃek-a</i>	'cut'	<i>tʃek-erer-a</i>	'cut up small'
	<i>sek-a</i>	'laugh'	<i>sek-erer-a</i>	'laugh on and on'

(51) 'Causative' suffix *-is-* ~ *-es-*

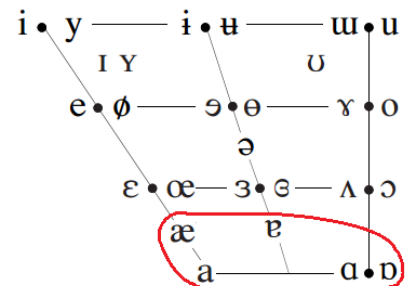
a.	<i>famb-a</i>	'wash'	<i>famb-is-a</i>	'make wash'
	<i>pamh-a</i>	'do again'	<i>pamh-is-a</i>	'make do again'
	<i>tʃejam-a</i>	'be twisted'	<i>tʃejam-is-a</i>	'make be twisted'
	<i>bʋum-a</i>	'agree'	<i>bʋum-is-a</i>	'make agree'
b.	<i>tond-a</i>	'face'	<i>tond-es-a</i>	'make to face'
	<i>ʃong-a</i>	'adorn self'	<i>ʃong-es-a</i>	'make adorn'
	<i>om-a</i>	'be dry'	<i>om-es-a</i>	'cause to get dry'

TONGUE BK/RT $\stackrel{\text{def}}{=} \{[\text{DOR}], [\text{FR}], [\text{HI}], [\text{LO}], [\text{RTR}]\}$

- This assimilation pattern causes alternations in nonfront vowels as well.
 - For instance, the ‘reversive’ suffix alternates between *-ur-* and *-or-*.
 - E.g., *naman-ur-a* ‘unstick’ vs. *monon-or-a* ‘uncoil’.
- The fact that mid vowels (*e, o*), but not the [low] vowel *a*, trigger height assimilation needs to be worked into the rule, however it is formulated.

(52) *Progressive assimilation/harmony of [high] in Shona*

- [low] harmony can be illustrated with so-called “sound symbolic words” in Korean (Sohn 1987).
 - Within sound-symbolic words, vowels are normally all [low], or else all nonlow, as shown in (53).



(53) *Korean sound symbolic words*

[low]	nonlow		[low]	nonlow	
<i>kəŋcəŋ</i>	<i>kəŋcun</i>	‘skipping’	<i>pæcək</i>	<i>picuk</i>	‘protruding’
<i>c^halsək</i>	<i>c^halsək</i>	‘lapping’	<i>cəlkaŋ</i>	<i>cilkəŋ</i>	‘chewing’
<i>panćak</i>	<i>pənćək</i>	‘flashing’	<i>talkakak</i>	<i>təlkəkək</i>	‘rattling’
<i>kəlkek</i>	<i>kulkək</i>	‘swallowing’	<i>cəmollak</i>	<i>cumullek</i>	‘kneading’
<i>səkək</i>	<i>suktək</i>	‘whispering’	<i>cəcal</i>	<i>cicəl</i>	‘chattering’
<i>allək</i>	<i>əlluk</i>	‘molted’	<i>c^holləŋ</i>	<i>c^hulləŋ</i>	‘splashing’

TONGUE BK/RT $\stackrel{\text{def}}{=} \{[\text{DOR}], [\text{FR}], [\text{HI}], [\text{LO}], [\text{RTR}]\}$

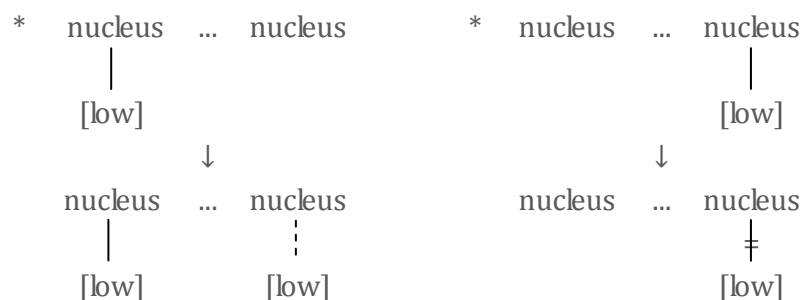
- In a related pattern, the infinitival suffix is [low] *a* if the verb vowel is [low] (*æ, a, ʌ*), and nonlow *ə* if the verb vowel is nonlow (*ə, e, i, u, ɪ*), as shown in (54).

(54) *Korean infinitives*

[low]		nonlow	
<i>cap-a</i>	'grasp'	<i>mək-ə</i>	'eat'
<i>nɒk-a</i>	'melt'	<i>cuk-ə</i>	'die'
		<i>me-ə</i>	'carry'
		<i>ki-ə</i>	'crawl'
		<i>nɪc-ə</i>	'be late'

- These patterns point to a process of [low] assimilation/harmony:

(55) *Progressive assimilation of [low] in Korean sound-symbolic words*



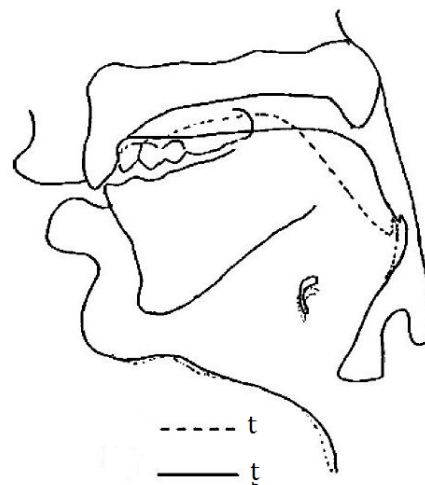
[RETRACTED TONGUE ROOT]

Consonants

- The feature [rtr] describes a *retracted tongue root* in certain consonants known as “emphatics”.
 - The IPA diacritic ˤ indicates a ‘retracted tongue root’ [rtr], in a sound: ˤt, ˤs, etc.

TONGUE BK/RT $\stackrel{\text{def}}{=} \{[\text{DOR}], [\text{FR}], [\text{HI}], [\text{LO}], [\text{RTR}]\}$

- Emphatics involve secondary dorso-pharyngealization, i.e. retraction of the body and root of the tongue into the pharynx.
- Accordingly, many prefer to use the diacritic $^{\text{ʕ}}$ for emphatics: $t^{\text{ʕ}}$, $s^{\text{ʕ}}$, etc.
- Emphatics are famously found in most Arabic dialects, e.g., Qatari Arabic *sad* ‘to prevail’ vs. *ṣad* (name of the letter) (Ladefoged & Maddieson 1996:365).



- X-ray tracings by Ghazeli (1977) =>

(56) *Emphatic contrasts in Arabic (Syrian dialect)*

[tʕi:n]	‘mud’	cf.	[ti:n]	‘figs’
[dʕal]	‘he stayed’		[dal]	‘he pointed’
[ʃu:ʃ]	‘chick’		[su:s]	‘licorice’
[ʔaʔ:al]	‘he gathered’		[ʔat:al]	‘he massacred’
[maʔ:a]	‘he wasted’		[mad:a]	‘table cloth’
[ðabaʔ]	‘he perfected’		[zat]	‘he threw’
[nað:omli]	‘he organized neatly’		[baz:aʔ]	‘he spat hard’
[ra:ʃi]	‘my head’		[ra:ʃi]	‘he’s anchored’
[haʔ:ab]	‘he fought’		[far:ad]	‘he separated’
[ʔa]	‘he peeped’		[tal]	‘hill’
[dʕaʔ:at]	‘she stayed’		[dal:at]	‘she pointed’

- Emphatics are mostly coronal. However, in the Arabic dialect spoken “[i]n [the] southern Anatolian Siirt [province of Turkey], the original interdentalals have become labiodentals /f, v, ɸ/” (Watson 2002:15) —note labial [ɸ].

(57) *Southern Anatolian Siirt Arabic* (Fischer & Jastrow 1980:50)

*θaʃlab	>	faʃlab	‘fox’
*ðahab	>	vahab	‘gold’
*ðarab	>	ɸarab	‘he hit’

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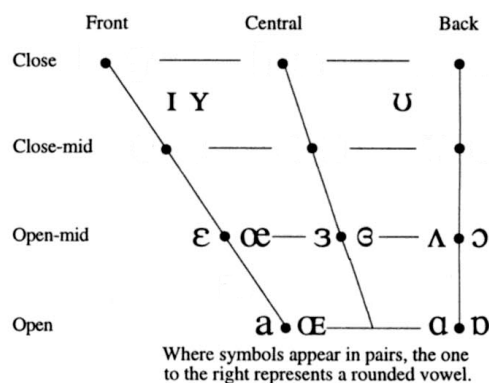
TONGUE BK/RT $\stackrel{\text{def}}{=} \{[\text{DOR}], [\text{FR}], [\text{HI}], [\text{LO}], [\text{RTR}]\}$

- Shahin (2002) found that St’at’imcets emphatics (and pharyngeals) sound just like Arabic ones when heard by (Palestinian) Arabs.
- McDowell’s (2004) ultrasonic study of emphatic laterals in Montana Salish also reports a lower and backed tongue position of [i, u] adjacent to retracted laterals in Montana Salish, a Southern Interior Salish language spoken in Montana.

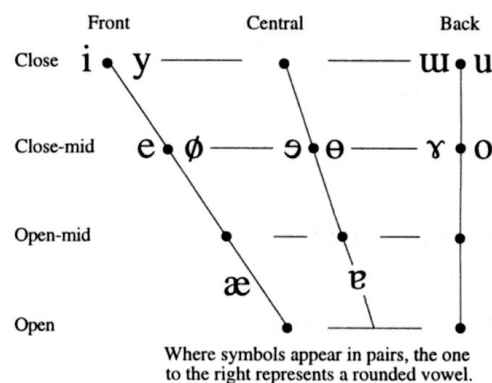
Vowels

- The feature [rtr] also distinguishes between vowels in which the tongue root is retracted or advanced, as shown in (58).

(58) a. [rtr] vowels



b. “advanced” vowels



- Because the tongue root is connected to the tongue body, there is much interaction between [rtr] and the tongue body features [high], [low], and [front].
 - In particular, [high] vowels tend to be *not* [rtr], because the tongue root is pulled forward as the Tongue Body is raised —as in /i, y, u, u/ (58b).
 - On the other hand, [low] vowels tend to be [rtr] because the tongue root tends to retract rather than advance when the tongue body is lowered —as in /a, æ, ɑ, ɒ/ (58a).

TONGUE BK/RT $\stackrel{\text{def}}{=} \{[\text{DOR}], [\text{FR}], [\text{HI}], [\text{LO}], [\text{RTR}]\}$

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Assimilation

- Palestinian Arabic (Davis 1995) shows a pattern of regressive [rtr] assimilation involving consonants.
 - As shown in (59a), sounds become dorsopharyngealized, or [rtr], when they precede an “emphatic” —a dorsopharyngealized sound.
 - This often leads to the whole word being [rtr], as shown in (59b).

(59) *Palestinian Arabic*

c) <i>Palestinian Arabic</i>		b.	[ballaːʃ]	‘thief’
a.	[ʕatʃaːn]		[ħaðː]	‘luck’
	[maʕʕaːʕiʃ]		[ʔabʕaʔ]	‘simpler’
	[naʕiːha]		[baːʃ]	‘bus’
	[kaʔuːʕa]		[maːnaːʃið]	‘ashtrays’
	[ʕiħa]		[xaʔaːʔ]	‘tailor’
	[zaːriʕa]		[naʕaːʔ]	‘energy’
			[taɪfiːta]	‘hair stylist’

TONGUE BK/RT $\stackrel{\text{def}}{=} \{[\text{DOR}], [\text{FR}], [\text{HI}], [\text{LO}], [\text{RTR}]\}$

- Of particular interest in Palestinian Arabic is that [rtr] does not spread *from* pharyngeals.
 - Consider, e.g., ʔaʕi:ħa, ʔaʕ:u:fa, ʕiħ:a, zari:fa.
 - This indicates that pharyngeals cannot be understood simply as [rtr] glides.
 - By contrast, the interpretation of pharyngeals as [low] glides (see previous class) correctly predicts that these sounds do not trigger retraction harmony (59a), though they may well undergo this process (59b).
- Relatedly, consider Davis (1995) on [a] in Palestinian Arabic:
 - “Evidence that low vowels are not underlyingly [RTR] comes from the fact that the low vowel allophone normally has a fronted pronunciation except in contexts where it undergoes emphasis spread. I assume that low vowels have the feature [+low] underlyingly ... I am positing that low vowels are not underlyingly represented as having the feature [RTR].” (p. 490, fn. 16)
- In Akan, mentioned above, the [rtr] specification of vowels in prefixes and suffixes agrees with the [rtr] specification of neighboring vowels in stems (Stewart 1967).
 - For example, in (60a) the prefix is advanced o-, as it is next to an advanced vowel in the stem *bisa*. But in (60b) the same prefix is retracted ɔ-, as it is next to a retracted vowel in the stem, *kɔri*.
 - Conversely, in (60a) the suffix is retracted -ɪ, as it is next to a retracted vowel in the stem *bisɔ*, while in (60b) it is advanced -i, as it is next to an advanced vowel in the stem, *kari*.

(60) Akan

a.	b i s a	‘to ask’		[o-bisa-ɪ]	‘he asked’
	[rtr]				

TONGUE BK/RT $\stackrel{\text{def}}{=} \{[\text{DOR}], [\text{FR}], [\text{HI}], [\text{LO}], [\text{RTR}]\}$

b. k a r i 'to weigh' [ɔ-kari-i] 'he weighed'
 |
 [rtr]

- In Wolof, another Niger-Congo language with over 4 million native speakers in West Africa (mainly Senegal), all vowels in each word agree in terms of [rtr]. The productivity of this [rtr] harmony process is also apparent in affix vowels (Archangeli & Pulleyblank 1994).

(61) *Wolof* (West Atlantic Africa)

<i>advanced</i>	[rtr]
[dɔ:r-e] 'to hit with'	[xɔ:l-ɛ] 'to look with'
[re:r-e] 'to be lost in'	[dɛm-ɛ] 'to go with'
[gæn-e] 'to be better in'	[xam-ɛ] 'to know in'
[dɔ:r-lɛ] 'to help hit'	[dʒɔx-lɛ] 'to help give'
[re:r-lɛ] 'to lose property'	[dɛ:-lɛ] 'to lose a relative'
[jæg-lɛ] 'to be better in'	[tak-k-lɛ] 'to help tie'
[re:r-o:n] 'was lost'	[rɛ:r-ɔ:n] 'had dinner'
[ɲow-o:n] 'came'	[dʒɔx-ɔ:n] 'gave'
[bægg-o:n] 'wanted'	[tak-k-ɔ:n] 'tied'
[lɛ:b-æɫ] 'to tell stories for'	[bej-al] 'to cultivate for'
[fo:t-æɫ] 'to launder for'	[wɔ:r-al] 'to fast for'
[dʒænd-æɫ] 'to buy for'	[wax-al] 'to speak for'
[genn-ændɔ:] 'to go out together'	[dænd-andɔ:] 'to be neighbors'
[te:x-ændɔ:] 'to smoke together'	[tɔpp-andɔ:] 'to imitate'
[dækk-ændɔ:] 'to live together'	[wax-andɔ:] 'to say together'

TONGUE BK/RT $\stackrel{\text{def}}{=} \{[\text{DOR}], [\text{FR}], [\text{HI}], [\text{LO}], [\text{RTR}]\}$

SCHWA

- At this point we have discussed all principal features which are used to specify vowels.

(62) Features for common vowels

	i	y	ɪ	ʏ	$\begin{Bmatrix} u \\ i \end{Bmatrix}$	$\begin{Bmatrix} u \\ ɨ \end{Bmatrix}$	ʊ	e	ø	ɛ	œ	$\begin{Bmatrix} ə \\ ʌ \\ ɐ \end{Bmatrix}$	$\begin{Bmatrix} ɔ \\ ɐ \end{Bmatrix}$	$\begin{Bmatrix} ʌ \\ ɜ \end{Bmatrix}$	$\begin{Bmatrix} ɔ \\ ɐ \end{Bmatrix}$	æ	a	ɑ	ɒ
[high]	✓	✓	✓	✓	✓	✓	✓												
[low]																✓	✓	✓	✓
[front]	✓	✓	✓	✓				✓	✓	✓	✓					✓	✓?		
[round]		✓		✓		✓	✓		✓		✓		✓		✓				✓
[rtr]			✓	✓			✓			✓	✓		✓	✓			✓	✓	✓

- Schwa [ə] is relatively common across languages.
- It is also by far the most frequent vowel in some languages, such as
 - Musqueam Salish [xʷməθkʷəjəm] (a.k.a. [hənq'əminəm]), e.g.:
 - [wə'jaθ tən wə 'kʷ'ekʷ'ətsnəxʷ ni ʔə ʔθeʔ] 'I always see him there'
 - [təmə'ʔəpsəm] 'pilated woodpecker'
 - [snə'səlməxʷ] 'butter'
 - English, e.g. [ə 'fejməs fə'nælədʒəst wəz də'pɔɪtəd frəm ə'meɪəkə tə 'kænədə]

(63) Examples of stressless [ə] in English

Alaska	[ə'læskə]
vanilla	[və'nɪlə]
messiah	[mə'saɪə]
behemoth	[bə'hi:məθ] ~ ['bi:əməθ] ~ ['bi:əməθ]
Arbuthnot	[ɑɪ'bʌθnət] ~ ['ɑɪbəθ,nət]

TONGUE BK/RT $\stackrel{\text{def}}{=} \{[DOR], [FR], [HI], [LO], [RTR]\}$

<i>molybdenum</i>	[ˌmɒləb'di:nəm] ~ [mə'libdɛnəm]
<i>abracadabra</i>	[ˌæbrɪkə'dæbrɪə]
<i>Peloponnesus</i>	[ˌpələpə'ni:səs]
<i>Crocodilopolis</i>	[ˌkrɒkədə'lɒpələs]
<i>trichomoniasis</i>	[ˌtrɪkəmə'najəsəs]

- Most phonologists abstract away from the precise realization of schwa, following Chomsky and Halle (1968:59, fn. 1): “Phonetically the vowel which we represent here as [ə] may often (or, in some dialects, always) be raised to the high central vowel [ɪ].”
 - Flemming & Johnson (2007) claim that American English schwa is usually [ɪ] (e.g., *roses* ['ɹo:zɪz]) except word-finally (e.g., *Rosa* ['ɹo:sə]) and before certain phrasal enclitics (e.g., *Rosa's* ['ɹo:səz]).
- However, [ə] and [ɪ] are somewhat distinct before velars in stressless syllables: in this [high] context, [ə] varies with [ɪ] (or perhaps [ɪ]), whereas lexical /ɪ/ fails to lower to [ə].

(64)	<i>bollocks</i>	[ˈbɒləks] ~ [ˈbɒlɪks]	<i>bollix</i>	[ˈbɒlɪks]
	<i>finnoc</i>	[ˈfɪnək] ~ [ˈfɪnɪk]	<i>Finnic</i>	[ˈfɪnɪk]
	<i>epoch</i>	[ˈɛpək] ~ [ˈɛpɪk]	<i>epic</i>	[ˈɛpɪk]
	<i>mattock</i>	[ˈmætək] ~ [ˈmætɪk]	<i>attic</i>	[ˈætɪk]
	<i>coracle</i>	[ˈkɒrəkəl] ~ [ˈkɒrɪkəl]	<i>cuticle</i>	[ˈkju:tɪkəl]
	<i>chaetognath</i>	[ˈki:təɡnæθ] ~ [ˈki:tɪɡnæθ]	<i>gelignite</i>	[ˈdʒɛlɪɡnɪt]
	<i>h</i>			
	<i>recognize</i>	[ˈɹɛkəɡnəɪz] ~ [ˈɹɛkɪɡnəɪz]	<i>designate</i>	[ˈdeɪzɪɡneɪt]
	<i>diagnosis</i>	[ˌdʒəɡnɒsəs] ~ [ˌdʒɪɡnɒsəs]	<i>alexander</i>	[ˌælɪɡˈzændə]
	<i>Isaac</i>	[ˈaɪzək] ~ [ˈaɪzɪk]	<i>Zelig</i>	[ˈzɛlɪɡ]
	<i>flummox</i>	[ˈflʌmɒks] ~ [ˈflʌmɪks]	<i>pharynx</i>	[ˈfeɪrɪŋks]
	<i>stomach</i>	[ˈstʌmək] ~ [ˈstʌmɪk]	<i>kamik</i>	[ˈkæmɪk]
	<i>eunuch</i>	[ˈju:nək] ~ [ˈju:nɪk]	<i>Munich</i>	[ˈmju:nɪk]
	<i>Yupik</i>	[ˈju:pək] ~ [ˈju:pɪk]	<i>music</i>	[ˈmju:zɪk]
	<i>havoc</i>	[ˈhævək] ~ [ˈhævɪk]	<i>Slavic</i>	[ˈslævɪk]
	<i>Potomac</i>	[pəˈto:mək] ~ [pəˈto:mɪk]	<i>ceramic</i>	[səˈɹæmɪk]
	<i>paddock</i>	[ˈpædək] ~ [ˈpædɪk]	<i>medic</i>	[ˈmedɪk]
	<i>umangite</i>	[ˈju:məŋɡaɪt] ~ [ˈju:mɪŋɡaɪt]	<i>Brobdignagian</i>	[ˌbrɒbdɪŋˈnæɡiən]

TONGUE BK/RT $\stackrel{\text{def}}{=} \{[\text{DOR}], [\text{FR}], [\text{HI}], [\text{LO}], [\text{RTR}]\}$

- Anyhow, [ə] can be described as a “neutral vowel” (Chomsky & Halle 1968) or as a “targetless vowel” (Browman & Goldstein 1992), since its realization makes no special demands of the articulators.
 - In making [ə] the lips are not rounded, the tongue body is not fronted, raised or lowered, and the tongue root is not retracted.
 - In terms of the features in (62), then, [ə] may be described as featureless (see, e.g., Borowsky 1986; McCarthy 1988; Kager 1990; Shaw 1992; 1994; 1994; Piggott 1995; Kinkade 1998; 1999; Blake 2000; Reiss 2003; 2004).
 - Having no place features makes schwa an unmarked vowel, since it avoids all markedness breaches associated with place features.
- Accordingly, schwa is widely analyzed as an empty syllable nucleus (Anderson 1982; Charette 1991:95; Dell & Tangi 1992; Shaw 1992; 1993; 1994; 1996b; a; Shaw et al. 1999; Bach et al. 2005, etc.)
- That [ə] has no place features of its own may explain, first, why this vowel is especially susceptible to phonetic coloring from adjacent sounds (e.g., Shaw 2004 on Musqueam).
 - For example, consider the varied realization of schwa in Heiltsuk, a Wakashan language of British Columbia (65): [ə ~ ɪ ~ i ~ ʊ ~ u ~ ɔ ~ o ~ ʌ ~ a ~ ɑ] (Lincoln & Rath 1980:15).
 - Crucially, the other vowels of Heiltsuk, /i u a/, do not vary as greatly according to surrounding consonants (ibid.).

(65) *Schwa-coloring in Heiltsuk*

“broad”	vs.	“narrow”	transcriptions ⁶³
[mətá]		[[mətá]]	‘to twitch’
[məx ^j á]		[[mix ^j é ~ mix ^j é]]	‘to punch’
[məx ^w əlá]		[[mox ^w ʊlá]]	‘fast worker, quick action’
[məχ ^w əlá]		[[mɔχ ^w ɔlá]]	‘damp (cloth)’

⁶³ A “broad” transcription is minimalist: it focuses on what’s gross and distinctive in a word, and ignores other details. A “narrow” transcription is maximalist: it includes subtle and non-distinctive information, and reports as many details as possible. For example, you can transcribe *can’t* broadly as [kænt] and narrowly as [[k^hæ̃t̚]].

TONGUE BK/RT $\stackrel{\text{def}}{=} \{[\text{DOR}], [\text{FR}], [\text{HI}], [\text{LO}], [\text{RTR}]\}$

[məqá]	[ʔmΛqá]	‘to shoot supernatural power’
[jəqá]	[jΛqá ~ jεqá]	‘to knit’
[wəχsí]	[wΛχsí ~ wɔχsí]	‘to spit in two (e.g., log, canoe)’
[χəwá]	[χowá ~ χawá ~ χawá]	‘to split wood evenly’
[həts’əχdí]	[hats’Λχdí]	‘tail of an animal’
[həx ^w əwá]	[hax ^w uwá]	‘to howl (dog)’
[həq ^w əs]	[haq ^w əs]	‘to lie face down outside’
[ʔəqá]	[ʔΛqá]	‘to widen, to open wide’

- The unmarkedness of schwa may also explain its preferred use in vowel *epenthesis*.
 - English examples include *rhyth*[ə]*m* (cf. *rhythmic* without schwa), *Evil K*[ə]*nievel* (*Knievel*), and (for some speakers) *fil*[ə]*m*.
 - Another example is provided by a pattern of infixation in vernacular English (recently popularized by Homer Simpson).
 - This pattern involves inserting the infix *-ma-* after the first two or three syllables of a word, as illustrated in (66a).
 - When the word itself is two syllables long, a schwa is epenthesized before the infix, as in (66b). (See Yu 2004 for details.)

(66) English Homeric infixation (Yu 2004)

a.	['wʌndə.ɪməfəl]	<i>wonderful</i>	b.	['ke.ɪməfəl]	<i>careful</i>
	['sæksəmə.fən]	<i>saxophone</i>		['ləjvəməli]	<i>lively</i>
	[,mɪsəmə'sɪpi]	<i>Mississippi</i>		['grɛjpəmə.fʌt]	<i>grapefruit</i>
	[,ʌnsəbmə'stænʃi.ejtəd]	<i>unsubstantiated</i>		['grɛjvəmə.jɑ:d]	<i>graveyard</i>
	[,mɛtətə.ɪmə'ɛjnɪən]	<i>Mediterranean</i>		['lɒ:nəməli]	<i>lonely</i>

- The notion that [ə] lacks place features is helpful, too, in explaining the fact that English vowels reduce to [ə] when unstressed (Chomsky & Halle 1968:111-6).
 - This reduction process is apparent in the following pairs.⁶⁴

⁶⁴ The relation between words in each pair is not always obvious, and it is apparent from misspellings that speakers often “guess” the underlying vowel, e.g., *to preduce*, *to ribel*, etc. In setting up the underlying full vowel which surfaces as schwa, speakers may draw on their awareness of related words, and on their

TONGUE BK/RT $\stackrel{\text{def}}{=} \{[\text{DOR}], [\text{FR}], [\text{HI}], [\text{LO}], [\text{RTR}]\}$

(67) *Reduction to schwa in English*

/i:/	r[ə]lay	cf. r[i]lay	/ɪ/	d[ə]scard	cf. d[i]scard
	r[ə]call	r[i]call		[ə]ncline	[i]ncline
/ej/	desol[ə]te	desol[e]te	/ɛ/	r[ə]cord	r[ɛ]cord
	separ[ə]te	separ[e]te		r[ə]bel	r[ɛ]bel
	altern[ə]te	altern[e]te		perf[ə]ct	perf[ɛ]ct
/o:/	pr[ə]test	pr[o]test	/ʌ/	s[ə]spect	s[ʌ]spect
	pr[ə]duce	pr[o]duce		s[ə]bjeɪt	s[ʌ]bjeɪt
/æ/	[ə]ddress	[æ]ddress	/ɑ/	pr[ə]gress	pr[ɑ]gress
	[ə]nalysis	[æ]nalyse		c[ə]mbine	c[ɑ]mbine

- In terms of our features, this reduction process can be seen as the loss (“delinking”) of features under the nucleus, leaving an empty nucleus.
- Finally, schwa is avoided altogether in many languages, such as Japanese, Spanish, Icelandic, Nuuchahnulth, and Tashlhiyt Berber.
 - The latter may well consider schwa a deficient vowel precisely because it lacks place features.
- Moreover, languages with schwa often avoid stressing it.⁶⁵
 - Again, languages may avoid stressed schwa because this vowel is deficient in having no place features (cf. Oostendorp 2000b).

knowledge of spelling. Such uncertainty and erratic learning is to be expected from a situation like this, in which schwa may correspond to any of /i:, ɪ, ej, ɛ, o:, ʌ, æ, ɑ/.

⁶⁵ For example, Salish languages abound in schwas but regular stress steers clear of these vowels (Kinkade 1998; Shaw et al. 1999). In the Northern Wakashan language Kwakw'ala, stress falls normally on the leftmost vowel (or nonglottalized syllabic sonorant) in the word, but stress shifts rightward to avoid falling on schwas (Boas 1947:218-9; Bach 1975; Lincoln & Rath 1980:20-1). Similarly, French assigns stress to the rightmost vowel in the word, except if that vowel is a schwa, in which case the before-last vowel is stressed (Walker 1975; 2001).

LARYNGEAL $\stackrel{\text{def}}{=} \{[\text{VOICE}], [\text{SPR. GL.}], [\text{CONSTR. GL.}]\}$

Laryngeal $\stackrel{\text{def}}{=} \{[\text{voice}], [\text{spr. gl}], [\text{constr. gl}]\}$

[VOICE]

- This feature distinguishes primarily between [voice] sounds which are produced with accompanying vocal fold vibration and voiceless sounds which do not involve any vibration of the vocal folds.⁶⁶
- In order for the vocal folds to vibrate, air needs to flow through them. In order for this to happen, the air pressure above the glottis (*supralaryngeal* or *supraglottal*) must be less than the air pressure below the glottis (*sublaryngeal* or *subglottal*).
 - It follows that the natural (*unmarked*) laryngeal state for obstruents ([stop] and [fricative]) is voicelessness, since by definition obstruents involve high supralaryngeal pressure.
 - We can express this relationship between voicing and sonorancy as a markedness tendency:

(1) *Voicing markedness*

* $\left[\text{voice}, \left\{ \begin{array}{l} [\text{stop}] \\ [\text{fricative}] \end{array} \right\} \right]$ “Obstruents must be voiceless.”

- Indeed, obstruents are exclusively voiceless in many languages, e.g., Hawaiian, Nuuchahnulth, etc.
- Still, many languages do allow voiced obstruents in addition to voiceless obstruents, against the above markedness constraint.⁶⁷

⁶⁶ Phonologists sometimes use the feature [slack vocal folds] in place of [voice], under the understanding that vocal folds vibrate (voicing) when they are “loose” [slack] and vocal folds do not vibrate (voiceless) when they are “taut” or “stiff” (non-[slack]) (Halle & Stevens 1971). The feature [slack] was proposed based on vocal cord modeling but has not been supported by experimental evidence in actual observation of speakers (Keating 1988).

LARYNGEAL $\stackrel{\text{def}}{=} \{[\text{VOICE}], [\text{SPR. GL.}], [\text{CONSTR. GL.}]\}$

(2) Voicing contrasts in obstruents

[stop]	{	p	p̂f	t	ts	t̩	tʃ	t̥	c	k	q
		[voice] b	b̂v	d	dz	d̩	dʒ	d̥	ɟ	g	g̥
[fricative]	{	ɸ	f	θ	s	ʈ	ʃ	ʂ	ç	x	χ
		[voice] β	v	ð	z	ɮ	ʒ	ʐ	ʝ	ɣ	ʁ

- The following word pairs illustrate [voice] contrasts among stops and fricatives in French:

(3) French

[pu]	'lice'	[fu]	'crazy'
[bu]	'end'	[vu]	'you'
[tu]	'all'	[su]	'penny'
[du]	'soft'	[zu]	'zoo'
[ku]	'neck'	[ʃu]	'cabbage'
[gu]	'taste'	[ʒu]	'cheek'

- The difficulty of implementing [voice] in obstruents can be vividly illustrated by Southern Barasano.
 - Recall that in this language, words are generally composed either of completely oral sounds or completely nasal sounds, as shown in the first two columns of (4).
 - A complication is now revealed in the third column of (4): voiced stops are prenasalized.

(4) Southern Barasano

<i>mãnõ</i>	'none'	<i>juka</i>	'vulture'	<i>ⁿdiro</i>	'fly'
<i>mĩnĩ</i>	'bird'	<i>wati</i>	'going?'	<i>wa^mba</i>	'come!'
<i>mãhãñĩ</i>	'comer'	<i>wesika</i>	'above'	<i>^mba^ŋgo</i>	'eater'
<i>ñãmõrõñĩ</i>	'ear'	<i>hikoro</i>	'tail'	<i>ho^ŋgoro</i>	'butterfly'
<i>ẽõnõ</i>	'mirror'			<i>ta^mboti</i>	'grass'

⁶⁷ Some languages, such as Nukuoro (Polynesian), reportedly have voiced stops but no voiceless ones. de Lacy (2002:287, n. 165) denies the existence of such languages, describing Nukuoro stops as voiceless unaspirated, perhaps much like [p, t, k] in English *s[p]an*, *S[t]an*, *s[k]an*, respectively.

LARYNGEAL $\stackrel{\text{def}}{=} \{[\text{VOICE}], [\text{SPR. GL.}], [\text{CONSTR. GL.}]\}$

- As Pulleyblank (1998:97) remarks, the prenasalized voiced stops of Southern Barasano, as exemplified in the third column of (4), raise several questions:
 - If prenasalization involves specification for the feature [nasal], why don't prenasalized stops initiate nasal harmony?
 - Why do prenasalized stops appear in otherwise fully oral words?
 - If prenasalization involves the assignment of [nasal] to a sound, then why don't the targeted sounds become fully nasal(ized)?
- Pulleyblank proposes to answer these difficult questions by relying on the notion of "nasal leakage" in voiced stops:⁶⁸
 - "Under the assumption that the input to the phonetic component is exactly as [*diro, waba, bago, hogoro*, etc.], there is a problem for the oral voiced stops. Phonetically, in order to maintain voicing there must be airflow from the lungs and through the larynx. With an oral stop, it is difficult to maintain such airflow because the supraglottal cavity is closed: as air flows up from the lungs, the supraglottal cavity will tend to increase in air pressure, counteracting the very airflow that is needed for voicing. To facilitate the realization of voicing during a stop, therefore, a mechanism must be found to facilitate maintenance of a pressure differential across the glottis. One way to maintain the airflow is to

⁶⁸ This phenomenon, as understood by Pulleyblank, highlights the distinction between phonology and phonetics. Gussenhoven and Kager (2001:1) give a helpful analogy for the relation between these two modules of our grammar:

[T]he relation between phonetics and phonology ... comes close to the relation between social perceptions of crimes and a Code of Criminal Law. The Code's definition of various types of crimes and the penalty each type carries ultimately reflect, to put it crudely, the feelings of the people. Also, the Code's development will reflect social change. Criminal codes will typically incorporate the changing perceptions of the general public, and will now begin to include articles devoted to the use of the Internet, for instance. But at the end of the day, what counts in a law suit is what is in the Criminal Code, not the feelings of the people. So it is with phonology. It is easy to show that lexical forms are frequently related to functional (ergonomic) considerations, and that the way the grammar processes them into surface representations will amount to a reasonable articulatory task for the speaker, while equally the acoustic result will enable the listener to recognise these forms with reasonable ease. However, ultimately we say things the way we do because our lexical representations are the way they are, and our phonological grammar is the way it is.

LARYNGEAL $\stackrel{\text{def}}{=} \{[\text{VOICE}], [\text{SPR. GL.}], [\text{CONSTR. GL.}]\}$

allow air to escape through the nasal cavity. Effectively, by allowing air to “leak” out through the nose, a speaker prevents air pressure from building up in the supraglottal cavity, and it becomes possible to maintain voicing during an oral closure.

- According to the proposal of nasal leakage, the prenasalized stops are not phonologically nasal at all. Phonologically, they are fully “oral”. This accounts for the fact that they do not trigger nasal spreading. It similarly accounts for why they occur in “oral” words and why they are not fully nasal.”
- Prenasalization in Southern Barasano highlights the phonetic difficulty of implementing voicing in obstruents. Given this difficulty, it is perhaps not surprising that in many languages, [voice] is distinctive only for obstruents in certain positions.
 - For example, German admits voiced obstruents, but not word-finally, as the following alternations illustrate:

(5) *Final devoicing in German*

a. Lo[p] ~ Lo[b]e ‘praise’ ~ pl.	cf. Perisko[p] ~ Perisko[p]e ‘periscope’ ~ pl.
b. Ra[t] ~ Rä[d]er ‘wheel’ ~ pl.	cf. Ra[t] ~ ra[t]en ‘advice’ ~ v.
c. Flu[k] ~ Flü[g]e ‘flight’ ~ pl.	cf. Vol[k] ~ Vol[k]e ‘people’ ~ dat.
d. akti[f] ~ akti[v]e ‘active’ ~ pl.	cf. Ho[f] ~ Hö[f]e ‘courtyard’ ~ pl.
e. Gra[s] ~ Grä[z]er ‘grass’ ~ ‘grasses’	cf. Ro[s] ~ Ro[s]e ‘horse’ ~ pl.

- More specifically, German grammar permits voiced obstruents in syllable-initial position, but not in syllable-final position, as the following alternations illustrate. (A period [.] indicates a syllable boundary; the following data are from Wiese (2000))

LARYNGEAL $\stackrel{\text{def}}{=} \{[\text{VOICE}], [\text{SPR. GL.}], [\text{CONSTR. GL.}]\}$

(6) Syllable-final devoicing in German

e[d]el ~ e.[d]les / e[t].les
 han[d]eln ~ Han.[d]lung / Han[t].lung
 schmu[g]eln ~ Schmu.[g]ler / Schmu[k].ler
 nör[g]eln ~ Nör.[g]ler / Nör[k].ler
 Ei[g]entum ~ Ei.[g]ner / Ei[k].ner / Ei[ç].ner
 Re[g]en ~ re.[g]nen / re[k].nen / re[ç].nen

- We might say that German has a *positional markedness constraint* against voiced obstruents in syllable-final position:

(7) Syllable-final voicing markedness

* $\left[\text{voice}, \left\{ \begin{array}{c} [\text{stop}] \\ [\text{fricative}] \end{array} \right\} \right]$. “Voiced obstruents are not permitted syllable-finally.”

- This constraint results in *positional neutralization*: lexical distinctions in [voice] are neutralized syllable-finally; underlying [voice] /b v d z ʒ g/ and underlying [voice]-less /p f t s ʃ k/ become identical as [p f t s ʃ k] in syllable-final position.
- Turning now to the possibility of a “floating” [voice] feature, consider first the case of *rendaku* in the native vocabulary of Japanese (Yamato). This process assigns [voice] to the initial consonant of the second member of a compound. For example:

(8) Rendaku in Japanese

ju ‘hot water’	+	[voice]	+	to:ɸu ‘tofu’	→	judo:ɸu ‘boiled tofu’
jo ‘night’	+	[voice]	+	sakura ‘cherry’	→	jozakura ‘blossoms at night’
ko ‘child’	+	[voice]	+	tanuki ‘raccoon’	→	kodanuki ‘baby raccoon’
mizu ‘water’	+	[voice]	+	seme ‘torture’	→	mizuzeme ‘water torture’

LARYNGEAL $\stackrel{\text{def}}{=} \{[\text{VOICE}], [\text{SPR. GL.}], [\text{CONSTR. GL.}]\}$

ori 'fold'	+	[voice]	+	kami 'paper'	→	origami 'origami'
jama 'mountain'	+	[voice]	+	tera 'temple'	→	jamadera 'mountain temple'
iro 'color'	+	[voice]	+	kami 'paper'	→	irogami 'colored paper'
take 'bamboo'	+	[voice]	+	saru 'net'	→	takezaru 'bamboo net'

- The feature [voice] which is assigned in this fashion is assumed to be “floating” a priori (Ito & Mester 1995; Avery & Idsardi 2001).
- Another example of floating [voice] comes from Aka, a Bantu C language spoken in the Central African Republic (Kosseke & Sitamon 1993; Roberts 1994; Akinlabi 1996).
 - In this language, the so-called “noun class 5” is marked by voicing the first consonant of the root, as shown in (9a). As Akinlabi (1996:286) explains, “the featural prefix is simply [voice].”

(9)	<i>Singular (class 5)</i>	<i>Plural (class 6)</i>	
a.	dèngé	mà-tèngé	'piercing tool'
	dòtò	mà-tòtò	'catridge'
	gásá	mà-kásá	'palm branch'
	gìnì	mà-kìnì	'fly'
	bòkí	mà-pòkí	'arch of the eyebrows'
	bàpùlàkà	mà-pàpùlàkà	'lung'
	βòndú	mà-φòndú	'goiter'
	βókó	mà-φókó	'hole'
b.	ɖú	mà-su	'cheek'
	ɖèlé	mà-sèlé	'lizard' (sp.)
c.	gòàlà	mà-gòàlà	'game of imitation'
	bèlèlè	mà-bèlèlè	'sound of a waterfall'
	ɖámà	mà-ɖámà	'mud'

LARYNGEAL $\stackrel{\text{def}}{=} \{[\text{VOICE}], [\text{SPR. GL.}], [\text{CONSTR. GL.}]\}$

- The examples in (9b) illustrate what happens with stems that begin with /s/.
 - As Akinlabi (1996:286) explains, Aka does not have [z], though it does have [d͡ʒ], so when [voice] is added to /s/, the result is not [z], which Aka happens to lack, but [d͡ʒ], its closest consonant.
 - In other words, when [voice] is added to /s/, so are [stop], [posterior] and [laminal].
- The examples in (9c) are provided to show that nothing happens in Class 5 when the stem-initial consonant is already [voice].
- Note, finally, that the independence of [voice] can also be motivated on the basis of evidence from speech errors. Here are some examples from Fromkin (1971):
 - *big and fat* >^e *pig and vat*
 - *call the girl* >^e *gall the curl*
 - *I'll wring his neck* >^e *I'll [ɹɪŋk] his [nɛg]*
 - *reveal* >^e *re[f]eal*
 - *defined* >^e *de[v]ined*
 - *referendum* >^e *re[v]erendum*
 - *documentation* >^e *documen[d]ation*
 - *Arthur Abrahamson* >^e *Ar[ð]ur ...*
 - *paradigms* >^e *para[t]igms*
 - *Bob McGord* >^e *... Mc[k]ord*
 - *vocal cords* >^e *...[g]ords*
 - *what does the course consist of* >^e *... [g]ourse ...*
 - *a real pussy cat* >^e *... [b]ussy ...*
 - *seeing is not believing* >^e *[z]eeing...*
 - *sit all day* >^e *[z]it...*

Assimilation/dissimilation

- [voice] assimilation is very common.
 - A well-known case of progressive assimilation is that observed with the regular verbal and nominal inflections in English, such as the plural *pot*+*[s]* vs. *pan*+*[z]*, *dog*+*[z]*, and the past tense *hack*+*[t]* (*hacked*) vs. *ban*+*[d]* (*banned*), *drag*+*[d]* (*dragged*).

LARYNGEAL $\stackrel{\text{def}}{=} \{[\text{VOICE}], [\text{SPR. GL.}], [\text{CONSTR. GL.}]\}$

- Because these suffixes always adjust to the voicing of the final sound of the stem, it is often suggested that they have no underlying voicing specification of their own.
- Many patterns of [voice] assimilation involve only obstruents ([stop], [fricative]) because [voice] is contrastive in these sounds.
 - For instance, word-final obstruents can contrast in voicing in Hungarian (10a). However, such a contrast is lost when another obstruent follows, since obstruents assimilate to the [voice] specification of a following obstruent (10b,c). Crucially, obstruents do not assimilate the voicing of a following sonorant (10d), nor do sonorants assimilate the [voice] specification of a following obstruent (10e).

(10) *Assimilation of obstruents in Hungarian* (Gnanadesikan 1997:22)

a. Contrasts in isolation

<i>nap</i>	[p.]	'day, sun'
<i>bab</i>	[b.]	'bean'

b. Voiceless assimilate to voiced

<i>tépdes</i>	[b.]	'tear, frequentive'
<i>lökdös</i>	[g.]	'shove, frequentive'

c. Voiced assimilate to voiceless

<i>megtalál</i>	[k.]	'find, perfective, 3p. sing.'
<i>rendkívul</i>	[t.]	'unusual'
<i>évbtized</i>	[f.]	'decade'

d. No change of obstruent before sonorant

<i>nappnyugta</i>	[p.]	'sunset 1'
<i>napplemente</i>	[p.]	'sunset 2'
<i>megmagyaráz</i>	[g.]	'explain, perfective, 3p. sing.'
<i>meglát</i>	[g.]	'catch sight of, perfective, 3p. sing.'

e. No change of sonorant before obstruent

<i>kénko</i>	[n.]	'sulfur stone'
<i>kéndioxid</i>	[n.]	'sulfur dioxide'
<i>nyommkod</i>	[m.]	'presses repeatedly'
<i>nyommda</i>	[m.]	'publishing press'

LARYNGEAL $\stackrel{\text{def}}{=} \{[\text{VOICE}], [\text{SPR. GL.}], [\text{CONSTR. GL.}]\}$

- The same state of affairs holds in Sudanese Arabic:

(11) *Assimilation of obstruents in Sudanese Arabic* (Gnanadesikan 1997:52)

- a. Contrasts in isolation

samak 'fish'

sabab 'reason'

- b. Obstruents are voiced before voiced

ʔagbar 'bigger/older' cf. *kabir* 'big/old'

ʔazba:b 'reasons' cf. *sabab* 'reason'

ʔabga:l 'mules' cf. *bagal* 'mule'

- c. Obstruents are voiceless before voiceless

ʔatfa:l 'children' cf. *tifil* 'child'

japsim 'to smile, imperf.' cf. *basam* 'to smile, perfect'

ʔaksa:m 'divisions' cf. *gisim* 'division'

- d. No change of obstruent before sonorant

ʔasma:k 'fish, pl.'

ʔagla:m 'pens'

- A famous case of [voice] assimilation in which sonorant consonants are ignored is provided by Russian (Halle 1959; Hayes 1984; Calabrese 1995).

- As shown in (12), obstruents assimilate to the [voice] specification of a following obstruent, as we saw in Hungarian (10) and Sudanese Arabic (11).

(12) *Voicing assimilation in Russian*

<i>o[t] ozera</i>	'from a lake'	<i>be[z] ozera</i>	'without a lake'
<i>o[t pt]its</i>	'from birds'	<i>be[s pt]its</i>	'without birds'
<i>o[d b]anka</i>	'from a bank'	<i>be[z b]anka</i>	'without a bank'
<i>o[d bd]enija</i>	'from a vigil'	<i>be[z bd]enija</i>	'without a vigil'
<i>o[d gr]exa</i>	'from a sin'	<i>be[z gr]exa</i>	'without a sin'
<i>o[t str]asti</i>	'from passion'	<i>be[s str]asti</i>	'without passion'
<i>o[t pr]agi</i>	'from Prague'	<i>be[s pr]agi</i>	'without Prague'

LARYNGEAL $\stackrel{\text{def}}{=} \{[\text{VOICE}], [\text{SPR. GL.}], [\text{CONSTR. GL.}]\}$

- The additional data in (13b) show that [voice] assimilation between obstruents can occur “at a distance”, across intervening sonorant consonants. That is, sonorants are transparent to voicing assimilation. This shows clearly that only *contrastive* instances of [voice] in obstruents ([stop], [fricative]) assimilate in Russian.

(13) Voicing assimilation in Russian

a.	<i>pe</i> [snʲ]	‘song’	<i>[tr]</i> avá	‘grass’
	<i>ži</i> [znʲ]	‘life’	<i>[dr]</i> ová	‘wood’
b.	<i>o</i> [t nr]avov	‘from morals’	<i>be</i> [z nr]avov	‘without morals’
	<i>o</i> [t mts]enska	‘from Mtsensk’	<i>be</i> [s mts]enska	‘without Mtsensk’
	<i>o</i> [t mst]itelʹnosti	‘from vindictiveness’	<i>be</i> [s mst]itelʹnosti	‘without vindictiveness’
	<i>o</i> [d mgl]i	‘from fog’	<i>be</i> [z mgl]i	‘without fog’
	<i>o</i> [d lg]uni	‘from the liar’	<i>be</i> [z lg]uni	‘without the liar’

- Modern Russian also has a well-known restriction whereby obstruents must be voiceless in syllable-final position, unless they are followed by a voiced obstruent, in which case both obstruents are obligatorily voiced (Gussmann 2002). Examples are given in (14).

- Note that the labial fricatives /v, vʲ/ behave like ordinary obstruents in this regard, as shown in several examples of (14).

(14)	<i>xleb</i>	[xlʲep]	‘bread’	<i>xleba</i>	[ˈxlʲeba]	‘gen. sg.’
	<i>drug</i>	[druk]	‘friend’	<i>drugu</i>	[ˈdrugu]	‘dat. sg.’
	<i>trav</i>	[traf]	‘grass, gen. pl.’	<i>trava</i>	[traˈva]	‘nom. sg.’
	<i>muž</i>	[muʃ]	‘husband’	<i>muža</i>	[ˈmuʒa]	‘gen. sg.’
	<i>mozg</i>	[mosk]	‘brain’	<i>mozgom</i>	[ˈmozgam]	‘instr. sg.’
	<i>nadežd</i>	[naˈdʲeʃt]	‘hope, gen. pl.’	<i>nadežda</i>	[naˈdʲeʒda]	‘nom. sg.’
	<i>trezv</i>	[tʲrʲesf]	‘sober, masc.’	<i>trezva</i>	[tʲrʲezˈva]	‘fem.’
	<i>kro</i> [fʲ]	[kʲ]ipit	‘blood is boiling’	<i>kro</i> [vʲ]	[d]vojanskaja	‘noble blood’
	<i>ro</i> [f]	[p]ustoj	‘empty ditch’	<i>ro</i> [v]	[g]lubokij	‘deep ditch’

- An obstruent is also obligatorily voiceless in syllable-final position even if it is followed by a voiced sonorant consonant, as shown in (15).

LARYNGEAL $\stackrel{\text{def}}{=} \{[\text{VOICE}], [\text{SPR. GL.}], [\text{CONSTR. GL.}]\}$

- Again, what is surprising is that /v, v^j/ pattern with sonorants in this regard: they fail to induce voicing in preceding obstruents, as shown by several examples in (15).

- (15)
- | | | | |
|-----------------|-------------------|----------------|---|
| <i>bra</i> [t] | [r] | <i>abotaet</i> | ‘the brother works’ |
| <i>vra</i> [k] | [n ^j] | <i>e spit</i> | ‘the enemy is not asleep’ |
| <i>kro</i> [f] | [l ^j] | <i>ětsja</i> | ‘blood is flowing’ |
| <i>uža</i> [s] | [v] | <i>ojny</i> | ‘horror of war’ |
| <i>vku</i> [s] | [v ^j] | <i>ina</i> | ‘the taste of wine’ |
| <i>svi</i> [st] | [v ^j] | <i>etra</i> | ‘whistle of the wind’ |
| <i>goro</i> [t] | [v] | <i>zjat</i> | ‘the town has been taken’ (cf. <i>goro</i> [d] <i>a</i> ‘town, gen. sg.’) |
| <i>sapo</i> [k] | [v] | <i>aš</i> | ‘your boot’ (cf. <i>sapo</i> [g] <i>om</i> ‘boot, instr. sg.’) |

- In other words, Russian labio-dental consonants are really two different phonological objects: they are [fricative] when located in syllable-final position, but they are sonorants when located in syllable-initial position.
 - Gussmann (2002:196) calls Russian [v] as “segmental double-agent”: “[v], although pronounced as a labio-dental spirant, patterns phonologically with sonorants. The expression ‘patterns with’ is a circumlocution: to say that a segment can ‘pattern with’ sonorants is simply to say that it is a sonorant itself. We must, then, nail our colors to the mast and say that in some contexts what sounds like a spirant is a sonorant.”
- Finally, an example of a language that spreads only the feature [voice] is provided by Ukrainian (Zilyns'kyi et al. 1979; Gnanadesikan 1997:43; Cho 1999).
 - In this language, [voice] spreads between obstruents (16a), but voicelessness does not (16b).

(16) Assimilation of obstruents in Ukrainian

a. Voiceless obstruent voices

/borot ^j -ba/	[d ^j .]	‘struggle’
/jak ^j -ze/	[g.]	‘how’
/os ^j -de/	[z ^j .]	‘here/there’

LARYNGEAL $\stackrel{\text{def}}{=} \{[\text{VOICE}], [\text{SPR. GL.}], [\text{CONSTR. GL.}]\}$

b. Voiced obstruent unaffected

/fvy~~d~~ko/ [d.] 'quick'
 /v^hi~~d~~-pov^hidajte/ [d.] 'answer (imper.)'

- A case of *dissimilation* of [voice] is found in Japanese. Recall from above that in the native vocabulary of Japanese (Yamato), [voice] is assigned to the initial consonant of the second member of a compound, as illustrated in (17a).
- This process ("rendaku") is blocked (or undone) in (17b). This is due to a kind of dissimilation on [voice]: no more than one voiced obstruent is permitted in each native Japanese root (i.e., there are no forms like **dabi*, **gugi*, etc.). Crucially, unmarked instances of [voice] in vowels and sonorant consonants fail to trigger [voice] dissimilation.

(17) Compounds in Japanese

a.	jo 'night'	+	[voice]	+	sakura 'cherry'	→ jozakura	'blossoms at night'
	ko 'child'	+	[voice]	+	tanuki 'raccoon'	→ kodanuki	'baby raccoon'
	mizu 'water'	+	[voice]	+	seme 'torture'	→ mizuzeme	'water torture'
	ori 'fold'	+	[voice]	+	kami 'paper'	→ origami	'origami'
b.	mori 'serve'	+	[voice]	+	soba 'soba'	→ morisoba	'soba serving'
	iro 'white'	+	[voice]	+	tabi 'tabi'	→ irotabi	'white tabi'
	ore 'broken'	+	[voice]	+	kugi 'nail'	→ orekugi	'broken nail'
	kami 'heaven'	+	[voice]	+	kaze 'wind'	→ kamikaze	'divine wind'

LARYNGEAL $\stackrel{\text{def}}{=} \{[\text{VOICE}], [\text{SPR. GL.}], [\text{CONSTR. GL.}]\}$

Postnasal voicing

- *Postnasal voicing*, the addition of [voice] to [stop] or [fricative] after [nasal], is very common.
 - For example, in Japanese an obstruent regularly becomes voiced after a nasal. Thus the gerundive suffix *-te* (e.g., *mi-te* ‘seeing’) becomes *-de* after a nasal (e.g., *jon-de* ‘reading’, *jin-de* ‘dying’).
 - Similarly, in the Puyo Pungo dialect of Quechua, the genitive suffix *-pa* (e.g., *sinik-pa* ‘porcupine’s’) changes to *-ba* after a nasal (e.g., *kam-ba* ‘yours’, *hatum-ba* ‘the big one’s’).
 - The same pattern can be observed in (18) from Zoque, a Mixe-Zoquean language of Mexico (Wonderly 1965).

(18)	<i>tih-u</i>	‘he arrived’	<i>min-u</i>	‘he came’
	<i>tih-pa</i>	‘he arrives’	<i>min-ba</i>	‘he comes’
	<i>tih-keʔtu</i>	‘he arrived again’	<i>min-geʔtu</i>	‘he came again’

- Hayes & Stivers (1995) remark that languages with postnasal voicing do not show a general voicing pattern after sonorants. For example, in Wembawemba, a Pama-Nyungan language of Australia, a [stop] onset does not become [voice] after a vowel or a liquid, though it does so after a nasal:

(19) *Wembawemba* (Hercus 1986)

<i>takʌ</i> (* <i>tagʌ</i>)	‘to hit’	<i>jandin</i> (* <i>jantin</i>)	‘me’
<i>milpʌ</i> (* <i>milbʌ</i>)	‘to twist’	<i>panbar</i> (* <i>panpar</i>)	‘shovel’

[SPREAD GLOTTIS]

- Sounds produced with the vocal folds held wide apart (“glottal abduction”), such as [h] and aspirated consonants, are [spread glottis] (Halle & Stevens 1971).⁶⁹

⁶⁹ FYI, vocal folds may become paralyzed in spread position (“bilateral adductor vocal fold paralysis”), which may result in aphonia.

LARYNGEAL $\stackrel{\text{def}}{=} \{[\text{VOICE}], [\text{SPR. GL.}], [\text{CONSTR. GL.}]\}$

- The following word pairs from Standard Chinese illustrate lexical distinctions based on [spread glottis]. (Aspirated obstruents are transcribed with the superscript [^h].)

(20) *Some [spread glottis] contrasts in Chinese* (all vowels are high level tone)

[p ^h a]	‘flower’	[t ^ʰ ʰa]	‘to stick in’
[pa]	‘eight’	[t ^s a]	‘to pierce’
[t ^h a]	‘it, he/she’	[t ^ʰ ʰa]	‘to dig fingernail into’
[ta]	‘to put up, build’	[t ^s a]	‘to add’
[t ^ʰ ʰa]	‘to wipe’	[k ^h a]	‘to scrape with knife’
[tsa]	‘take food with tongue’	[kai]	‘ought to, must’

- Standard Chinese has a full series of fricatives [f, s, ʃ, ɕ, x] but these do not contrast in [spread glottis].
- Standard Chinese is typical in this regard—in having distinctive [spread glottis] among its stops but not among its fricatives.
- Contrastive aspiration in fricatives is extremely rare.
 - A possible case comes from Burmese (a.k.a. Myanmar; Sino-Tibetan, Burma).
 - Many—but not all—speakers of this language make a three-way contrast, presumably [fricative] vs. [fricative, voice] vs. [fricative, spread glottis],
 - E.g., sà ‘hungry’ vs. zà ‘lace’ vs. s^hà ‘letter’ (Ladefoged & Maddieson 1996:179).
- Burmese is also well-known for distinguishing voiced nasals from voiceless ones, as shown below.
 - The basis for this distinction is assumed to be [spread glottis].
 - As Ladefoged and Maddieson (1996:111) remark: “These voiceless nasals usually have an open glottis for most of the articulation.”

LARYNGEAL $\stackrel{\text{def}}{=} \{[\text{VOICE}], [\text{SPR. GL.}], [\text{CONSTR. GL.}]\}$

(21) *Burmese* (Ladefoged & Maddieson 1996:111)

	<i>Bilabial</i>	<i>Alveolar</i>	<i>Palatal</i>	<i>Velar</i>	<i>Labialized-alveolar</i>
<i>Voiced</i>	mă 'hard'	nă 'pain'	ɲă 'right'	ŋă 'fish'	n ^w ă 'cow'
<i>Voiceless</i>	m̥ă 'notice'	n̥ă 'nose'	ɲ̥ă 'considerate'	ŋ̥ă 'borrow'	n̥ ^w ă 'peel'

- The feature [spread glottis] also presumably distinguishes between [ɰ] (also written [w̥] or [w^h]) and [w], which are two contrastive phones in many dialects of English, e.g. Scottish:

(22) *Scottish English: aspirated [ɰ] vs. plain [w]* (Davenport & Hannahs 1998:110)

[mɛɪɪz]	'whales'	[wɛɪɪz]	'Wales'
[ɰɪɪʃ]	'which'	[wɪɪʃ]	'witch'
[mɛðɪɪ]	'whether'	[wɛðɪɪ]	'weather'
[ɰaɪɪ]	'white'	[waɪɪ]	'wipe'
[əwɪɪ]	'awhile'	[əwɔɪ]	'awash'
[maɪɪ]	'why'	[weɪɪ]	'way'
[ɰɪɪp]	'whip'	[wɔɪnt]	'want'

- It is worth noting here that aspiration plays an important role in English *phonetics* (if not *phonology*):⁷⁰
 - at the beginning of words and stressed syllables, voiceless stops (and immediately following consonants, if any) are phonetically aspirated, apparently to enhance their distinction from voiced stops.
 - This enhancement is so strong that unstressed vowels devoice between voiceless stops, as in [p^hɛ^thɛɪrɔ] 'potato'.
 - No comparable aspiration occurs after /s/, because stops do not contrast for [voice] in this context.

⁷⁰ Iverson & Salmons (1995) argue that [spread glottis], rather than [voice], is the key lexical feature of Germanic.

LARYNGEAL $\stackrel{\text{def}}{=} \{[\text{VOICE}], [\text{SPR. GL.}], [\text{CONSTR. GL.}]\}$

(23) *Aspirated vs. unaspirated allophones in English*

$[\text{p}^{\text{h}}]an$	vs.	$s[\text{p}]an$
$[\text{t}^{\text{h}}]op$	vs.	$s[\text{t}]op$
$[\text{k}^{\text{h}}]an$	vs.	$s[\text{k}]an$
$p[\text{ɪ}]ant$	vs.	$s[\text{ɪ}]ant$
$p[\text{ɔ}]oud$	vs.	$sh[\text{ɔ}]oud$
$p[\text{j}]ure$	vs.	$sp[\text{j}]ew$
$qu[\text{w}]een$	vs.	$squ[\text{w}]eeze$

- Consider now the notion that [spread glottis] and [voice] belong to a natural class called “laryngeal” (Lombardi 1994).⁷¹
 - Evidence of their class behavior comes from a common form of reduction whereby laryngeal distinctions are suppressed in syllable-final position.
 - For example, many languages oppose aspirated, voiced and plain stops $[\text{p}^{\text{h}}, \text{b}, \text{p}]$ in syllable-initial position but limit the syllable-final position to just $[\text{p}]$. One such language is Thai.

(24) *Laryngeal contrasts in Thai*

$[\text{p}^{\text{h}}\text{a}:]$ ‘cloth’	$[\text{ba}:]$ ‘crazy’	$[\text{panja}]$ ‘brains’	$[\text{ri:p}]$ ‘hurry’
$[\text{p}^{\text{h}}\text{j}\text{a}:]$ ‘title’	$[\text{bil}]$ ‘Bill’	$[\text{pen}]$ ‘alive’	$[\text{sip}]$ ‘ten’
$[\text{p}^{\text{h}}\text{r}\text{e}:]$ ‘silk’	$[\text{bru}:]$ ‘fast’	$[\text{pl}\text{a}:]$ ‘fish’	$[\text{rap}]$ ‘take’

- As Kenstowicz (1994:160) reasons: “Given the feature tree, this sound change can be described as the delinking of the Laryngeal articulator and replacement with a default $[-\text{spread gl}, -\text{voiced}]$ specification. Evidence that such neutralizations are to be described as delinking rather than as simply a plus-to-minus change in the laryngeal features is the fact that the delinked material can sometimes show up at another position in the string.”
 - This is a general trait of distinctive features, known as *stability*.

⁷¹ Other natural classes include “liquid” $\{[\text{lateral}], [\text{rhotic}]\}$, “obstruent” $\{[\text{stop}], [\text{fricative}], [\text{strident}]\}$, and “(primary) place” $\{[\text{labial}], [\text{coronal}], [\text{dorsal}]\}$.

LARYNGEAL $\stackrel{\text{def}}{=} \{[\text{VOICE}], [\text{SPR. GL.}], [\text{CONSTR. GL.}]\}$

- For example, in Yoruba when a nasal vowel is deleted, the nasality is usually transferred to an adjacent vowel. Here is Pulleyblank (1998:90):

[l]n the phrase [kpí olú] ‘divide mushrooms’, vowel deletion optionally applies to delete the nasalized vowel of the first word (the verb). When this deletion takes place, the nasality of the deleted vowel is not lost; on the contrary, it survives on the initial vowel of the following noun: [kpólú].

- A similar pattern occurs in Québec French, which also has a process of vowel coalescence: two vowels merge to form a long vowel.
 - As the data in (25a-f) make clear, the first vowel deletes before the second one, which is lengthened.
 - Crucially, data such as (25f,g) reveal that while the first vowel deletes in coalescence, its feature [nasal] survives on the remaining vowel.
 - As Dumas (1994:114) states: “the feature of nasality ... is absolutely immune to any reduction and is systematically transferred to the vowel that remains” (my translation).

(25) *Vowel coalescence in Québec French* (Prunet 1992)

e a	[isõta:truve]	<i>ils sont allés (l)a trouver</i>	‘they went to see her’
i e	[sto:se:kœ:rã]	<i>c’est aussi écoeurant!</i>	‘it’s just disgusting’
e o	[jã:nepo:so:tã]	<i>il en est passé autant</i>	‘so many went by’
i ã	[sa:prã:syk]	<i>ça a pris en sucre</i>	‘it turned into sugar’
e ã	[ʒe:tãpefe]	<i>j’ai été empêché</i>	‘I was prevented’
ẽ e	[sa:bẽtsi:re]	<i>ça a ben étiré</i>	‘it stretched well’
ẽ a	[lẽmulã:lave]	<i>le moulin à laver</i>	‘the washing-machine’

LARYNGEAL $\stackrel{\text{def}}{=} \{[\text{VOICE}], [\text{SPR. GL.}], [\text{CONSTR. GL.}]\}$

- A possible example of stability with [spread glottis] is offered by Vaux (1998), who claims that [s] in Proto-Indo-European was [spread glottis], and that when [s] deleted in Pali, its [spread glottis] feature survived on an adjacent sound.⁷²

(26)	<i>Sanskrit</i>	<i>Pali</i>	
	<i>skand^há-</i>	<i>k^hand^ha-</i>	‘shoulder’
	<i>stána-</i>	<i>t^hana-</i>	‘breast’
	<i>sparfa</i>	<i>p^has:a-</i>	‘touch’
	<i>hásta-</i>	<i>hat:^ha-</i>	‘hand’
	<i>jaṣṭí-</i>	<i>jaṭ:^hi-</i>	‘pole’

- Here is Vaux (1998:504): “What is relevant for our purposes is the fact that the laryngeal features of the delinked segments survive. In *stána-* ‘breast’, for example, the initial *s* delinks, but the floating [+spread] specification of the *s* then attaches to the following segment, producing a voiceless aspirate.”
- Note that Vaux (1998:497) crucially assumes that “the unmarked specification for fricatives is [+spread].”

Debuccalization

- Vaux’s (1998) view that voiceless fricatives have the feature [spread glottis] appears to be supported by the phenomenon of **debuccalization** (literally, loss of oral features).⁷³
 - When debuccalization applies to fricatives, typically in syllable coda position, the result is frequently [h].
 - The following examples are from variety of Spanish spoken in northern Dominican Republic (Piñeros 2002:7).

⁷² Vaux argues that, despite appearances, [s] is not part of the same onset as [p, t, k] in Sanskrit. It is “appended”.

⁷³ Trask (1996:106) recommends the term ‘deoralization’ — “any phonological process in which a consonant segment loses its oral articulation.”

LARYNGEAL $\stackrel{\text{def}}{=} \{[\text{VOICE}], [\text{SPR. GL.}], [\text{CONSTR. GL.}]\}$

(27) *Northern Rustic Dominican Spanish*⁷⁴

/pes.'ka.ðo/	→	[peh.'ka.ðo]	'fish'
/a.'bis.pa/	→	[a.'βih.pa]	'whasp'
/a.'ros/	→	[a.'roh]	'rice'
/'mos.ka/	→	['moh.ka]	'fly'
/ðif.'te.ria/	→	[ðih.'te.rja]	'diphtheria'
/af.ga.nis.'taN/	→	[ah.ga.nih.'taN]	'Afghanistan'
/re.'lox/	→	[re.'loh]	'watch'

- But another interpretation is that when [fricative] codas lose their place features ([labial], [coronal], [dorsal]), we are left with a placeless [fricative], which is a possible representation for [h].
 - Assimilation and stability effects (described below) still argue that [h] is [spread glottis].
- The before-last example of (27) is transcribed with [N], which is not to be confused with uvular [ŋ].
- [N] is a **placeless glide** which is found in Indic languages.
 - Sanskrit grammarians described this glide as an unmodified nasal following a vowel and accordingly referred to it as *anusvara*, literally “after sound” (anu+svara).
 - It involves no particular articulator except the soft palate, which is lowered.
- The so-called “mora nasal” of Japanese, e.g. *hoN* ‘book’, is also arguably a nasal glide (Catford 1977; Vance 1987).
- Nasal glides are common in some varieties of Spanish, where they occur before nonstops or word-finally (D’Introno & Sosa 1984:2-3).

⁷⁴ Piñeros points out that [h] optionally deletes in this variety.

LARYNGEAL $\stackrel{\text{def}}{=} \{[\text{VOICE}], [\text{SPR. GL.}], [\text{CONSTR. GL.}]\}$

(28) *Nasal glides in Northern Rustic Dominican Spanish* (Piñeros 2002).⁷⁵

- a. [oj.ɬeN.sja] ‘proper name’
 [eN.fej.mo] ‘sick’
 [saN.ha] ‘ditch’
 [oN.ra.ðo] ‘honest’
 [eN.la.se] ‘link’
- b. [ra.ɬoN] ‘mouse’
 [se.ɣuN] ‘according to’
 [bweN] ‘good’

- The nasal glide here sounds like “a very weak and ‘reduced’ velar nasal [ŋ] (Jimenez Sabater 1975:117).
- Incidentally, even [spread glottis] /h/ may be specified [nasal].
 - For example, Kwangali, a Kovango (Bantu) language spoken in Namibia, has nasalized h’s which are written <nh>, e.g. *nhonho* [h̃oŋho] ‘devil’s horn’.

(29) *Kwangali* (Ladefoged & Maddieson 1996:132)

[h̃oŋho]	‘devil’s thorn’	cf.	[hompɑ]	‘chief’
[h̃uŋhwa]	‘fowl’		[huma]	‘bite’
[muŋho]	‘kind of spear’		[muhona]	‘master’
[koŋhi]	‘beneath, under’		[ruhunga]	‘feather’

- Note, finally, that the two laryngeal features [spread glottis] and [voice] can combine in a single syllable onset or coda, yielding a voiced aspirate.
 - It is widely believed that Proto-Indo-European had voiced aspirates, which changed to simple voiced consonants in Proto-Germanic. Compare the following cognates in Sanskrit and English.⁷⁶

⁷⁵ Piñeros points out that in this variety, N is sometimes realized as [ŋ] or else simply deleted, in which case the [nasal] feature survives in the preceding nucleus —an instance of ‘stability’.

⁷⁶ The change PIE **b^h*, **d^h*, **g^h* > Germanic *b*, *d*, *g* was accompanied by another change: PIE **b*, **d*, **g* > Gc *p*, *t*, *k*, which is evident by comparing French and English cognates. (Both changes are part of “Grimm’s Law”.)

LARYNGEAL $\stackrel{\text{def}}{=} \{[\text{VOICE}], [\text{SPR. GL.}], [\text{CONSTR. GL.}]\}$

(30)	SANSKRIT	ENGLISH
a.	<i>b^hrá:tar</i>	<i>brother</i>
	<i>b^hára-</i>	<i>bear</i>
b.	<i>d^ha:-</i>	<i>do, did, deed</i>
c.	<i>hamsa < *g^h</i>	<i>goose</i>

- Voiced aspirates survive in Indic languages. For example, Sindhi differentiates onsets that are [stop] versus [stop, voice] versus [stop, spread glottis] versus [stop, voice, spread glottis] (Ladefoged & Maddieson 1996:83):
tāru ‘bottom’ vs. *dāru* ‘door’ vs. *t^hāru* ‘trunk of body’ vs. *d^hāru* (district name)

Assimilation/dissimilation

- A first example of [spread glottis] assimilation is provided by the Seville dialect of Spanish (Vaux 1998:504, Javier Martin-Gonzales, personal communication).
 - Here syllable-final [s] not only regularly debuccalizes to [h], as it does in many dialects of Spanish (see, e.g., (27) on p. 177), it also causes a following stop to become aspirated, e.g., *los padres* ‘the parents’ is pronounced [loh p^haðreh].⁷⁷

FRENCH	ENGLISH	FRENCH	ENGLISH
<i>genou</i>	<i>knee</i>	<i>dent</i>	<i>tooth < tanθ</i>
<i>grain</i>	<i>corn</i>	<i>deux</i>	<i>two</i>

⁷⁷ The glottal [h] that results from syllable-final /s/ actually deletes before pause or a consonant in Seville Spanish, though not without aspirating a following stop —a “stability” effect (Lévesque 1992:17-8; Dobrovolsky & Shaw 1993).

<i>después</i>	[de'p ^h we]	‘after’
<i>más pobre</i>	[ma'p ^h oβre]	‘poorer’
<i>lo hiciste</i>	[loi'sit ^h e]	‘you did it’
<i>los tíos</i>	[lo't ^h io]	‘the uncles’
<i>escuchar</i>	[ek ^h u'tʃar]	‘to listen’
<i>dos cosas</i>	[do'k ^h osa]	‘two things’

LARYNGEAL $\stackrel{\text{def}}{=} \{[\text{VOICE}], [\text{SPR. GL.}], [\text{CONSTR. GL.}]\}$

- Ancient Greek is an example in which the features [voice] and [spread glottis] pattern together in assimilation as a result of their grouping as “laryngeal” (Kenstowicz 1994).
 - The data in (31) illustrate that the laryngeal features of a suffix-initial stop spread to a preceding stop, which thereby loses its own lexically-specified laryngeal features.

(31) Ancient Greek

[tri:b-]	‘rub’	[tri:b-o:]	-o:	[tɛtri:p-tai]	-tai
[grap ^h -]	‘write’	[grap ^h -o:]	1s.ind	[gɛgrap-tai]	3s.perf.ind.med-pass
[pɛmp-]	‘send’	[pɛmp-o:]		[ɛpɛmp ^h -t ^h ɛ:n]	-t ^h en
[tri:b-]	‘rub’	[tri:b-o:]		[ɛtri:p ^h -t ^h ɛ:n]	1s.sg.aorist.ind.pass
[klept-]	‘steal’	[klept-o:]		[kleb-dɛ:n]	-den
[grap ^h -]	‘write’	[grap ^h -o:]		[grab-dɛ:n]	‘by’ (adv)

- Similarly, according to Lombardi (1991a:140) [voice] and [spread glottis] both spread in Sanskrit, e.g. (32).⁷⁸
 - Note that unlike Greek, Sanskrit has voiced aspirates, and its laryngeal assimilation is progressive.

(32) Sanskrit

<i>bud^h-ta</i>	→	<i>bud^hd^ha</i>	(no glosses provided)
<i>lab^h-ta</i>	→	<i>lab^hd^ha</i>	
<i>rund^h-t^has</i>	→	<i>rund^hd^has</i>	

- Ancient Greek and Sanskrit also provide a famous example of *dissimilation* of [spread glottis].
 - As shown below, [spread glottis] stops deaspirated historically when they were followed by another [spread glottis] stop in the same word.

⁷⁸ Lombardi (ib.) explains that C^hC^h is always realized phonetically as CC^h.

LARYNGEAL $\stackrel{\text{def}}{=} \{[\text{VOICE}], [\text{SPR. GL.}], [\text{CONSTR. GL.}]\}$

- This effect is known as “Grassmann’s Law”, after the mathematician-physicist-philologist Hermann Grassmann (1809-1877) who discovered it.

(33) *Grassmann’s Law* (Lombardi 1991b)

a. GREEK

$p^h ep^h uka$	→	$pep^h uka$	‘converted’
$t^h it^h e:mi$	→	$tit^h e:mi$	‘I put’
$t^h rik^h os$	→	$trik^h os$	‘hair’
$t^h rep^h o$	→	$trep^h o$	‘I rear’

b. SANSKRIT

$b^h ab^h u:va$	→	$bab^h u:va$	‘became’
$b^h od^h ati$	→	$bod^h ati$	‘he/she knows’
$b^h ub^h od^h a$	→	$bubod^h a$	‘he/she knew’
$d^h ad^h a:mi$	→	$dad^h a:mi$	‘I put’

[CONSTRICTED GLOTTIS]

- The feature [constricted glottis] (“glottal adduction”)⁷⁹ is widely assumed to be the phonological feature shared by:⁸⁰
 - ejectives
 - implosives
 - glottalized or laryngealized (“creaky”) sonorants
 - glottal stop.

⁷⁹ FYI, vocal folds can also become paralyzed in this position; this is a life-threatening condition (“bilateral abductor paralysis”) which requires immediate tracheostomy!

⁸⁰ These are sound types which go by a wide variety of names in the literature. For example, ejectives alone have been referred to variously as glottalized, glottalic, abruptive, checked, popped, with supraglottal expiration, with glottal occlusion, evulsive, with glottalic pressure, glottalic egressive, glottal stop sound, glottocclusive, glottal occlusive, recursive, etc! (Fallon 2002:6).

LARYNGEAL $\stackrel{\text{def}}{=} \{[\text{VOICE}], [\text{SPR. GL.}], [\text{CONSTR. GL.}]\}$

- Thus [constricted glottis] has a variety of phonetic implementations across languages and even within languages.
 - For instance, in the Chadic language Hausa, [constricted glottis] is implemented as *creaky implosion* in bilabial and alveolar stops (34a), as *ejection* (postglottalization) in alveolar fricatives and velar stops (34b), and as *preglottalization* in glides (34c):

(34) Hausa (Ladefoged & Maddieson 1996:86)

	GLOTTALIZED		PLAIN
a.	[ɓa:tà] 'spoil'	[ba:tà:] 'line'	
	[ɗa:mè:] 'tighten (belt)'	[da:mè:] 'mix thoroughly'	
b.	[s'a:rà:] 'arrange'	[sa:rà:] 'cut'	
	[k'a:rà:] 'increase'	[ka:rà:] 'put near'	
	[k ^w a:rà:] 'shea nut'	[k ^w a:rà:] 'pour'	
c.	[ʔja:] 'daughter'	[ja:] 'he' [comp.]	

- Like the other laryngeal features, [constricted glottis] can be very restricted in distribution in some languages.
 - In the Wakashan language Nuuchah-nulth (Sapir & Swadesh 1939; Howe & Pulleyblank 2001), for instance, ejectives occur only in syllable onset position.
 - This is exemplified in the following table where examples are given of word-initial ejectives, intervocalic ejectives and postconsonantal/prevocalic ejectives. Crucially, there are no examples of either word-final or preconsonantal ejectives in Nuuchah-nulth.

(35) Surface distribution of ejectives

a.	WORD-INITIAL	[p'u:ʔi] 'halibut'	[tʃ'a.ʔak] 'water'
		[t'uh.ts'i.ti] 'head'	[k'af.k ^w a.ʔjap] 'put things away'
		[ts'a.ʔak] 'river'	[k ^w i.sa:] 'snowing'
		[tʃ'u.pa:] 'sunny'	
b.	INTERVOCALIC	[tu.p'aʔ] 'sea, ocean'	[k ^w a.tʃaq] 'sea otter belt'
		[ʔa.t'a] 'thick'	[wi.k'atʃ] 'not'
		[q ^w a.ja.ts'i:k] 'wolf'	[t'a.k ^w as] 'gills'
		[ʔi.tʃ'a.ʔap] 'to lift'	

LARYNGEAL $\stackrel{\text{def}}{=} \{[\text{VOICE}], [\text{SPR. GL.}], [\text{CONSTR. GL.}]\}$

c. POSTCONSONANTAL	[ʔaphs.p'a.t'u]	'bird wing'	[hi.ta:q'as]	'woods, forest'
	[ts'im.t'u:]	'squirrel'	[tʰ'as.k'as.ʔi]	'the surface is smooth'
	[tʰuʔ.ts'u:ʔi]	'it is clean'	[ʔin.kʷ'aʰs]	'lamp, ceiling light'
	[ʔim.tʃ'a:p]	'to play'		

- Ejectives contrast with sequences of a consonant followed by a glottal stop:

(36) *Contrasts between glottalized obstruents and clusters with [ʔ]*

VC'V	[t'a.ʔja.ts'u]	'fish line (straight down fishing)'
VCʔV	[ʔaps.ʔin]	'abalone'

- Other possible combinations of ejectives with a glottal stop are not possible because ejectives cannot occur preconsonantly (explaining the absence of VCʔV) and glottal stops cannot occur except syllable-initially/prevocally (explaining the absence of VʔCV and VʔC'V).
- The distribution of ejectives is faithfully repeated by the glottalized sonorants in Nuu-chah-nulth. As with ejectives, glottalized sonorants occur only in prevocalic/syllable-initial position.
 - Examples are given in (37) of word-initial, intervocalic and postconsonantal but prevocalic glottalized sonorants. As with ejectives, there are no examples of either word-final or preconsonantal glottalized sonorants.

(37) *Surface distribution of glottalized sonorants*

a. WORD-INITIAL	[ʔmi.tʰa:]	'raining'
	[ʔnu.ʔwi:q.su.ʔi]	'the father'
	[ʔja.ʔi.si]	'butter clams'
	[ʔwa.saq.ʔi]	'cough'
b. INTERVOCALIC	[ʔja.ʔma]	'salal berry'
	[ki.ʔnu.tsak]	'blue'
	[kʷi.ʔjas]	'snow on the ground'
	[ʔi.ʔwah.mis]	'cloud'

LARYNGEAL $\stackrel{\text{def}}{=} \{[\text{VOICE}], [\text{SPR. GL.}], [\text{CONSTR. GL.}]\}$

c. POSTCONSONANTAL	[ʔu:ʈʃ.ʔmu:p]	'sister'
	[ma.maʈ.ʔni]	'European, white person'
	[wik.ʔju.ʔatʰs]	'I have not'
	[ʈʰat.ʔwa:]	'paddle a canoe'

- Again like the ejectives, a contrast is observed between glottalized sonorants and clusters with a glottal stop:

(38) *Contrasts between glottalized sonorants and clusters with [ʔ]*

VRV	[qin.ħa:ʔma]	'egg'
VRʔV	[ʔum.ʔi:q.su]	'mother'

- Finally, it is important to focus on glottal stops themselves.
 - It has been noted that glottal stops occur only syllable-initially/prevocally in Nuu-chah-nulth.
 - Some examples have been seen already, but here we add to those to show the full range of contexts for a glottal stop.

(39) *Surface distribution of glottal stop*

a. WORD-INITIAL	[ʔaħ.ku:]	'here'
	[ʔi:ħ]	'big'
	[ʔutʃ.qak]	'foggy'
	[ʔu:f.tup]	'something'
b. INTERVOCALIC	[ʃa.ʔuk]	'lake'
	[na.ʔa:]	'hear'
	[hu:ʔi:ʔaħ]	'Ohiaht tribe'
	[hi.ʔi:s]	'there on ground'
c. POSTCONSONANTAL	[ʈʰ'a:ʈʃ.ʔa:ʈ]	'thimbleberry'
	[ʈʃim.ʔiʈ]	'bed'
	[ʔust.ʔiʈ]	'floor, downstairs'
	[muʃ.ʔa.sum]	'door'

LARYNGEAL $\stackrel{\text{def}}{=} \{[\text{VOICE}], [\text{SPR. GL.}], [\text{CONSTR. GL.}]\}$

- As with both ejectives and glottalized sonorants, a glottal stop may not occur either word-finally or before a consonant.
 - To account for the parallel behavior of ejection in obstruents, creak in sonorants (glottalization is realized as creakiness in the initial portion of glottalized sonorants) and a plain glottal stop, a single unified feature of [constricted glottis] is needed.
 - The crucial factor in determining the distribution of [constricted glottis] in Nuu-chah-nulth is syllabic position. We may say that Nuu-chah-nulth has a *positional markedness constraint* against glottalization in syllable-final position:
- (40) *Syllable-final glottalization markedness*
- *[constricted glottis] . “Glottalization is not permitted syllable-finally.”
- So far, no mention has been made of glottalized fricatives. When it accompanies a fricative, the feature [constricted glottis] is normally realized as ejection.
 - Glottalized fricatives are extremely rare crosslinguistically but are commonly found in Tlingit, a Dene-Yeniseian language spoken in British Columbia, the Yukon and Alaska (Ladefoged & Maddieson 1996:179):

(41) *Tlingit*

	ALVEOLAR	VELAR	ROUNDED VELAR	UVULAR	ROUNDED UVULAR
PLAIN	[sa:] 'be narrow'	[xa:t] 'protrude'	[x ^w a:s] 'hang'	[χe:t] 'multiply'	[χ ^w a:l] 'shake, tremble'
EJECTIVE	[s'a:] 'claim'	[x'a:t] 'file'	[x ^w a:s'k] 'be numb'	[χ'e:t'] 'gnaw, chew'	[χ ^w a:s'] 'become bald'

- Turning now to the possibility of a floating [constricted glottis], in his grammar of Klamath (a Penutian language of Oregon), Barker (1964:263) posits a “morphophoneme |'|”, which is represented on the phonemic level by the glottalization of some neighboring consonant”, and which Blevins (1993:266) interprets as “a floating [constricted glottis] feature”.

LARYNGEAL $\stackrel{\text{def}}{=} \{[\text{VOICE}], [\text{SPR. GL.}], [\text{CONSTR. GL.}]\}$

- This feature, which accompanies the diminutive /-ʔa:k'/ for example, affects stops (42a) and affricates (42b) as well as sonorants (42c,d). Note, too, that with vowel-final stems (42e) glottalization is realized as [ʔ].
- With a single feature, [constricted glottis], a pattern such as this is straightforwardly accounted for.

(42) *Klamath diminutive*

- | | | | | |
|----|---|---|---|--------------------------------|
| a. | /Red + $\text{nep}^h + \text{ʔa:k}'$ / | → | $[\text{n̥en.p}^h\text{a:k}]$ | 'distributive little hands' |
| b. | /Red + $\text{p}^h\text{et}^h + \text{ʔa:k}'$ / | → | $[\text{p̥ep.t}^h\text{a:k}]$ | 'distributive little feet' |
| c. | /Red + $\text{qt}^h\text{u:l} + \text{ʔa:k}'$ / | → | $[\text{q̥t}^h\text{uq.t}^h\text{u:l̥a:k}]$ | 'distributive little star' |
| d. | /Red + $\text{ʔank}^h\text{u} + \text{ʔa:k}'$ / | → | $[\text{ʔa.ʔank.wa:k}]$ | 'distributive little buffalos' |
| e. | /Red + $\text{k}^h\text{owe} + \text{ʔa:k}'$ / | → | $[\text{k}^h\text{ok.we.ʔa:k}]$ | 'distributive little frogs' |

- Similarly, Buckley (1990:84) reports that in Kashaya, a Pomoan language of California, "the Assertive morpheme is a floating [+constricted glottis] feature which links to an immediately preceding consonant, thereby glottalizing it".

- Stops and sonorants are both affected by the same glottalizing feature.

(43) *Kashaya*

- | | | | | |
|----|-----------------|---|--------------------------------|-----------------|
| a. | /jah.mot + ʔ/ | → | $[\text{jah.mot}^h]$ | 'it's a cougar' |
| b. | /ts'ij.kan + ʔ/ | → | $[\text{ts}^h\text{ij.kan}^h]$ | 'it's pretty' |

- To conclude this section we note that all three laryngeal features can be used contrastively in a single language.

- For example, Yuchi, a language isolate now spoken by just a handful of speakers in Oklahoma, has the following inventory of stop sounds (Crawford 1973:174):

LARYNGEAL $\stackrel{\text{def}}{=} \{[\text{VOICE}], [\text{SPR. GL.}], [\text{CONSTR. GL.}]\}$

(44) *Laryngeal specifications and examples of Yuchi stops and affricates*

	UNMARKED	[voice]	[spread gl.]	[constr. gl.]
LABIALS	p [[pa] 'sack']	b [[ba] 'burn']	p ^h [[p ^h a] 'cut']	p' [[go.p'a] 'look']
ALVEOLARS	t [[ge.ta] 'hold on']	d [[go.da] 'wash']	t ^h [[go.t ^h a] 'pick']	t' [[jõf.t'a] 'Shawnee']
ALVEOLAR	ts [[di.ts'a] 'I sleep']	dz [[ʔa.di.dza] 'I say']	ts ^h [[ts ^h ja] 'dry']	ts' [[ts'a] 'I cry']
AFFRICATES	tʃ [[tʃu] 'boat']	dʒ [[go.k ^h a.dʒu] 'armpit']	tʃ ^h [[tʃ ^h u] 'bed']	tʃ' [[se.tʃ'a] 'she drowns']
ALVEOPALATAL				
AFFRICATES				
VELARS	k [[ja.ka] 'white']	g [[sjo.ga] 'she rests']	k ^h [[dzo.k ^h a] 'flour']	k' [[do.k'a] 'I sift']

- Note that the features [spread glottis] and [constricted glottis] are logically opposite, and so they never occur in the same syllabic position.
- It is possible, however, for [constricted glottis] to combine phonologically with [voice].
 - Uduk is a Nilo-Saharan language that contrasts [constricted glottis] in both [voice] and voiceless consonants.
 - Note that Uduk additionally has contrastively aspirated stops

(45) *Uduk* (Ladefoged & Maddieson 1996:82)

		BILABIAL	ALVEOLAR
[stop]	VOICELESS	[pàl] 'to try'	[tèr] 'to collect'
[stop, voice]	VOICED	[baʔ] 'to be something'	[dèd] 'to shiver'
[stop, constr. gl.]	EJECTIVE	[p'àc ^h àd] 'fermented'	[t'èd] 'to lick'
[stop, voice, c.g.]	IMPLOSIVE	[bàʔ] 'back of neck'	[dek'] 'to lift'
[stop, spread gl.]	ASPIRATED	[p ^h à.lal] 'centipede'	[t ^h èr] 'to pour off'

LARYNGEAL $\stackrel{\text{def}}{=} \{[\text{VOICE}], [\text{SPR. GL.}], [\text{CONSTR. GL.}]\}$

Assimilation/dissimilation

- A first example of [constricted glottis] assimilation is provided by the Cushitic language Oromo (Owens 1985; Fallon 2002).
 - Glottalization spreads from a stem-final consonant to a suffix-initial consonant, e.g., (46a).
 - In fact, progressive laryngeal assimilation appears to be quite general in Oromo, since voicing also spreads in this way (46b).

(46) *Oromo* (Fallon 2002:43)

a.	/tʃap'-ti/	[tʃap't'i]	'it (f.) breaks'
	/me:k'-te/	[me:t't'e]	'you turned'
	/me:k'-ta/	[me:t't'a]	'you turn'
cf.	/tʃap'-s-ta/	[tʃap'sita]	'you break sth.'
b.	/did-te/	[didde]	'you refused'
	/k'ab-ta/	[k'abda]	'you have'
	/gub-tan/	[gubdan]	'you (pl.) burn sth.'
	/fi:g-te/	[fi:gde]	'you escaped'

- Literary Adyghe (West Circassian: Kumaxov 1967; Fallon 2002) shows a comparable pattern, except that laryngeal assimilation is regressive in this case.
 - For instance, the personal pronouns (sə 'I, tə 'we, ɕʷə 'you (pl.)', etc.) assimilate [constricted glottis] (47a) as well as [voice] (47b) in a following obstruent.

(47) *Adyghe* (Fallon 2002:47-8)

a.	/p-ʃəʁe/	[pʃəʁe]	'you made'
	/t-ʃəʁe/	[tʃəʁe]	'we made'
b.	/s-ʁekʷaʁ/	[zʁekʷaʁ]	'I forced to go'
	/t-ʁekʷaʁ/	[dʁekʷaʁ]	'we forced to go'
	/ɕʷ-ʁekʷaʁ/	[ʁʷekʷaʁ]	'you (pl.) forced to go'

LARYNGEAL $\stackrel{\text{def}}{=} \{[\text{VOICE}], [\text{SPR. GL.}], [\text{CONSTR. GL.}]\}$

- Similarly in Mingrelian (Kartvelian: Harris 1991:339; Fallon 2002:55ff.) the prefixes for first person and second person objects assimilate the [constricted glottis] and [voice] specifications of a following obstruent, but here they do so even across an intervening sonorant consonant (*r, n*), as shown in (48-49).

(48) *First person object*: *p-* ~ *p̣-* ~ *b-* (49) *Second person object*: *k-* ~ *ḳ-* ~ *g-*

- | | | | | | |
|----|-------------------|-------------------|----|----------------|----------------------|
| a. | [p-rtʃχunk] | 'you wash me' | a. | [k-rtʃχuns] | 'she washes you' |
| | cf. [p-tχoruns] | 'he buries me' | | cf. [me-k-tʃi] | 'I gave you (sth.)' |
| b. | [p'-rts'q'unk] | 'you water me' | b. | [k'-rtʃip'uns] | 's/he stretches you' |
| | [p'-nts'q'unk] | 'you ruin me' | c. | [g-rduns] | 's/he raises you' |
| | cf. [p'-tʃ'k'uns] | 'it eats me' | | | |
| c. | [b-rdunk] | 'you raise me' | | | |
| | cf. [b-goruns] | 'he looks for me' | | | |

- Such laryngeal assimilation “at a distance” also occurs in Tepehua, a language isolate spoken in Eastern Mexico (Watters 1985).
 - The second person singular is marked on verbs by mapping a [constricted glottis] feature onto all glottalizable sounds, i.e., stops and /h/ in this language.
 - Note that only prevocalic stops are eligible docking sites.
 - This pattern, which is illustrated in (50), suggests that the second person singular is the feature [constricted glottis], and that this feature is spread across the word.

(50)	3SG. (UNMARKED)	2SG.	
	[ʔaqtajhu:-j]	[ʔaqtʔajʔu:-j]	<i>help-IMPF</i>
	[pa:tahu:-j]	[p'a:t'aʔu:-j]	<i>fall-IMPF</i>
	[nahun]	[naʔun]	<i>say</i>
	[wahin]	[waʔin]	<i>eat (intrans.)</i>
	[paʃa:-j]	[p'aʃa:-j]	<i>bathe</i>
	[ʃapa-j]	[ʃap'a-j]	<i>plane</i>

LARYNGEAL $\stackrel{\text{def}}{=} \{[\text{VOICE}], [\text{SPR. GL.}], [\text{CONSTR. GL.}]\}$

- Turning to **dissimilation** of [constricted glottis], a clear example is provided by Shuswap, an Interior Salish language (Kuipers 1974; Thompson & Thompson 1985; Fallon 2002:206).

- As Kuipers (1974:23) describes: “if a root has the shape K_1VK_2 , K_1VRK_2 , K_1RVK_2 , and K_2 is glottalized, then K_1 is never glottalized. In any type of reduplication, the first occurrence of a reduplicated obstruent is never glottalized. Thus ... $\acute{p}$... is reduplicated ... p ... $\acute{p}$...” [K = obstruent, R = sonorant, V = vowel]
- Deglottalization is illustrated below in two types of Shuswap reduplication, one prefixal (CV-), the other suffixal (-VC).

(51) *Shuswap CV- redup.* (Thompson & Thompson 1985:136; Fallon 2002:206-7)

[tʰlut]	‘rushes’	[tsi-tʰlútlex ^w]	‘tubular goosegrass’
[kʰej]	‘be cold, freeze’	[t-kj-kʰij-t]	‘chilled’
[ʔs-tʰil]	‘to stop, quit’	[te-tʰil-t]	‘keeping still’
[tʰekʔ-ém]	‘support, prop up’	[x-tek-tʰekʔ-éχn]	‘crutches’
[qʰiw-t]	‘to break’	[qw-qʰíw]	‘brittle’

(52) *Shuswap -VC reduplication* (Taylor 1996:84ff.; Fallon 2002:210)

/patʰ-RED/	[pət-átʰ]	‘overflow, boil, hang down around edges’
/t-xetʰ-RED/	[t-xət-étʰ]	‘to join, to fall in with (a herd)’
cf. /qʰux ^w -RED/	[qʰ ^w əx ^w -úx ^w]	‘stiff (from cold)’

- The dissimilation of glottalized consonants is also evident historically. The following examples illustrate deglottalization in the development of Shuswap from Proto-Interior-Salish (PIS).
- Data from neighboring and closely related Thompson River Salish are also provided, for comparison.

(53) *Shuswap deglottalization* (Thompson & Thompson 1985:136; Fallon 2002:219)

PIS	SHUSWAP	THOMPSON
*[kʰípʰ]	[kipʰ-m]	[kʰípʰ-m]
*[qʰ ^w atsʰ]	[qʰ ^w étsʰ-t]	[qʰ ^w étsʰ-t]

LARYNGEAL $\stackrel{\text{def}}{=} \{[\text{VOICE}], [\text{SPR. GL.}], [\text{CONSTR. GL.}]\}$

*[p'utɬ']	'fog'	[s-pút'-nt]	[s-p'útɬ'-t]
*[ts'ékʷ]	'bright, shine'	[tsekʷ-tsekʷ]	[ts'ékʷ]

EXERCISES

Exercises

1. Turkana, a Nilotic language of Kenya, presents alternations between velar and uvular consonants. Develop an account of [k] vs. [q] in Turkana based on the following examples.

Turkana (Zetterstrand 1996)

- | | | | | | |
|----|-------------------------------|-------------------|----|---------------|----------------|
| a. | [a.ki.ru] | 'rain' | b. | [ε.qɔ.ɾɪ] | 'rattle' (sg.) |
| | [a.ma.kuk] | 'stool' | | [ε.qɔ.l.cɔr:] | 'pelican' |
| | [ɲi.ke.no] | 'fireplace' (pl.) | | [e.qod] | 'tax' (sg.) |
| | [ɲa.kɪ.maq] | 'old woman' | | [e.qoj] | 'matter' |
| | [a.ɾu.kum] | 'cough' | | [ε.qa.le:s] | 'ostrich' |
| | [a.kε.pu] | 'vein' | | | |
| c. | [ɲɪ.ka.do.χot ~ ɲɪ.qa.do.χot] | 'monkeys' | | | |
| | [a.mʊ.kat ~ a.mʊ.qat] | 'shoes' | | | |
| | [ni.kor ~ ni.qor] | 'Samburu' (pl.) | | | |
| | [ɲɪ.ka.jo ~ ɲɪ.qa.jo] | 'tree' (pl.) | | | |
| | [lo.u.ko ~ lo.u.qo] | 'in this lung' | | | |

2. Account for the different	[ɔp.seʁ.ve]	'observe'		
pronunciations of consonants in French	[a.nɛg.dɔt]	'anecdote'	[bez.bal]	'baseball'
vs. English words:	[ɔp.tə.niʃ]	'obtain'	[ɛg.zɛʁ.sis]	'exercise'

3. According to Golla (1964), the Yokuts (Penutian) word **talim* 'trout' has become [t'a_lim] in Chukchansi. Suggest an explanation.

4. Try to explain the allomorphy of the adjectival suffix in Georgian (Aronson 1990).

<i>asur-uli</i>	'Asyrrian'	<i>asur-uli</i>	'Asyrrian'
<i>somχ-uri</i>	'Armenian'	<i>dan-uri</i>	'Danish'
<i>ungr-uli</i>	'Hungarian'	<i>tʃerk'ez-uli</i>	'Cherkessian'
<i>kimi-uri</i>	'chemical'	<i>fizik-uri</i>	'physical'
<i>frang-uli</i>	'French'	<i>reakti-uri</i>	'reactive'
<i>real-uri</i>	'real'	<i>terminal-uri</i>	'terminal'

EXERCISES

5. In Irish, when pronouns are added to a word beginning with the voiceless plain coronals [t] and [s] or their palatalized counterparts [tʲ] and [sʲ], these consonants reduce to [h] and [hʲ], respectively. How can this process be formulated? (Kenstowicz 1994).

<i>talə</i>	'land'	<i>mə halə</i>	'my land'
<i>soləs</i>	'light'	<i>mə holəs</i>	'my light'
<i>tʰo:xt</i>	'temperature'	<i>mə hʰo:xt</i>	'my temperature'
<i>sʰo:l</i>	'sail'	<i>mə hʰo:l</i>	'my sail'

6. Try to explain the allomorphy of the plural infix in Sundanese (Cohn 1992).

SING.	PL.	
<i>kusut</i>	<i>k-ar-usut</i>	'messy'
<i>visualisasi</i>	<i>v-ar-isualisasi</i>	'visualize'
<i>daman</i>	<i>d-ar-aman</i>	'well' (adj.)
<i>poho</i>	<i>p-ar-oho</i>	'forget'
<i>ᵛoplok</i>	<i>ᵛ-ar-oplok</i>	'flop down'
<i>gʲilis</i>	<i>g-ar-ilis</i>	'beautiful'
<i>mahal</i>	<i>m-ar-ahal</i>	'expensive'
<i>dahar</i>	<i>d-al-ahar</i>	'eat'
<i>hormat</i>	<i>h-al-ormat</i>	'respect'
<i>pərceka</i>	<i>p-al-ərceka</i>	'handsome'
<i>combrek</i>	<i>c-al-ombrek</i>	'cold'
<i>motret</i>	<i>m-al-otret</i>	'take a picture'
<i>bᵛᵇhar</i>	<i>b-al-ᵛᵇhar</i>	'rich'

The French words *raport* 'report' and *directeur* 'director' are borrowed as *lapor* and *dalektur* in Sundanese. Can you explain this?

7. Try to explain the allomorphy of the adjectival suffix in Georgian (Aronson 1990).

a.	<i>p'olonuri</i>	'Polish'	<i>danuri</i>	'Danish'
	<i>somᵇuri</i>	'Armenian'	<i>fizikuri</i>	'physical'
	<i>kimiuri</i>	'chemical'		

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- b. *asuruli* 'Assyrian' *franguli* 'French'
p'rusiuli 'Prussian' *tferk'ezuli* 'Cherkessian'
ungruli 'Hungarian' *reaktiuli* 'reactive'
- c. *kartluri* 'Kartvelian' *avast'raluri* 'Australian'
realuri 'real' *terminaluri* 'terminal'

8. Examine t/ts and d/dz in Canadian French. What conditions their distribution? (Davenport & Hannahs 1998).

[ak.tsɪf]	'active'	[tsy]	'you'
[dzi]	'say'	[twe]	'you' (obj.)
[tu]	'all' (masc.)	[dɛ.ʒɑ]	'already'
[dɔ.ne]	'give'	[dzyk]	'duke'
[ad.mɛt]	'admit'	[dzɪsk]	'record' (noun)
[tɔ.tal]	'total'	[dɔt]	'doubt'
[tut]	'all' (fem.)	[sɔr.tsi]	'exit'
[tsɪp]	'type'	[mɔr.dzy]	'bitten'

9. Gitksan is a Tsimshian language spoken in the Skeena River valley of British Columbia, mainly between Kispiox and Kitwanga. The following data are from Hoard (1978). Explain the changes in the stops.

/xpi/	[xbiʔ]	'ten'	/kitʔ/	[grɪʔ]	'vermillion'
/paχ/	[beχ]	'to run'	/tk ^w antx ^w /	[t ^h g ^w antx ^w]	'to trip, stumble'
/pan/	[ban]	'belly'	/qan/	[ɡan]	'tree, wood'
/taw/	[dew]	'ice'	/qu:t/	[ɡə:t ^h]	'heart'
/xti:/	[xdi:]	'tea'	/qats/	[ɡats]	'spill'
/tu:s/	[du:s]	'cat'	/nik ^w u:t/	[nɪɡ ^w ə:t ^h]	'father'
/tsak ^w /	[dʒek ^{wh}]	'kill'	/nik ^w u:t+i/	[nɪɡ ^w ə:di]	'my father'
/tsák ^w asx ^w /	[dʒeg ^w esx ^w]	'animal'	/wak/	[wɛkʰ]	'brother'
/kat/	[gʲɛt ^h]	'man'	/wak+m/	[wɛgʲɪm] ~	'our brother'
/kup/	[ɡup]	'to eat'		[wɛgʲim]	

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Next, try to explain why implosives derive from underlying ejectives in Gitksan:

/p't'al/	[p'dal]	'rib'	/q'ujp'áx/	[gɔjɓáx]	'bright'
/t'a:/	[ɬa:]	'to sit'	/t'is/	[ɬis]	'to punch'
/t'k'a/	[t'ɬa]	'skin'	/q'ilt/	[ɬɛlt]	'top (of hill)'

10. Suggest a possible historical explanation for the following alternations:

<i>electri</i> [k]	<i>electri</i> [s]ity
<i>classi</i> [k]al	<i>classi</i> [s]ist
<i>criti</i> [k]al	<i>criti</i> [s]ism
<i>publi</i> [k]	<i>publi</i> [s]ity
<i>Catholi</i> [k]	<i>Catholi</i> [s]ism
<i>medi</i> [k]ate	<i>medi</i> [s]ine
<i>dupli</i> [k]ate	<i>dupli</i> [s]ity

11. Explain the changes observed in the following Finnish data (Kiparsky 1993).

a.	/halut-i/	[ha.lu.si]	'wanted'
	/halut-a/	[ha.lu.ta]	'to want'
b.	/hakkat-i/	[hak.ka.si]	'hewed'
c.	/turpot-i/	[tur.po.si]	'swelled'
d.	/avat-i/	[a.va.si]	'opened'
e.	/vete/	[ve.si] ⁸¹	'water'
	/vete-næ/	[ve.te.næ]	'water' (ess.)

12. Try to explain the form of the following loanwords in Japanese. (N.B.: The “default” vowel for insertion (epenthesis) is [u], e.g., *glove* > gulovu, *public* > paburik:u.)

	<i>Japanese</i>	<i>Original</i>	
a.	[tsu:pi:su]	[tu:pi:s]	English: 'two piece(s)'
b.	[tsu:ru:zu]	[tu.luz]	French: 'Toulouse' (place name)

⁸¹ Word-final /e/ is regularly raised to [i] in Finnish.

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c. [ka.tsu.re.tsu] [kat.lət] English: 'cutlet'

Try now to explain this different pattern also observed in these loans (Mah 2001):

'toast' > [to.su.to] 'skate' > [su.ke.to]

13. Explain the use of [d] versus [ð] in Osage (Siouan), as spoken by the late Fred M. Lookout of Oklahoma (Wolff 1952):

'tʃεðε	'he killed it'	'dabəðĩ	'three'
datʃ'pε	'to eat'	'aðikhã ʒã	'he lay down'
'ðεzε	'tongue'	da'kʔε	'to dig'
'dalĩ	'good'	'ðie	'you'
'ðiʃki	'to wash'	'lōðĩ	'drunk'
da'tsε	'house'	ðu'ʒa	'to wash'
da'ʃtú	'to bite'	mã'ʃtĩke ida mãʒi	'I didn't see the rabbit'

14. Labialized consonants are illustrated below in the West African language Kuteb. (In these data, [ɕ] is a dorsal-coronal fricative, [ʒ] its voiced counterpart, and [tɕ], its affricate counterpart; accents on vowels are tones, which may be ignored.) What determines the phonetic form of the labialized element? (Roca & Johnson 2000)

[[bap ^w a]]	'they grind'	[[ba.ʒvam]]	'they begged'
[[bat ^w ap]]	'the picked up'	[[a.ɕfá.paŋ]]	'groundnuts'
[[ba.tsfáp]]	'they chose'	[[bas.k ^w áp]]	'they are foolish'
[[ba.tɕfák]]	'they sleep'	[[ba.sfa]]	'they kneel'
[[nsá.zvak.k ^w à]]	'the water is hot'	[[ba.ŋ ^w án]]	'they slip'
[[ba.b ^w a]]	'they deceived'	[[ba.m ^w à]]	'they measured'
[[ba.mb ^w à]]	'they tasted'	[[ba.ŋg ^w à]]	'they drink'
[[ba.nd ^w ap]]	'they wove'		

15. Explain the possible pronunciation of *sandwich* as [sæmwɪʃ].

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16. Many Spanish dialects change /s/ to glottal [h] syllable-finally. For example, determiners such as /dos/ ‘two’ and /mis/ ‘my (pl.)’ are normally pronounced with [h], e.g. *do[h] amigos* ‘two friends’, *mi[h] amigos* ‘my friends’. However, the change from /s/ to [h] fails to apply before words that contain the sound x, which is written *j* and pronounced [h] in the dialects in question, e.g., *do[s] ojos* ‘my eyes’, *mi[s] hijos* ‘my children’ (Lipski 2000). Provide an explanation.

17. Try to explain the following cases of allomorphy in Tashlhiyt Berber.

Reflexive prefix alternation: [m ~ n]

[m-xazar]	‘scowl’	[n-fara]	‘disentangle’
[m-saggal]	‘look for’	[n-ħaʃʃam]	‘be shy’
[m-ʃawar]	‘ask advice’	[n-xalaf]	‘place crosswise’
[m:-ʒla] ⁸²	‘lose’	[n-kaddab]	‘consider a liar’

Agentive prefix alternation: [am ~ an]

[am-las]	‘shear’	[an-ɾmi]	‘be tired’
[am-krz]	‘plow’	[an-bur]	‘remain celibate’
[am-agur]	‘remain’	[an-ɖfur]	‘follow’
[am-zug]	‘abscond’	[an-ʃazum]	‘fast’

18. State the context where each Korean liquid is found.

<i>mul</i>	‘water’	<i>mal</i>	‘horse’
<i>mulkama</i>	‘place for water’	<i>malkama</i>	‘place for horse’
<i>mure</i>	‘at the water’	<i>mare</i>	‘at the horse’
<i>pal</i>	‘foot’	<i>səul</i>	‘Seoul’
<i>pari</i>	‘of the foot’	<i>rupi</i>	‘ruby’
<i>ilkop</i>	‘barber’	<i>ration</i>	‘radio’

What difficulty is a name such as *Lori Roland* likely to present to the Korean learner of English? (Kenstowicz 1994)

⁸² Ignore lengthening of *m*- in this example; this is due to a regular prosodic process in Berber.

EXERCISES

19. Explain the alternations in the following sets from Veneto Italian (Walker 2001).

Singular vs. plural in Veneto Italian

<i>fior</i>	'flower' (masc. sg.)	<i>fiur-i</i>	'flower' (masc. pl.)
<i>ver-o</i>	'true' (masc. sg.)	<i>vir-i</i>	'true' (masc. pl.)
<i>amor</i>	'love' (masc. sg.)	<i>amur-i</i>	'love' (masc. pl.)
<i>negr-o</i>	'negro' (masc. sg.)	<i>nigr-i</i>	'negro' (masc. pl.)
<i>ov-o</i>	'egg' (masc. sg.)	<i>uv-i</i>	'egg' (masc. pl.)
<i>calset-o</i>	'sock' (masc. sg.)	<i>calsit-i</i>	'sock' (masc. pl.)

1s vs. 2s in Veneto Italian

<i>met-o</i>	'I put'	<i>mit-i</i>	'you put'
<i>scolt-o</i>	'I listen'	<i>scult-i</i>	'you listen'
<i>bev-o</i>	'I drink'	<i>bi-vi</i>	'you drink'

20. Which consonants may precede [w] at the beginnings of words in English (CwV...)?

21. Explain the alternations in the form of suffixes in the following data from Finnish (Roca & Johnson 2000:168). (Be warned that there's a tricky complication.)

<i>talo-ssa</i>	'in the house'	<i>kylæ-ssæ</i>	'in the village'
<i>turu-ssa</i>	'in Turku'	<i>kæde-ssæ</i>	'in the hand'
<i>pori-ssa</i>	'in Pori'	<i>vene:-sæ</i>	'in the boat'
<i>porvo:-ssa</i>	'in Porvoo'	<i>helsingi-ssæ</i>	'in Helsinki'
<i>tuo-ko</i>	'that?'	<i>tæmæ-kø</i>	'this?'
<i>tuo-ssa-ko</i>	'in that?'	<i>tæ-ssæ-kø</i>	'in this?'
<i>naise-lta</i>	'from the woman'	<i>tytø-ltæ</i>	'from the girl'
<i>sisare-lta</i>	'from the sister'	<i>velje-ltæ</i>	'from the brother'

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22. Explain the alternations in the aorist suffix in Wikchimani (a California Penutian language)(Archangeli 1984:159).

[p ^h iŋ-fi]	'stung'
[tɣʔys-fy]	'made'
[t ^h an-fi]	'went'
[huɬ-fu]	'knew'
[mo:xitɬ-fi]	'got old'

23. Moore (Nikiema 2002) is a Gur language in Burkina Faso. Give a rule to explain why the suffixes *-go* and *-re* change to *-gu* and *-ri*, respectively. Illustrate how your rule works with some examples.

[kor-go]	'sack'	[kug-ri]	'stone'
[laŋ-go]	'hole'	[tub-re]	'ear'
[bid-go]	'sorrel'	[gob-re]	'left hand'
[zu-gu]	'granary'	[rakil-ri]	'fagot of wood'
[rɔg-go]	'pot'	[gel-re]	'egg'
[sen-go]	'rainy season'		

24. Explain the alternations in the following data from Welsh (Davenport & Hannahs 1998):

[kɛɡɪn]	'kitchen'	[əŋ ɲɛɡɪn]	'my kitchen'
[bʊθɪn]	'cottage'	[əm mʊθɪn]	'my cottage'
[ti:]	'house'	[ən ɲi:]	'my house'
[pɛntɾɛ]	'village'	[əm ɲɛntɾɛ]	'my village'
[dəfrɪn]	'valley'	[ən nəfrɪn]	'my valley'
[kəmri:]	'Wales'	[əŋ ɲəmri:]	'my Wales'

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25. What accounts for the allomorphy in the Latin suffixes *-al/-ar* in the following noun forms? (Spencer 1991:71)

<i>animal</i>	'animal'	<i>kalkar</i>	'spur'
<i>koklear</i>	'spoon'	<i>exemplar</i>	'copy'
<i>laku:nar</i>	'type of ceiling'	<i>luperkal</i>	'cave on Palatine hill'
<i>pulwi:nar</i>	'type of couch'	<i>toral</i>	'valance (of couch)'
<i>torkular</i>	'wine press'	<i>tribunal</i>	'tribunal'

26. Which consonants may precede [w] at the beginnings of words in English (CwV...)?

27. Explain the various realizations of the singular noun-class prefix in Nawuri, a Kwa language of Ghana (Casali 1990; 1993).

[gɛ-mɛ:]	'duck'	[gi-mu]	'head'
[gi-pula]	'burial'	[gi-fufuli]	'white'
[gu-su]	'ear'	[gu-tʃule:]	'mushroom'
[gɛ-lam ^w ɛ:]	'tiger nut'	[gi-gidimu]	'tadpole'
[gu-lɔ]	'illness'	[gi-kpo:]	a type of dance
[gɛ-ka:]	'head pad'	[gɛ-p ^w ɛ:]	'guilt'
[gi-bo:to:]	'leprosy'	[gi-ni]	'tooth'
[gɛ-b ^w a:ru:]	'water yam'	[gu-du]	'egg'
[gu-ku:]	'digging'	[gi-fitiri]	'grass'
[gɛ-ba:]	'hand'	[gɛ-mu]	'it'
[gu-dʒo]	'yam'	[gi-nɪnɪriboto:]	'millipede'
[gɛ-sɪbita]	'sandal'	[gɛ-f ^w ɪ]	'bodily gas'
[gu-kulɔŋ]	'one item'	[gi-ke:li:]	'kapok tree'
		[gɛ-b ^w ɪ:ba:]	'guinea corn'

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28. Explain the dialect differences in Chilean Spanish, based on the following examples.

STANDARD	NONSTANDARD	
[tekla]	[tekla]	'key'
[eklipse]	[ekliwse ~ eklijse]	'eclipse'
[regla]	[regla]	'ruler'
[kaptura]	[kawtura ~ kajtura]	'capture'
[etniko]	[ejniko]	'ethnic'
[akto]	[awto ~ ajto]	'act, deed'
[aplikar]	[aplikar]	'to apply'
[dogma]	[dowma ~ dojma]	'dogma'
[admirar]	[ajmirar]	'admire'
[korekto]	[korewto ~ korejto]	'correct'
[tekla]	[tekla]	'key'
[adkirir]	[ajkirir]	'acquire'
[letra]	[letra]	'letter'
[un dato]	[un dato]	'a datum'
[atleta]	[ajleta]	'athlete'
[un bono]	[un bono]	'a bonus'
[afrika]	[afrika]	'Africa'
[digno]	[diwno ~ dijno]	'worthy'
[ombre]	[ombre]	'man'
[atlantiko]	[ajlantiko]	'Atlantic'
[esa broma]	[esa broma]	'that joke'
[soplar]	[soplar]	'to blow'
[atlas]	[ajlas]	'atlas'
[isla]	[isla]	'island'
[obxeto]	[owxeto ~ ojxeto]	'object'
[konsepto]	[konsewto ~ konsejto]	'concept'
[represa]	[represa]	'dam'
[atmosfera]	[ajmosfera]	'atmosphere'
[absurdo]	[awsurdo ~ ajsurdo]	'absurd'
[advertir]	[ajvertir]	'to warn'
[katre]	[katre]	'cot'
[afganistan]	[afganistan]	'Afghanistan'
[sakro]	[sakro]	'sacred'

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[loko]	[loko]	‘crazy’
[aŋkla]	[aŋkla]	‘anchor’
[el grito]	[el grito]	‘the cry’
[esa droga]	[esa droga]	‘that drug’
[direktor]	[direwtor ~ direjtor]	‘correct’
[bradli]	[brajli]	proper name
[magdalena]	[mawdalena ~ majdalena]	proper name

29. Syllable-final [t, n] shifted to [k, ŋ] in some Min dialects of Chinese (Chen 1973; Rice 1996:512), such that the Xiamen words *ts^hit* ‘seven’ and *sin* ‘new’ are pronounced with final [k, ŋ] in adjacent Chaozhou (cf. Xiamen/Chaozhou: *pak* ‘north’, *taŋ* ‘winter’) (Norman 1988:236-7). Suggest an account of this development.

30. Explain the allomorphy in the following Turkish data (Halle et al. 2000:396).

- a. [ʃim.di.ki] ‘current’
[ʃim.di] ‘now’
- b. [bu.gyn.ky] ‘today’s’
[bu.gyn] ‘today’
- c. [ja.rɪn.ki] ‘tomorrow’s’
[ja.rɪn] ‘tomorrow’

31. Explain the broad change affecting vowels in the development from Proto-Malayo-Polynesian to Muna (Van Den Berg 1991:6).

PMP		Muna
* <i>tasik</i>	‘sea’	<i>tehi</i>
* <i>laŋuy</i>	‘swim’	<i>leni</i>
* <i>babuy</i>	‘pig’	<i>wewi</i>
* <i>tapi</i>	‘winnow’	<i>tepi</i>
* <i>qapur</i>	‘lime’	<i>yefi</i>
* <i>sabur</i>	‘scatter’	<i>hewi</i>
* <i>hapuy</i>	‘fire’	<i>ifi</i>
* <i>isa</i>	‘one’	<i>ise</i>

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**quzan* 'rain' *yuse*
 **putaq* 'white' *pute*

32. The following data are some English loanwords in Hawaiian, a Polynesian language. Describe and explain the adaptation of English consonants into Hawaiian, using features. (Ignore vowels.)

[ki.ki.ki]	'ticket'	[we.ke.ke]	'whiskey'
[ka.mu.e.la]	'Samuel'	[ko.pa]	'soap'
[la.i.ki]	'rice'	[ki.pi.ke.li.a]	'diphtheria'
[ka.u.ka.ni]	'thousand'	[pi.ka]	'pitcher'
[wa.i.na]	'wine'	[no.le.wa.i]	'Norway'
[ko.lo.ke]	'crocket'	[pa.la.o.a]	'flour'

Note: Hawaiian has the following onsets/consonants: *p, k, m, n, l, w, h*.

33. Based on the following data from Kinande (Bantu, Congo), give a formal explanation for the various forms of the 'benefactive' suffix in Kinande. (For now you can ignore the final [-a] suffix; it is added to all words in Kinande.)

[hum-ir-a]	'to beat for'
[bɔh-er-a]	'to tie for'
[lim-ir-a]	'to exterminate for'
[himat-ir-a]	'to squeeze for'
[huk-ir-a]	'to cook for'
[kar-ir-a]	'to tie for'
[lim-ir-a]	'to cultivate for'
[hek-er-a]	'to carry for'
[gumat-ir-a]	'to stuff mouth for'

34. Explain the various shapes of the prefixes in the following examples.

<i>infallible</i>	* <i>imfallible</i>	<i>impale</i>	* <i>inpale</i>
<i>impossible</i>	* <i>inpossible</i>	<i>infamous</i>	* <i>imfamous</i>
<i>involuntary</i>	* <i>imvoluntary</i>	<i>impenitent</i>	* <i>inpenitent</i>

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implicit **implicit*
invariable **imvariable*

infinite **imfinite*
imbue **inbue*

Similarly for these data:

confess **comfess*
composit **conposit*
confirm **comfirm*
combust **conbust*
convoke **comvoke*

complacent **conplacent*
confederacy **comfederacy*
compassion **conpassion*
convert **comvert*
combine **conbine*

35. Traditional Arab grammarians divide the consonants of their language into two groups on the basis of their effect on the definite prefix *ʔal-*. The “sun” letters induce a complete assimilation of the lateral consonant in the prefix while the “moon” letters have no effect. Study the following examples to determine the basis for the distinction. (Kenstowicz 1994)

- | | |
|--------------------------|--------------------------|
| a. [ʔal.qamr] ‘the moon’ | b. [ʔaʃ.ʃams] ‘the sun’ |
| [ʔal.ʃa.ras] ‘the mare’ | [ʔad.da:r] ‘the house’ |
| [ʔal.kita:b] ‘the book’ | [ʔaz.zaʃt] ‘the oil’ |
| [ʔal.ħarb] ‘the war’ | [ʔan.nahr] ‘the river’ |
| [ʔal.ʔab] ‘the father’ | [ʔaθ.θawb] ‘the garment’ |

Given your solution, predict the definite form of the following nouns.

- | | |
|-------------------|------------------------|
| [ra.ʒul] ‘man’ | [ðalq] ‘tip of tongue’ |
| [xa:.tam] ‘ring’ | [wa.lad] ‘boy’ |
| [ba:b] ‘gate’ | [ti.ʒa:.ra] ‘commerce’ |
| [sa.na] ‘year’ | [la.ban] ‘milk’ |
| [mawt] ‘death’ | [ya.da] ‘lunch’ |
| [ha.rab] ‘escape’ | |

36. Explain the following speech error (Fromkin 1971): *glear plue sky*.

EXERCISES

37. Building on the above discussion of Dakota reduplication, try to account for the following additional data:

[tʃó.na.la]	[tʃók.tʃó.na.la]	'to be few'
[lí.la]	[lík.li.la]	'very'

38. Explain all alternations in the following data from Japanese (Clements 1999). Note: the verb /fuum/ means 'step on'.

[tsu.ke.ru]	'attach'	[fun.dzu.ke.ru]	'trample on'
[ki.ru]	'cut'	[fun.gi.ru]	'give up'
[fi.ba.ru]	'tie'	[fun.dʒi.ba.ru]	'immobilize'

39. Shahin (1995) reports that laryngeals [h, ʔ] (variably) replace pharyngeals [ħ, ʕ] in Child (Palestinian) Arabic, e.g.:

Substitution of laryngeals for pharyngeals in Child (Palestinian) Arabic

/ħæ:mi/	[hæmi]	'difficult'	2;2
/rʕu:ħ/	[luh]	'to go'	2;4
/ʕusʕsʕ/	[ʔas]	'to press, squeeze'	1;11

Provide an analysis of this pattern.

40. Explain the alternations in the class 10 plural prefix in the following data from Zulu (Padgett 1995). (l, ɬ, ll are dental, palatoalveolar and lateral, respectively.)

izim-pap ^h ε	'feathers'	iziŋ-lezu	'slices'
izin-ti	'sticks'	iziŋ-ɬuŋɬulu	'species of bird' (pl.)
iziŋ-kezo	'spoons'	iziŋ-llaŋlla	'green frogs'

EXERCISES

41. Provide a full explanation for the following alternations in Tahltan, a Dene-Yeniseian language of British Columbia.

1. Alternations in '1st person sing.'

θεθðεł	'I'm hot'
hudıfı̃ja	'I love them'
εsk'a:	'I'm gutting fish'
dεθk ^w uθ	'I cough'
εjɔ̃ɔ̃ni	'I'm singing'
nadεdε:sba:ɬ	'I hung myself'
εθdu:θ	'I whipped him'
łεnεfı̃ju:ʃ	'I'm folding it'
εsdan	'I'm drinking'
mεθεθεθ	'I'm wearing (on feet)'
nεjjeł	'I'm growing'
sεsxεł	'I'm going to kill it'
naθɬθ'et	'I fell off'
nεstεł	'I'm sleepy'
εdεdεθdu:θ	'I whipped myself'
noʔεdε:ʃεdɔ̃zi	'I melted it over and over'
taθɬθał	'I'm dying'
jaʃɬεtʃ	'I splashed it'
xaʔεθt'aθ	'I'm cutting the hair off'

2. Alternations in '1st pers. pl.'

dεθigitɬ	'we threw it'
dεsid̃zel	'we shouted'
ıfı̃tɔ̃tɬ	'we blew it up'
naθiba:ɬ	'we hung it'
xasi:dεts	'we plucked it'
tε:dεnεjɔ̃ɔ̃zu:t	'we chased it away'
θi:ɬθædi	'we ate it'
dεsit'ʌs	'we are walking'
uʃid̃zε	'we are called'
nisit'a:ts	'we got up'
mεʔεjıt'otʃ	'we are breastfeeding'

42. Kinyarwanda seems to allow syllable onsets of considerable complexity, e.g., (a). This fact clashes with the evidence from nativization of German loanwords, which suggest that consonant clusters are not permitted (b). Try to resolve this contradiction.

a.	[tkwa.ŋga]	'we hate'
	[ka.ri:.ndgwi]	'seven'
	[i.mŋe:.ru.mŋe]	'male dog'
	[u.bga:.ŋwa]	'beard'
	[mŋa:.ŋho.re.je]	'you (pl.) worked for me'
	[nda.me.sa]	'I wash'

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- b. [bu.ru.gu.me.si.ti.ri] < *Bürgermeister*
 [re.pu.bu.ri.ka] < *Republik*
 [pe.re.zi.da] < *Präsident*
 [pe.re.fe] < *Präfek*

43. Rhotics have changed from [r] to [ʀ] in dialects of many languages, including French (Straka 1965), German (Howell 1987) and several Scandinavian languages (Swedish, Danish, Norwegian: Torp 2001).⁸³ Describe this change featurally.

44. In these data from Isthmus Zapotec, determine the underlying form of the stems and explain the phonological alternations.

<i>geta</i>	'corncake'	<i>sketabe</i>	'his corncake'	<i>sketalu?</i>	'your corncake'
<i>bere</i>	'chicken'	<i>sperebe</i>	'his chicken'	<i>sperelu?</i>	'your chicken'
<i>doʔo</i>	'rope'	<i>stoʔobe</i>	'his rope'	<i>stoʔolu?</i>	'your rope'
<i>ja:ga</i>	'wood'	<i>sja:gabe</i>	'his wood'	<i>sja:galu?</i>	'your wood'
<i>diʔidʒa</i>	'word'	<i>stiʔidʒabe</i>	'his word'	<i>stiʔidʒalu?</i>	'your word'
<i>palu</i>	'stick'	<i>spalube</i>	'his stick'	<i>spalulu?</i>	'your stick'
<i>ku:ba</i>	'dough'	<i>sku:babe</i>	'his dough'	<i>sku:balu?</i>	'your dough'
<i>tapa</i>	'four'	<i>stapabe</i>	'his four'	<i>stapaluf</i>	'your four'

45. In Lithuanian the prefix cognate with English/Latin 'con-' shows various shapes depending on the following consonant. Explain the prefixal variants in feature geometry.

[sam.bu:ris]	'assembly'	[bu:ri:s]	'crowd'
[sam.pi.las]	'stock'	[pil.nas]	'full'
[san.do.ra]	'covenant'	[do.ra]	'virtue'
[san.ta.ka]	'confluence'	[te.ke:ti]	'to flow'
[saŋ.ka.ba]	'connection'	[ka.be:]	'hook'

⁸³ Other examples include:

Portuguese (Noll 1997), Italian (Ladefoged & Maddieson 1996:225), Spanish (Puerto Rican: Granda 1966; Navarro Tomás 1966), English (Northumbrian and Sierra Leonean: Rydland 1995; Ladefoged & Maddieson 1996:236), Dutch (Gussenhoven 1999), Yiddish (Eastern: King & Beach 1998:284-6), Russian (Ladefoged & Maddieson 1996:225), and several Central Sulawesi languages (Lauje, Dampelas and Tolitoli: Himmelmann 1991).

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[sa:.vo.ka]	'idea'	[vok.ti]	'to understand'
[sa:.skam.bis]	'harmony'	[skam.be:.ti]	'to ring'
[sa:.fla.vos]	'sweepings'	[fluo.ti]	'to sweep'
[sa:.zi.ne]	'conscience'	[zi.no.ti]	'to know'
[sa:.ra.fas]	'list, register'	[ra.fi:.ti]	'to write'

46. Two brothers living with their parents in Cambridge, MA, aged 4 and 5.5, were observed to speak a dialect of English. What rules distinguish the children's phonology from the phonology of the adult community? (Halle & Clements 1983)

<i>puppy</i>	[pəʔi:]	<i>can</i>	[kænd]	<i>walked</i>	[wakt]
<i>kick</i>	[kɪʔ]	<i>did</i>	[dɪʔ]	<i>Bobby</i>	[baʔi:]
<i>baby</i>	[bejʔi:]	<i>beat</i>	[bi:t]	<i>tag</i>	[tæg]
<i>walks</i>	[wakt]	<i>cake</i>	[kejʔ]	<i>paper</i>	[pejʔəɪ]
<i>ran</i>	[rænd]	<i>died</i>	[dajʔ]	<i>takes</i>	[tejkt]
<i>men</i>	[mænd]	<i>took</i>	[tʊk]	<i>dogs</i>	[dagd]
<i>pet</i>	[pæt]	<i>bit</i>	[bɪt]	<i>toot</i>	[tu:ʔ]
				<i>suit</i>	[tu:ʔ]

47. In the Friulian dialect of Italian (Kenstowicz 1994), there is an alternation between voiced and voiceless obstruents. Suggest an explanation to account for the following voicing alternations. (Ignore accents.)

<i>wárp</i>	'blind'	<i>kwárp</i>	'body'
<i>warb-ít</i>	'sty'	<i>kwarp-út</i>	dimin.
<i>piérd-i</i>	'to lose'	<i>dínt</i>	'tooth'
<i>piért</i>	3sg.	<i>dint-isín</i>	dimin.

48. Suggest an explanation for the fact that vowels devoice before /s/ and /h/ in Comanche (Northern Uto-Aztecan: Armagost 1986; Dobrovolsky & Shaw 1993).

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49. Explain changes in the final consonants in the development from Middle Chinese (MC) to Fuzhou Chinese (FC), as illustrated in the following data (Chen 1973; Norman 1988:228-39).

	MC	FC		MC	FC		
a.	śjəm	> tʰiŋ	‘deep’	b.	diep	> tʰak	‘stack up’
	duân	> touŋ	‘break off’		ngjwət	> ŋuok	‘moon’
	dung	> tɕiŋ	‘copper’		ńźjiuk	> nyk	‘meat’

50. Explain the alternations in the following data from Chamorro, an Austronesian language spoken in the Marianas Islands.

a.	<i>hulat</i>	'tongue'	<i>i hilat</i>	'the tongue'
b.	<i>fogon</i>	'stove'	<i>i fegon</i>	'the stove'
c.	<i>lahi</i>	'man'	<i>i læhi</i>	'the man'
d.	<i>hulo</i>	'up'	<i>sæn hilo</i>	'in the direction up'
e.	<i>tunjo</i>	'to know'	<i>in tiŋo</i>	'we (excl.) know'
			<i>en tiŋo</i>	'you (pl.) know'

51. At age two years, two months, S is a lively and intelligent child. State the rules needed to derive S's forms from the adult forms, for consonants only. (Halle & Clements 1983)

<i>sock</i>	[gɔk]	<i>other</i>	[ʌdə]	<i>brush</i>	[bʌt]
<i>leg</i>	[gɛk]	<i>scream</i>	[gi:m]	<i>bath</i>	[ba:t]
<i>signing</i>	[giŋiŋ]	<i>uncle</i>	[ʌgu]	<i>John</i>	[dɔn]
<i>chockie</i>	[gɔgi:]	<i>dark</i>	[ga:k]	<i>bump</i>	[bʌp]
<i>stop</i>	[bɔp]	<i>lock</i>	[gɔk]	<i>drink</i>	[gik]
<i>spoon</i>	[bu:n]	<i>table</i>	[be:bu]	<i>skin</i>	[gin]
<i>zoo</i>	[du:]	<i>bus</i>	[bʌt]	<i>stuck</i>	[gʌk]
<i>nipple</i>	[mibu]	<i>smith</i>	[mit]	<i>new</i>	[nu:]
<i>tent</i>	[dɛt]	<i>thank you</i>	[gɛgu]	<i>swing</i>	[wiŋ]
<i>snake</i>	[ŋe:k]	<i>tickle</i>	[gigu]		
<i>knife</i>	[majp]	<i>apple</i>	[ɛbu]		
<i>swing</i>	[wiŋ]	<i>crumb</i>	[gʌm]		

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52. Provide a full account of the pattern exhibited in the following paradigm from Sudanese Arabic (Kenstowicz 1994).

	PERFECT			IMPERFECT			
a.	<i>nabaħ</i>	<i>ja-mbaħ</i>	‘bark’	g.	<i>nakar</i>	<i>ja-ŋkur</i>	‘deny’
b.	<i>nafad</i>	<i>ja-mfid</i>	‘save’	h.	<i>naxar</i>	<i>ja-ŋxar</i>	‘puncture’
c.	<i>nazal</i>	<i>ja-nzil</i>	‘descend’	i.	<i>nagal</i>	<i>ja-ŋgul</i>	‘transfer’
d.	<i>nasaf</i>	<i>ja-nsif</i>	‘demolish’	j.	<i>naħar</i>	<i>ja-nħar</i>	‘slaughter’
e.	<i>nafar</i>	<i>ja-ŋfur</i>	‘spread’	k.	<i>niħis</i>	<i>ja-nħas</i>	‘fall asleep’
f.	<i>naʒaħ</i>	<i>ja-ŋʒaħ</i>	‘succeed’	l.	<i>nahab</i>	<i>ja-nhab</i>	‘rob’

53. Alveolar and uvular rhotics alternate freely in many dialects of European languages. Interestingly, in several such dialects [r] is favored in syllable-initial position while [ʀ] is favored in syllable-final position. Zhirmunksii (1962) first reported this distribution for some Cologne dialects of German. For instance, he found that syllable-final [ʀ] in, e.g., *Ferkel*, *werfen*, *Sturm* is realized [r] if these words are pronounced with anaptyxis (added vowel): *fērəkəl*, *vērəpə*, *štōrəm* (p. 378). Suggest an account of this alternation.

54. Explain the alternations in the form of suffixes in the following data from Turkish (cf. discussion above) (Roca & Johnson 2000:167-8).

	Nom. sg.	Gen. sg.	Nom. pl.	Gen. pl.
a. 'face'	jyz	jyzyn	jyzler	jyzlerin
b. 'stamp'	pul	pulun	pullar	pulların
c. 'village'	køj	køjyn	køjler	køjlerin
d. 'end'	son	sonun	sonlar	sonların

55. Give a possible historical explanation of the development Modern English *goose* vs. *geese*, *tooth* vs. *teeth*, from Old English *gos* vs. *gosi*, *toθ* vs. *toθi*. (The Old English forms have plural *-i*.)

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56. Explain vocalic differences between Classical Armenian and the Agn dialect of this language (Vaux 1999a).

Armenian (Halle et al. 2000:400)

<i>Classical</i>	<i>Agn</i>		<i>Classic</i>	<i>Agn</i>	
doł	d ^h øɤ	‘tremor’	galot	g ^h aløɤ	‘coming’
gałt-uk	g ^h aɤdyk	‘secret’	heru	hery	‘last year’
at ^h or	at ^h ør	‘chair’	bofs ^h	b ^h ofs ^h	‘flame’
moraťs ^h ot	morts ^h ør	‘forgetting’	port	bord	‘navel’
tj ^h ors	tj ^h ør	‘four’	p ^h otk ^h	p ^h oxg	‘throat’
tjuxa	tjyxa	‘cloth’	Mufeł	Mufex	personal name
d̂zur	d̂z ^h yr	‘water’	kots ^h	g ^h ots ^h	‘closed’
nor	nør	‘new’	k ^h or	k ^h or	‘unit of grain’
xofor	xofør	‘large’	gud	gud	‘grain’
sox	søx	‘onion’	xuts ^h	xurts ^h	‘room’

57. Explain the alternations in the following sets from Veneto Italian (Walker 2001).

Singular vs. plural in Veneto Italian

<i>fior</i>	‘flower’ (masc. sg.)	<i>fiur-i</i>	‘flower’ (masc. pl.)
<i>ver-o</i>	‘true’ (masc. sg.)	<i>vir-i</i>	‘true’ (masc. pl.)
<i>amor</i>	‘love’ (masc. sg.)	<i>amur-i</i>	‘love’ (masc. pl.)
<i>negr-o</i>	‘negro’ (masc. sg.)	<i>nigr-i</i>	‘negro’ (masc. pl.)
<i>ov-o</i>	‘egg’ (masc. sg.)	<i>uv-i</i>	‘egg’ (masc. pl.)
<i>calset-o</i>	‘sock’ (masc. sg.)	<i>calsit-i</i>	‘sock’ (masc. pl.)

1s vs. 2s in Veneto Italian

<i>met-o</i>	‘I put’	<i>mit-i</i>	‘you put’
<i>scolt-o</i>	‘I listen’	<i>scult-i</i>	‘you listen’
<i>bev-o</i>	‘I drink’	<i>bi-vi</i>	‘you drink’

58. Santerre (1979) reports the following pronunciations in Montreal French: *arracher* [aʃaʃe] ‘to tear off’ (cf. standard Canadian French [aʀaʃe]), *carabine* [kaʃabɪn] ‘rifle’ (cf. standard Canadian French [karabɪn]). He (1982) also reports that in Havre St-Pierre, Quebec, young

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people pronounce *Henri Richard* [ãʁi ʁiʃaʁ] (cf. Standard Canadian French [ãʁi ʁiʃaʁ]). What (featural) change is involved in these pronunciations?

59. Recall that in Turkish, suffix vowels assimilate the [front] specification of stem vowels.

Turkish (Goldsmith 1990:304)

	NOM. SG.	GEN. SG.	NOM. PL.	GEN. PL.
'rope'	<i>ip</i>	<i>ip-in</i>	<i>ip-ler</i>	<i>ip-ler-in</i>
'hand'	<i>el</i>	<i>el-in</i>	<i>el-ler</i>	<i>el-ler-in</i>
'girl'	<i>kız</i>	<i>kız-in</i>	<i>kız-lar</i>	<i>kız-lar-in</i>
'stalk'	<i>sap</i>	<i>sap-in</i>	<i>sap-lar</i>	<i>sap-lar-in</i>
'container'	<i>kap</i>	<i>kab-in</i>	<i>kap-lar</i>	<i>kap-lar-in</i>

Try to explain the alternations in the following additional data (Roca & Johnson 2000:167-8).

	NOM. SG.	GEN. SG.	NOM. PL.	GEN. PL.
'face'	<i>jyz</i>	<i>jyz-yn</i>	<i>jyz-ler</i>	<i>jyz-ler-in</i>
'stamp'	<i>pul</i>	<i>pul-un</i>	<i>pul-lar</i>	<i>pul-lar-in</i>
'village'	<i>køj</i>	<i>køj-yn</i>	<i>køj-ler</i>	<i>køj-ler-in</i>
'end'	<i>son</i>	<i>son-un</i>	<i>son-lar</i>	<i>son-lar-in</i>

60. Try to explain the following data from Korean (Schane & Bendixen 1978).

Korean

<i>nak</i> 'fall'	+ <i>hwa</i> 'flower'	→	<i>nak^hwa</i>	'fall flower'
<i>kup</i> 'bend'	+ <i>hita</i> (causative suffix)	→	<i>kup^hita</i>	'to bend'
<i>ʈfoh</i> 'good'	+ <i>ko</i> 'and'	→	<i>ʈfo^hko</i>	'good and'
<i>noh</i> 'to lay'	+ <i>ta</i> (verb ending)	→	<i>not^ha</i>	'to lay (eggs)'

61. According to Buckley (1994:83), aspiration does not get copied in reduplication in Kashaya (Southern Pomo), e.g., /RED-*k^hi*/ → [kik^hi] 'gill cover', /RED-*t^he-n̩*/ → [te:t^he_{n̩}] 'my mother'. Suggest an explanation.

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62. More Canadian French: can you predict the distribution of “tense” vowels [i, y, u] vs. “lax” vowels [ɪ, ʏ, ʊ] in the following data from Canadian French? If so, give the rule.

tuf	‘hairlock’	vites	‘speed’	vid	‘empty’
anyle	‘to cancel’	plym	‘feather’	tuf	‘touches’
rasin	‘root’	krutō	‘crouton’	midzi	‘noon’
signale	‘to signal’	zyp	‘skirt’	sud	‘welds’
lib	‘free’	pusē	‘chick’	libreri	‘bookstore’
zy	‘juice’	vil	‘city’	zys	‘fair’
ful	‘crowd’	lynet	‘glasses’	fyg	‘flight’
pus	‘push’	vit	‘fast’	vif	‘live’
riʃ	‘rich’	mu	‘soft’	buk	‘buck’
byfō	‘buffoon’	piton	‘head’	krydzite	‘crudity’
lyn	‘moon’	plyme	‘to pluck’	rim	‘rhyme’
riʃes	‘wealth’	krut	‘crust’	sumi	‘submitted’
byt	‘mount’	tsyk	‘tuque’	ryʃ	‘hive’
sude	‘to weld’	tsybylyr	‘tubule’	tu	‘cough’
elektrik	‘electric’	nyl	‘null’	tsyb	‘tube’
byf	‘buffalo’	puse	‘to push’	ki	‘who’
vis	‘screw’	pip	‘pipe’	vilaz	‘village’
bom	‘party’	ārasine	‘to take root’	ryd	‘rough’
si	‘if’	siŋ	‘sign’	tufe	‘to touch’
sudenmā	‘suddenly’	tsy	‘you’	tupi	‘toupis’
li	‘read’	krup	‘top’	lig	‘league’

Next consider the following additional data, and propose another rule:

abyzif	<i>abusif</i>	inytil	<i>inutile</i>
bɪsɪk	<i>bicycle</i>	ʒyʁɪdzɪk	<i>juridique</i>
ʃukʁut	<i>choucroute</i>	minyɪt	<i>minute</i>
klɪnɪk	<i>clinique</i>	filɪp	<i>Philippe</i>
kɔmynɪs	<i>communisme</i>	pɪlyl	<i>pillule</i>
kuzɪn	<i>cousine</i>	pypɪt	<i>pupitre</i>
kutsym	<i>coutume</i>	skɔpyl	<i>scrupule</i>

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<i>definitısf</i>	<i>définitif</i>	<i>sukup</i>	<i>soucoupe</i>
<i>dzıfısl</i>	<i>difficile</i>	<i>tubısl</i>	<i>touriste</i>
<i>abıtsyd</i>	<i>habitude</i>	<i>ynık</i>	<i>unique</i>

Some additional data from Walker (1984:61ff.):

<i>pɔzıtsıf</i>	<i>positif</i>	cf.	<i>pɔzıtsivite</i>	<i>positivité</i>
<i>pɔımitsıf</i>	<i>primitif</i>		<i>pɔımitsivite</i>	<i>primitivité</i>
<i>myzık</i>	<i>musique</i>		<i>myzısjē</i>	<i>musicien</i>
<i>kıızın</i>	<i>cuisine</i>		<i>kıızine</i>	<i>cuisiner</i>
<i>minıs</i>	<i>ministre</i>		<i>ministe:ɤ</i>	<i>ministère</i>

63. Explain all alternations in the following data from Zoque (Mexico: Wonderly 1965).

<i>paloma</i>	'bird'	<i>m-baloma</i>	'my bird'
<i>pama</i>	'clothing'	<i>m-bama</i>	'my clothing'
<i>burru</i>	'burro'	<i>m-burru</i>	'my burro'
<i>tatah</i>	'father'	<i>n-datah</i>	'my father'
<i>tsima</i>	'calabash'	<i>n-dzima</i>	'my calabash'
<i>disko</i>	'disk'	<i>n-disko</i>	'my disk'
<i>tʃoʔŋgoja</i>	'rabbit'	<i>n-dʒoʔŋgoja</i>	'my rabbit'
<i>kama</i>	'cornfield'	<i>ŋ-gama</i>	'my cornfield'
<i>gallu</i>	'rooster'	<i>ŋ-gallu</i>	'my rooster'

64. Examine the following data from Yiddish (Lombardi 1994), and explain all of the alternations.

<i>frajb</i>	'I write'	<i>red</i>	'I speak'
<i>vog</i>	'weight'	<i>ajz</i>	'ice'
<i>briv</i>	'letter'		
<i>vokfoj</i>	'scale'	<i>ajskastn</i>	'ice box'
<i>brıftreger</i>	'mailman'		
<i>bak</i>	'cheek'	<i>bagbejn</i>	'cheekbone'
<i>fvıtsn</i>	'sweat' (v)	<i>fvidzbod</i>	'steambath'
<i>zis</i>	'sweet'	<i>zizvarg</i>	'candy'
<i>kop</i>	'head'	<i>kobvejtik</i>	'headache'

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frajb+st → *frajpst* 'you (fam.) write'
red+st → *retst* 'you (fam.) speak'

65. Try to give a simple explanation for the different pronunciations of Malay words in the Standard dialect versus the Kelantan dialect (Trigo 1991; Halle 1995).⁸⁴

STANDARD	KELANTAN	
<i>ʔasap</i>	<i>ʔasaʔ</i>	'smoke'
<i>kilat</i>	<i>kilaʔ</i>	'lightning'
<i>masaʔ</i>	<i>masʔʔ</i>	'cook'
<i>balas</i>	<i>balah</i>	'finish'
<i>negatef</i>	<i>negatɪh</i>	'negative'
<i>ʔalem</i>	<i>ʔaliN</i>	'pious'
<i>sabon</i>	<i>saboN</i>	'soap'
<i>dukoŋ</i>	<i>dukoN</i>	'carry'
<i>batal</i>	<i>bata:</i>	'cancel'
<i>jujo:</i>	<i>jujo:</i>	'sincere'
<i>yumãh</i>	<i>yumõh</i>	'house'

66. In Irish, when pronouns are added to a word beginning with the voiceless plain coronals [t] and [s] or their palatalized counterparts [tʲ] and [sʲ], these consonants reduce to [h] and [hʲ], respectively. How can this process, illustrated below, be formulated? (Kenstowicz 1994).

<i>talə</i>	'land'	<i>mə halə</i>	'my land'
<i>soləs</i>	'light'	<i>mə holəs</i>	'my light'
<i>tʰo:xt</i>	'temperature'	<i>mə hʰo:xt</i>	'my temperature'
<i>sʰo:l</i>	'sail'	<i>mə hʰo:l</i>	'my sail'

67. Try to explain the following data from Korean (Schane & Bendixen 1978).

⁸⁴ For our purpose here, you can ignore the change from [ã] to [õ] before [h] in the last example.

EXERCISES

<i>nak</i> 'fall'	+ <i>hwa</i> 'flower'	→	<i>nak^hwa</i>	'fall flower'
<i>kup</i> 'bend'	+ <i>hita</i> (causative suffix)	→	<i>kup^hita</i>	'to bend'
<i>tfoh</i> 'good'	+ <i>ko</i> 'and'	→	<i>tfo^hko</i>	'good and'
<i>noh</i> 'to lay'	+ <i>ta</i> (verb ending)	→	<i>no^th^a</i>	'to lay (eggs)'

68. Suggest an explanation for the adaptation of consonants in loanwords from Greek into Classical Armenian (Vaux 1998).

GREEK		CLASSICAL ARMENIAN
<i>psammetik^hos</i>	→	<i>p^hsametikos</i> 'Psammetichus'
<i>psalmos</i>	→	<i>p^hsalmos</i> 'psalm'
<i>apsint^hion</i>	→	<i>ap^hsndin</i> 'wormwood'
<i>kserkse:s</i>	→	<i>k^hserk^hse:s</i> 'Xerxes'
<i>kseste:s</i>	→	<i>k^hsest</i> 'sextary, jar'
<i>douks</i>	→	<i>duk^hs</i> 'leader, prince'
<i>kuriake:</i>	→	<i>ki(w)rake:</i> 'Sunday'
<i>pant^he:r</i>	→	<i>pant^her</i> 'panther'

69. According to Buckley (1994:83), aspiration does not get copied in reduplication in Kashaya (Southern Pomo), e.g., /RED-k^hi/ → [kik^hi] 'gill cover', /RED-t^he-ŋ/ → [te:t^heŋ] 'my mother'.

70. In Sundanese (Anderson 1972; Cohn 1993:55), [nasal] spreads to following vowels. Onsets other than [h] block the spread of nasality. Try to explain this.

A.	<i>bare stems</i>	<i>with nasal affix (underlined)</i>
	[gə.de] 'big'	[gu. <u>m</u> ə.de] 'be conceited'
	[ra.sa] 'feel'	[ru. <u>m</u> ã.sa] 'admit to'
	[in.dit] 'leave'	[pa. <u>ŋ</u> ĩn.dit] 'reason for leaving'
	[o.mõŋ] 'say'	[pa. <u>ŋ</u> õ.mõŋ] 'reason for saying'
	[di.his] 'approach'	[du. <u>m</u> ĩ.hĩs] 'approach a superior'
	[saŋ.liŋ] 'to polish'	[si. <u>n</u> ãŋ.liŋ] 'to glitter'

EXERCISES

<i>B.</i>	<i>nasal spreading</i>	[-al-] ~ [-ar-]
	[ɲĩ.ãr] 'seek'	[ɲã.lĩ.ãr] 'seek' (pl.)
	[ɲã.ũr] 'say'	[ɲã.lã.ũr] 'say' (pl.)
	[mĩ.ã.sih] 'love'	[mã.rĩ.ã.sih] 'love' (pl.)
	[mã.hãl] 'expensive'	[mã.rã.hãl] 'expensive' (pl.)
	[mĩ.hãk] 'take sides'	[mã.rĩ.hãk] 'take sides' (pl.)

<i>C.</i>	<i>nasal spreading</i>	<i>nasal spreading blocked</i>
	[ɲĩ.ãr] 'seek'	[ɲã.tur] 'arrange'
	[ɲã.ũr] 'say'	[ɲõ.bah] 'change'
	[mã.hãl] 'expensive'	[ɲũ.li.at] 'stretch'
	[mĩ.hãk] 'take sides'	[mã.ri.os] 'examine'
	[mã.nẽh] 'you'	[ɲĩ.wat] 'elope'
	[nĩʃis] 'to take a holiday'	[ɲã.wi.daŋ] 'to dry skins'
	[bɪŋ.ħãr] 'to be rich'	[ɲã.jak] 'sift'
	[ku.mã.hã] 'how?'	[mĩʔãsih] 'to love'
	[o.mõŋ] 'say'	[ɲĩ.sər] 'displace'
	[nã.ʔãt.kɪn] 'dry'	

71. The Georgian words *k'ak'-ali* 'walnut' and *k'ots'aḫur-i* 'barberry' have been borrowed into Svan (Kartvelian: Schmidt 1991:480) as *gak'* and *gots'ḫir*, respectively. Similarly, the Mingrelian word *p'ap'a* 'priest' has been borrowed into Svan as *bap'*. Explain the adaptation of consonants.

72. In the Gurage language Muher, a labialized [kʷ] is realized as [ʔʷ] after vowels, as illustrated in the following data. Provide an analysis of this pattern.

ROOT	PERFECT	IMPERFECT	JUSSIVE	
/kʷm/	[kʷəməm]	[jiʔʷəmu]	[jəʔʷim]	'stand'
/kʷr/	[kʷəkʷərəm]	[jiʔʷəkʷir]	[jəʔʷəʔʷir]	'squeeze, wring'
/lak'/	[laʔʷim]	[jiləʔʷit]	[jələʔʷi]	'surpass'

EXERCISES

/nk'-nk'/ [niʔənnəʔ^wim] [jɪnk'ənniʔ^wit] [jənəʔnəʔ^wi] 'shake'

73. High vowels are regularly dropped from the ends of words in the dialect of Japanese spoken in Kagoshima. Develop an analysis of the changes ensuing from this deletion. (N.B.: Japanese has *h*'s, but as in English this sound is not allowed at the end of words.)

STANDARD	KAGOSHIMA	
<i>tobu</i>	<i>toʔ</i>	'fly'
<i>tani</i>	<i>taN</i>	'valley'
<i>kutʃi</i>	<i>kuʔ</i>	'mouth'
<i>k^waʃi</i>	<i>k^waʃ</i>	'sweets'
<i>kutsu</i>	<i>kuʔ</i>	'shoes'
<i>inu</i>	<i>iN</i>	'dog'
<i>kaki</i>	<i>kaʔ</i>	'persimmon'
<i>kami</i>	<i>kaN</i>	'paper'
<i>aʒi</i>	<i>aʔ</i>	'taste'
<i>usu</i>	<i>us</i>	'a mortar'
<i>miʒu</i>	<i>miʔ</i>	'water'
<i>çiru</i>	<i>çij</i>	'noon'
<i>ojogu</i>	<i>ojoʔ</i>	'swim'
<i>kasu</i>	<i>kas</i>	'number'
<i>mari</i>	<i>maj</i>	'ball'
<i>doku</i>	<i>doʔ</i>	'poison'

SAMPLE SPEECH SOUNDS AND THEIR FEATURES

Sample speech sounds and their features

$\begin{bmatrix} \text{cr} \\ \text{ps} \\ \text{lm} \\ \text{vc} \end{bmatrix} = [\text{j}]$	$\begin{bmatrix} \text{fv} \\ \text{sd} \\ \text{cr} \\ \text{ps} \\ \text{lm} \\ \text{dr} \\ \text{hi} \\ \text{sg} \end{bmatrix} = [\text{h}, \text{h}^h]$	$\begin{bmatrix} \text{fv} \\ \text{cr} \\ \text{ps} \\ \text{lm} \\ \text{hi} \\ \text{fn} \\ \text{sg} \end{bmatrix} = [\text{ç}, \text{ç}^j, \text{ç}^h, \text{ç}^{jh}, \text{j}, \text{j}^h]$
$\begin{bmatrix} \text{dr} \\ \text{hi} \\ \text{fn} \\ \text{vc} \end{bmatrix} = [\text{j}]$	$\begin{bmatrix} \text{fv} \\ \text{cr} \\ \text{ps} \\ \text{lm} \\ \text{fn} \end{bmatrix} = [\text{ç}, \text{ç}^j, \text{j}]$	$\begin{bmatrix} \text{fv} \\ \text{cr} \\ \text{ps} \\ \text{lm} \\ \text{hi} \\ \text{fn} \\ \text{vc} \end{bmatrix} = [\text{j}, \text{j}^j, \text{j}]$
$\begin{bmatrix} \text{dr} \\ \text{hi} \\ \text{vc} \end{bmatrix} = [\text{u}, \text{y}]$	$\begin{bmatrix} \text{fv} \\ \text{cr} \\ \text{ps} \\ \text{lm} \\ \text{fn} \\ \text{sg} \end{bmatrix} = [\text{ç}, \text{ç}^j, \text{ç}^h, \text{ç}^{jh}, \text{j}, \text{j}^h]$	$\begin{bmatrix} \text{fv} \\ \text{cr} \\ \text{ps} \\ \text{lm} \\ \text{hi} \\ \text{fn} \\ \text{vc} \end{bmatrix} = [\text{ç}, \text{ç}^h, \text{j}, \text{j}^h]$
$\begin{bmatrix} \text{dr} \\ \text{vc} \end{bmatrix} = [\text{u}, \text{y}]$	$\begin{bmatrix} \text{fv} \\ \text{cr} \\ \text{ps} \\ \text{lm} \\ \text{fn} \\ \text{sg} \end{bmatrix} = [\text{j}, \text{j}^j, \text{j}]$	$\begin{bmatrix} \text{fv} \\ \text{cr} \\ \text{ps} \\ \text{lm} \\ \text{hi} \\ \text{fn} \\ \text{vc} \end{bmatrix} = [\text{x}, \text{x}^h, \text{u}, \text{u}^h]$
$\begin{bmatrix} \text{fn} \\ \text{rr} \\ \text{vc} \end{bmatrix} = [\text{ε}, \text{e}, \text{ɜ}, \text{ə}]$	$\begin{bmatrix} \text{fv} \\ \text{cr} \\ \text{ps} \\ \text{lm} \\ \text{fn} \\ \text{vc} \end{bmatrix} = [\text{ç}, \text{ç}^j, \text{j}]$	$\begin{bmatrix} \text{fv} \\ \text{dr} \\ \text{hi} \\ \text{sg} \end{bmatrix} = [\text{y}, \text{u}]$
$\begin{bmatrix} \text{fn} \\ \text{vc} \end{bmatrix} = [\text{e}, \text{ə}]$	$\begin{bmatrix} \text{fv} \\ \text{cr} \\ \text{ps} \\ \text{lm} \\ \text{fn} \\ \text{vc} \end{bmatrix} = [\text{ç}, \text{ç}^j, \text{j}]$	
$\begin{bmatrix} \text{fv} \\ \text{cr} \\ \text{lm} \end{bmatrix} = [\text{θ}]$		
$\begin{bmatrix} \text{fv} \\ \text{cr} \\ \text{lm} \\ \text{sg} \end{bmatrix} = [\text{θ}, \text{θ}^h]$		
$\begin{bmatrix} \text{fv} \\ \text{cr} \\ \text{lm} \\ \text{vc} \end{bmatrix} = [\text{ð}]$		
$\begin{bmatrix} \text{fv} \\ \text{sd} \\ \text{cr} \\ \text{ps} \\ \text{lm} \\ \text{dr} \\ \text{hi} \end{bmatrix} = [\text{h}]$		

SAMPLE SPEECH SOUNDS AND THEIR FEATURES

$$\begin{bmatrix} \text{fv} \\ \text{lb} \end{bmatrix} = [\phi, \upsilon]$$

$$\begin{bmatrix} \text{fv} \\ \text{lb} \\ \text{hi} \end{bmatrix} = [\text{f}]$$

$$\begin{bmatrix} \text{fv} \\ \text{lb} \\ \text{rd} \\ \text{dr} \\ \text{hi} \\ \text{sg} \end{bmatrix} = [\text{m}, \text{w}^{\text{h}}]$$

$$\begin{bmatrix} \text{fv} \\ \text{lb} \\ \text{rd} \\ \text{hi} \\ \text{sg} \end{bmatrix} = [\text{m}, \text{w}^{\text{h}}]$$

$$\begin{bmatrix} \text{fv} \\ \text{lb} \\ \text{rr} \end{bmatrix} = [\text{f}]$$

$$\begin{bmatrix} \text{fv} \\ \text{lb} \\ \text{sg} \end{bmatrix} = [\phi, \phi^{\text{h}}, \upsilon, \upsilon^{\text{h}}]$$

$$\begin{bmatrix} \text{fv} \\ \text{lb} \\ \text{vc} \end{bmatrix} = [\beta, \upsilon]$$

$$\begin{bmatrix} \text{fv} \\ \text{lo} \\ \text{sg} \end{bmatrix} = [\text{h}, \text{h}, \text{h}^{\text{h}}, \text{h}^{\text{h}}]$$

$$\begin{bmatrix} \text{fv} \\ \text{lo} \\ \text{vc} \end{bmatrix} = [\text{r}, \text{r}, \text{h}, \text{h}]$$

$$\begin{bmatrix} \text{fv} \\ \text{lt} \end{bmatrix} = [\text{t}, \text{l}]$$

$$\begin{bmatrix} \text{fv} \\ \text{lt} \\ \text{sg} \end{bmatrix} = [\text{t}, \text{t}^{\text{h}}, \text{l}]$$

$$\begin{bmatrix} \text{fv} \\ \text{lt} \\ \text{vc} \end{bmatrix} = [\text{b}, \text{l}]$$

$$\begin{bmatrix} \text{fv} \\ \text{rd} \\ \text{dr} \\ \text{hi} \\ \text{sg} \end{bmatrix} = [\text{m}, \text{w}^{\text{h}}]$$

$$\begin{bmatrix} \text{fv} \\ \text{rh} \\ \text{cr} \\ \text{ps} \\ \text{vc} \end{bmatrix} = [\text{r}]$$

$$\begin{bmatrix} \text{fv} \\ \text{rh} \\ \text{cr} \\ \text{vc} \end{bmatrix} = [\text{r}, \text{r}]$$

$$\begin{bmatrix} \text{fv} \\ \text{sd} \\ \text{cr} \end{bmatrix} = [\text{s}, \text{s}]$$

$$\begin{bmatrix} \text{fv} \\ \text{sd} \\ \text{cr} \\ \text{fn} \end{bmatrix} = [\text{s}^{\text{j}}, \text{s}^{\text{j}}]$$

$$\begin{bmatrix} \text{fv} \\ \text{sd} \\ \text{cr} \\ \text{hi} \end{bmatrix} = [\text{s}]$$

$$\begin{bmatrix} \text{fv} \\ \text{sd} \\ \text{cr} \\ \text{hi} \\ \text{vc} \end{bmatrix} = [\text{z}]$$

$$\begin{bmatrix} \text{fv} \\ \text{sd} \\ \text{cr} \\ \text{ps} \end{bmatrix} = [\text{s}]$$

$$\begin{bmatrix} \text{fv} \\ \text{sd} \\ \text{cr} \\ \text{ps} \\ \text{lm} \\ \text{fn} \end{bmatrix} = [\text{c}, \text{c}^{\text{j}}]$$

$$\begin{bmatrix} \text{fv} \\ \text{sd} \\ \text{cr} \\ \text{ps} \\ \text{lm} \\ \text{fn} \\ \text{sg} \end{bmatrix} = [\text{c}, \text{c}^{\text{h}}, \text{c}^{\text{j}}, \text{c}^{\text{jh}}]$$

$$\begin{bmatrix} \text{fv} \\ \text{sd} \\ \text{cr} \\ \text{ps} \\ \text{lm} \\ \text{fn} \\ \text{vc} \end{bmatrix} = [\text{z}, \text{z}^{\text{j}}]$$

$$\begin{bmatrix} \text{fv} \\ \text{sd} \\ \text{cr} \\ \text{ps} \\ \text{lm} \\ \text{hi} \end{bmatrix} = [\text{j}]$$

$$\begin{bmatrix} \text{fv} \\ \text{sd} \\ \text{cr} \\ \text{ps} \\ \text{lm} \\ \text{hi} \\ \text{sg} \end{bmatrix} = [\text{j}, \text{j}^{\text{h}}]$$

$$\begin{bmatrix} \text{fv} \\ \text{sd} \\ \text{cr} \\ \text{ps} \\ \text{lm} \\ \text{hi} \\ \text{vc} \end{bmatrix} = [\text{z}]$$

$$\begin{bmatrix} \text{fv} \\ \text{sd} \\ \text{cr} \\ \text{ps} \\ \text{lm} \\ \text{sg} \end{bmatrix} = [\text{j}, \text{j}^{\text{h}}]$$

SAMPLE SPEECH SOUNDS AND THEIR FEATURES

$$\begin{bmatrix} \text{fv} \\ \text{sd} \\ \text{cr} \\ \text{ps} \\ \text{lm} \\ \text{vc} \end{bmatrix} = [3]$$

$$\begin{bmatrix} \text{fv} \\ \text{sd} \\ \text{cr} \\ \text{ps} \\ \text{sg} \end{bmatrix} = [s, s^h]$$

$$\begin{bmatrix} \text{fv} \\ \text{sd} \\ \text{cr} \\ \text{ps} \\ \text{vc} \end{bmatrix} = [z]$$

$$\begin{bmatrix} \text{fv} \\ \text{sd} \\ \text{cr} \\ \text{rr} \end{bmatrix} = [s^{\text{c}}, s^{\text{c}}, {}^{\text{c}}s, {}^{\text{c}}s, s^{\text{c}}, s^{\text{c}}]$$

$$\begin{bmatrix} \text{fv} \\ \text{sd} \\ \text{cr} \\ \text{rr} \end{bmatrix} = [s]$$

$$\begin{bmatrix} \text{fv} \\ \text{sd} \\ \text{cr} \\ \text{rr} \\ \text{vc} \end{bmatrix} = [z]$$

$$\begin{bmatrix} \text{fv} \\ \text{sd} \\ \text{cr} \\ \text{sg} \end{bmatrix} = [s, s^h]$$

$$\begin{bmatrix} \text{fv} \\ \text{sd} \\ \text{cr} \\ \text{vc} \end{bmatrix} = [z, s]$$

$$\begin{bmatrix} \text{fv} \\ \text{sd} \\ \text{dr} \end{bmatrix} = [\chi]$$

$$\begin{bmatrix} \text{fv} \\ \text{sd} \\ \text{dr} \\ \text{rr} \end{bmatrix} = [\chi]$$

$$\begin{bmatrix} \text{fv} \\ \text{sd} \\ \text{dr} \\ \text{rr} \\ \text{sg} \end{bmatrix} = [\chi, \chi^h]$$

$$\begin{bmatrix} \text{fv} \\ \text{sd} \\ \text{dr} \\ \text{rr} \\ \text{vc} \end{bmatrix} = [\varkappa]$$

$$\begin{bmatrix} \text{fv} \\ \text{sd} \\ \text{dr} \\ \text{sg} \end{bmatrix} = [\chi, \chi^h]$$

$$\begin{bmatrix} \text{fv} \\ \text{sd} \\ \text{dr} \\ \text{vc} \end{bmatrix} = [\varkappa]$$

$$\begin{bmatrix} \text{fv} \\ \text{sd} \\ \text{lb} \end{bmatrix} = [f]$$

$$\begin{bmatrix} \text{fv} \\ \text{sd} \\ \text{lb} \\ \text{sg} \end{bmatrix} = [f, f^h]$$

$$\begin{bmatrix} \text{fv} \\ \text{sd} \\ \text{lb} \\ \text{vc} \end{bmatrix} = [v]$$

$$\begin{bmatrix} \text{fv} \\ \text{sd} \\ \text{ns} \\ \text{cr} \end{bmatrix} = [{}^n s, {}^n s, s^n, s^n]$$

$$\begin{bmatrix} \text{fv} \\ \text{sd} \\ \text{ns} \\ \text{cr} \\ \text{vc} \end{bmatrix} = [{}^n z, {}^n z, z^n, z^n]$$

$$\begin{bmatrix} \text{fv} \\ \text{sd} \\ \text{rd} \\ \text{cr} \end{bmatrix} = [s^w, s^w]$$

$$\begin{bmatrix} \text{fv} \\ \text{sg} \end{bmatrix} = [h, h]$$

$$\begin{bmatrix} \text{fv} \\ \text{vc} \end{bmatrix} = [h, h]$$

$$\begin{bmatrix} \text{fv} \\ \text{vc} \\ \text{sg} \end{bmatrix} = [h, h]$$

$$\begin{bmatrix} \text{hi} \\ \text{fn} \\ \text{rr} \\ \text{vc} \end{bmatrix} = [l, \frac{i}{t}, \frac{e}{t}]$$

$$\begin{bmatrix} \text{hi} \\ \text{fn} \\ \text{vc} \end{bmatrix} = [i, i, j, i, \frac{i}{t}]$$

$$\begin{bmatrix} \text{hi} \\ \text{rr} \\ \text{vc} \end{bmatrix} = [i, i]$$

$$\begin{bmatrix} \text{hi} \\ \text{vc} \end{bmatrix} = [i]$$

$$\begin{bmatrix} \text{hi} \\ \text{vc} \end{bmatrix} = [u, u]$$

$$\begin{bmatrix} \text{lb} \\ \text{rd} \\ \text{dr} \\ \text{hi} \\ \text{fn} \\ \text{vc} \end{bmatrix} = [u, w^j]$$

SAMPLE SPEECH SOUNDS AND THEIR FEATURES

$\begin{bmatrix} \text{lb} \\ \text{rd} \\ \text{dr} \\ \text{hi} \\ \text{sg} \end{bmatrix} = [\text{ʌ}, \text{ʌ}^h, \text{w}^{\frac{h}{\text{g}}}]$

$\begin{bmatrix} \text{lb} \\ \text{rd} \\ \text{dr} \\ \text{hi} \\ \text{vc} \end{bmatrix} = [\text{w}]$

$\begin{bmatrix} \text{lb} \\ \text{rd} \\ \text{hi} \\ \text{fn} \\ \text{vc} \end{bmatrix} = [\text{ʋ}, \text{w}^j]$

$\begin{bmatrix} \text{lb} \\ \text{rd} \\ \text{hi} \\ \text{vc} \end{bmatrix} = [\text{w}]$

$\begin{bmatrix} \text{lb} \\ \text{vc} \end{bmatrix} = [\text{v}, \beta]$

$\begin{bmatrix} \text{lo} \\ \text{fn} \\ \text{rr} \\ \text{vc} \end{bmatrix} = [\text{a}, \text{a}, \text{a}, \text{a}, \text{æ}]$

$\begin{bmatrix} \text{lo} \\ \text{fn} \\ \text{rr} \\ \text{vc} \\ \text{cg} \end{bmatrix} = [\text{a}, \text{a}, \text{a}, \text{a}, \text{æ}]$

$\begin{bmatrix} \text{lo} \\ \text{fn} \\ \text{rr} \\ \text{vc} \\ \text{sg} \end{bmatrix} = [\text{a}, \text{a}, \text{a}, \text{a}, \text{æ}, \text{a}, \text{a}, \text{a}]$

$\begin{bmatrix} \text{lo} \\ \text{fn} \\ \text{vc} \end{bmatrix} = [\text{æ}, \text{a}]$

$\begin{bmatrix} \text{lo} \\ \text{rr} \\ \text{vc} \end{bmatrix} = [\text{a}, \text{a}, \text{a}, \text{a}]$

$\begin{bmatrix} \text{lo} \\ \text{rr} \\ \text{vc} \end{bmatrix} = [\text{a}, \text{a}]$

$\begin{bmatrix} \text{lo} \\ \text{rr} \\ \text{vc} \\ \text{cg} \end{bmatrix} = [\text{a}, \text{a}, \text{a}, \text{a}]$

$\begin{bmatrix} \text{lo} \\ \text{rr} \\ \text{vc} \\ \text{sg} \end{bmatrix} = [\text{a}, \text{a}, \text{a}, \text{a}, \text{a}, \text{a}, \text{a}, \text{a}]$

$\text{a}^h, \text{a}^h, \text{a}^h, \text{a}^h$

$\begin{bmatrix} \text{lo} \\ \text{sg} \end{bmatrix} = [\text{h}, \text{h}^h, \text{h}]$

$\begin{bmatrix} \text{lo} \\ \text{vc} \end{bmatrix} = [\text{e}]$

$\begin{bmatrix} \text{lo} \\ \text{vc} \end{bmatrix} = [\text{ɪ}, \text{h}]$

$\begin{bmatrix} \text{lt} \\ \text{cr} \\ \text{hi} \\ \text{vc} \end{bmatrix} = [\text{t}]$

$\begin{bmatrix} \text{lt} \\ \text{cr} \\ \text{ps} \\ \text{lm} \\ \text{hi} \\ \text{vc} \end{bmatrix} = [\text{ʌ}]$

$\begin{bmatrix} \text{lt} \\ \text{cr} \\ \text{ps} \\ \text{lm} \\ \text{vc} \end{bmatrix} = [\text{ʌ}]$

$\begin{bmatrix} \text{lt} \\ \text{cr} \\ \text{ps} \\ \text{vc} \end{bmatrix} = [\text{ʌ}]$

$\begin{bmatrix} \text{lt} \\ \text{cr} \\ \text{rr} \\ \text{vc} \end{bmatrix} = [\text{t}]$

$\begin{bmatrix} \text{lt} \\ \text{cr} \\ \text{vc} \end{bmatrix} = [\text{l}]$

$\begin{bmatrix} \text{lt} \\ \text{dr} \\ \text{hi} \\ \text{vc} \end{bmatrix} = [\text{L}]$

$\begin{bmatrix} \text{ns} \\ \text{cr} \\ \text{hi} \end{bmatrix} = [\text{h}]$

$\begin{bmatrix} \text{ns} \\ \text{cr} \\ \text{ps} \\ \text{lm} \\ \text{vc} \end{bmatrix} = [\text{n}]$

$\begin{bmatrix} \text{ns} \\ \text{cr} \\ \text{ps} \\ \text{vc} \end{bmatrix} = [\text{n}]$

$\begin{bmatrix} \text{ns} \\ \text{cr} \\ \text{rr} \end{bmatrix} = [\text{h}]$

$\begin{bmatrix} \text{ns} \\ \text{cr} \\ \text{sg} \end{bmatrix} = [\text{h}, \text{n}^h]$

$\begin{bmatrix} \text{ns} \\ \text{cr} \\ \text{vc} \end{bmatrix} = [\text{n}]$

$\begin{bmatrix} \text{ns} \\ \text{dr} \\ \text{hi} \\ \text{vc} \end{bmatrix} = [\text{n}]$

$\begin{bmatrix} \text{ns} \\ \text{dr} \\ \text{rr} \\ \text{vc} \end{bmatrix} = [\text{N}]$

SAMPLE SPEECH SOUNDS AND THEIR FEATURES

$\begin{bmatrix} \text{ns} \\ \text{dr} \\ \text{vc} \end{bmatrix} = [\text{N}]$

$\begin{bmatrix} \text{ns} \\ \text{fn} \\ \text{vc} \end{bmatrix} = [\tilde{\epsilon}, \hat{\eta}]$

$\begin{bmatrix} \text{ns} \\ \text{lb} \\ \text{hi} \end{bmatrix} = [\mathfrak{m}]$

$\begin{bmatrix} \text{ns} \\ \text{lb} \\ \text{rr} \end{bmatrix} = [\mathfrak{m}]$

$\begin{bmatrix} \text{ns} \\ \text{lb} \\ \text{vc} \end{bmatrix} = [\text{m}, \mathfrak{m}]$

$\begin{bmatrix} \text{ns} \\ \text{vc} \end{bmatrix} = [\text{N}]$

$\begin{bmatrix} \text{ps} \\ \text{fn} \\ \text{rr} \\ \text{vc} \end{bmatrix} = [\epsilon]$

$\begin{bmatrix} \text{ps} \\ \text{fn} \\ \text{vc} \end{bmatrix} = [\epsilon]$

$\begin{bmatrix} \text{ps} \\ \text{hi} \\ \text{fn} \\ \text{vc} \end{bmatrix} = [\text{i}]$

$\begin{bmatrix} \text{ps} \\ \text{rr} \\ \text{vc} \end{bmatrix} = [\mathfrak{z}]$

$\begin{bmatrix} \text{ps} \\ \text{vc} \end{bmatrix} = [\mathfrak{z}]$

$\begin{bmatrix} \text{ps} \\ \text{vc} \end{bmatrix} = [\mathfrak{z}]$

$\begin{bmatrix} \text{rd} \\ \text{cr} \\ \text{ps} \\ \text{lm} \\ \text{vc} \end{bmatrix} = [\text{u}]$

$\begin{bmatrix} \text{rd} \\ \text{dr} \\ \text{hi} \\ \text{fn} \\ \text{vc} \end{bmatrix} = [\text{u}, \text{w}^j]$

$\begin{bmatrix} \text{rd} \\ \text{dr} \\ \text{hi} \\ \text{sg} \end{bmatrix} = [\mathfrak{M}, \mathfrak{M}, \mathfrak{W}, \text{w}^h]$

$\begin{bmatrix} \text{rd} \\ \text{dr} \\ \text{hi} \\ \text{vc} \end{bmatrix} = [\text{w}, \mathfrak{M}]$

$\begin{bmatrix} \text{rd} \\ \text{fn} \\ \text{rr} \\ \text{vc} \end{bmatrix} = [\mathfrak{ae}, \mathfrak{ae}, \mathfrak{e}, \mathfrak{e}]$

$\begin{bmatrix} \text{rd} \\ \text{fn} \\ \text{vc} \end{bmatrix} = [\emptyset, \emptyset, \mathfrak{e}, \mathfrak{e}]$

$\begin{bmatrix} \text{rd} \\ \text{hi} \\ \text{fn} \\ \text{rr} \\ \text{vc} \end{bmatrix} = [\text{y}, \text{y}, \mathfrak{y}, \mathfrak{y}, \mathfrak{e}]$

$\begin{bmatrix} \text{rd} \\ \text{hi} \\ \text{fn} \\ \text{vc} \end{bmatrix} = [\text{y}, \text{y}, \mathfrak{y}, \mathfrak{y}]$

$\begin{bmatrix} \text{rd} \\ \text{hi} \\ \text{rr} \\ \text{vc} \end{bmatrix} = [\mathfrak{u}]$

$\begin{bmatrix} \text{rd} \\ \text{hi} \\ \text{rr} \\ \text{vc} \end{bmatrix} = [\text{u}]$

$\begin{bmatrix} \text{rd} \\ \text{hi} \\ \text{vc} \end{bmatrix} = [\text{u}]$

$\begin{bmatrix} \text{rd} \\ \text{hi} \\ \text{vc} \end{bmatrix} = [\mathfrak{u}]$

$\begin{bmatrix} \text{rd} \\ \text{lo} \\ \text{rr} \\ \text{vc} \end{bmatrix} = [\text{v}]$

$\begin{bmatrix} \text{rd} \\ \text{ps} \\ \text{hi} \\ \text{vc} \end{bmatrix} = [\text{u}]$

$\begin{bmatrix} \text{rd} \\ \text{ps} \\ \text{rr} \\ \text{vc} \end{bmatrix} = [\mathfrak{v}]$

$\begin{bmatrix} \text{rd} \\ \text{rr} \\ \text{vc} \end{bmatrix} = [\mathfrak{e}, \mathfrak{v}]$

$\begin{bmatrix} \text{rd} \\ \text{vc} \end{bmatrix} = [\mathfrak{e}, \mathfrak{v}]$

$\begin{bmatrix} \text{rh} \\ \text{cr} \\ \text{hi} \end{bmatrix} = [\mathfrak{x}, \mathfrak{f}]$

$\begin{bmatrix} \text{rh} \\ \text{cr} \\ \text{ps} \\ \text{lm} \\ \text{vc} \end{bmatrix} = [\text{ɹ}]$

$\begin{bmatrix} \text{rh} \\ \text{cr} \\ \text{ps} \\ \text{vc} \end{bmatrix} = [\mathfrak{r}, \text{ɹ}]$

$\begin{bmatrix} \text{rh} \\ \text{cr} \\ \text{rr} \end{bmatrix} = [\mathfrak{x}, \mathfrak{f}]$

$\begin{bmatrix} \text{rh} \\ \text{cr} \\ \text{vc} \end{bmatrix} = [\text{r}, \mathfrak{r}, \text{ɹ}]$

$\begin{bmatrix} \text{rh} \\ \text{dr} \\ \text{vc} \end{bmatrix} = [\text{R}]$

SAMPLE SPEECH SOUNDS AND THEIR FEATURES

$\begin{bmatrix} \text{rh} \\ \text{dr} \\ \text{rr} \\ \text{vc} \end{bmatrix} = [\text{R}]$

$\begin{bmatrix} \text{rh} \\ \text{lb} \\ \text{vc} \end{bmatrix} = [\text{B}]$

$\begin{bmatrix} \text{rr} \\ \text{vc} \end{bmatrix} = [\text{ʒ}, \text{ʌ}]$

$\begin{bmatrix} \text{st} \\ \text{cg} \end{bmatrix} = [\text{ʔ}]$

$\begin{bmatrix} \text{st} \\ \text{cr} \end{bmatrix} = [\text{t}, \text{d}]$

$\begin{bmatrix} \text{st} \\ \text{cr} \end{bmatrix} = [\text{t}]$

$\begin{bmatrix} \text{st} \\ \text{cr} \\ \text{cg} \end{bmatrix} = [\text{t}', \text{ }^2\text{t}]$

$\begin{bmatrix} \text{st} \\ \text{cr} \\ \text{dr} \end{bmatrix} = [\text{!}]$

$\begin{bmatrix} \text{st} \\ \text{cr} \\ \text{fn} \end{bmatrix} = [\text{t}^j, \text{d}^j, \text{ }^j\text{t}, \text{ }^j\text{d}]$

$\begin{bmatrix} \text{st} \\ \text{cr} \\ \text{fn} \end{bmatrix} = [\text{t}^j]$

$\begin{bmatrix} \text{st} \\ \text{cr} \\ \text{fn} \\ \text{vc} \end{bmatrix} = [\text{d}^j]$

$\begin{bmatrix} \text{st} \\ \text{cr} \\ \text{hi} \end{bmatrix} = [\text{t}]$

$\begin{bmatrix} \text{st} \\ \text{cr} \\ \text{hi} \end{bmatrix} = [\text{t}^{\text{ʁ}}, \text{d}^{\text{ʁ}}, \text{ }^{\text{ʁ}}\text{t}, \text{ }^{\text{ʁ}}\text{d}, \text{t}^{\text{ʉ}}, \text{d}^{\text{ʉ}}, \text{ }^{\text{ʉ}}\text{t}, \text{ }^{\text{ʉ}}\text{d}]$

$\begin{bmatrix} \text{st} \\ \text{cr} \\ \text{hi} \\ \text{vc} \end{bmatrix} = [\text{d}^{\text{ʁ}}]$

$\begin{bmatrix} \text{st} \\ \text{cr} \\ \text{lm} \end{bmatrix} = [\text{t}^{\text{ʁ}}]$

$\begin{bmatrix} \text{st} \\ \text{cr} \\ \text{lm} \end{bmatrix} = [\text{t}^{\text{ʁ}}]$

$\begin{bmatrix} \text{st} \\ \text{cr} \\ \text{lm} \end{bmatrix} = [\text{t}^{\text{θ}}]$

$\begin{bmatrix} \text{st} \\ \text{cr} \\ \text{lm} \\ \text{dr} \end{bmatrix} = [\text{l}, \text{q}^{\text{l}}]$

$\begin{bmatrix} \text{st} \\ \text{cr} \\ \text{lm} \\ \text{dr} \\ \text{hi} \end{bmatrix} = [\text{l}, \text{k}^{\text{l}}]$

$\begin{bmatrix} \text{st} \\ \text{cr} \\ \text{lm} \\ \text{dr} \\ \text{hi} \\ \text{sg} \end{bmatrix} = [\text{l}^{\text{h}}, \text{k}^{\text{h}}]$

$\begin{bmatrix} \text{st} \\ \text{cr} \\ \text{lm} \\ \text{dr} \\ \text{hi} \\ \text{vc} \end{bmatrix} = [\text{l}, \text{g}^{\text{l}}]$

$\begin{bmatrix} \text{st} \\ \text{cr} \\ \text{lm} \\ \text{vc} \end{bmatrix} = [\text{d}^{\text{ʁ}}]$

$\begin{bmatrix} \text{st} \\ \text{cr} \\ \text{lm} \\ \text{vc} \end{bmatrix} = [\text{d}^{\text{ʁ}}]$

$\begin{bmatrix} \text{st} \\ \text{cr} \\ \text{lm} \\ \text{vc} \end{bmatrix} = [\text{d}^{\text{θ}}]$

$\begin{bmatrix} \text{st} \\ \text{cr} \\ \text{lm} \\ \text{vc} \end{bmatrix} = [\text{d}^{\text{n}}]$

$\begin{bmatrix} \text{st} \\ \text{cr} \\ \text{lm} \\ \text{vc} \\ \text{cg} \end{bmatrix} = [\text{d}, \text{d}^{\text{ʁ}}, \text{d}^{\text{ʁ}}]$

$\begin{bmatrix} \text{st} \\ \text{cr} \\ \text{ps} \end{bmatrix} = [\text{t}, \text{d}^{\text{ʁ}}]$

$\begin{bmatrix} \text{st} \\ \text{cr} \\ \text{ps} \\ \text{dr} \end{bmatrix} = [\text{q}^{\text{!}}, \text{!q}]$

$\begin{bmatrix} \text{st} \\ \text{cr} \\ \text{ps} \\ \text{dr} \\ \text{hi} \end{bmatrix} = [\text{!}, \text{k}^{\text{!}}]$

$\begin{bmatrix} \text{st} \\ \text{cr} \\ \text{ps} \\ \text{dr} \\ \text{hi} \\ \text{sg} \end{bmatrix} = [\text{!}^{\text{h}}, \text{k}^{\text{h}}]$

$\begin{bmatrix} \text{st} \\ \text{cr} \\ \text{ps} \\ \text{dr} \\ \text{hi} \\ \text{vc} \end{bmatrix} = [\text{l}, \text{g}^{\text{l}}]$

SAMPLE SPEECH SOUNDS AND THEIR FEATURES

$$\begin{bmatrix} \text{st} \\ \text{cr} \\ \text{ps} \\ \text{lm} \end{bmatrix} = [c, \text{ʃ}]$$

$$\begin{bmatrix} \text{st} \\ \text{cr} \\ \text{ps} \\ \text{lm} \\ \text{dr} \\ \text{hi} \end{bmatrix} = [\text{ʈ}, k\text{ʈ}]$$

$$\begin{bmatrix} \text{st} \\ \text{cr} \\ \text{ps} \\ \text{lm} \\ \text{dr} \\ \text{hi} \\ \text{sg} \end{bmatrix} = [\text{ʈ}^h, k\text{ʈ}^h]$$

$$\begin{bmatrix} \text{st} \\ \text{cr} \\ \text{ps} \\ \text{lm} \\ \text{dr} \\ \text{hi} \\ \text{vc} \end{bmatrix} = [\text{ʈ}, g\text{ʈ}]$$

$$\begin{bmatrix} \text{st} \\ \text{cr} \\ \text{ps} \\ \text{lm} \\ \text{vc} \end{bmatrix} = [\text{ʈ}, \text{ç}]$$

$$\begin{bmatrix} \text{st} \\ \text{cr} \\ \text{ps} \\ \text{lm} \\ \text{vc} \\ \text{cg} \end{bmatrix} = [f]$$

$$\begin{bmatrix} \text{st} \\ \text{cr} \\ \text{ps} \\ \text{vc} \end{bmatrix} = [d, \text{ʈ}]$$

$$\begin{bmatrix} \text{st} \\ \text{cr} \\ \text{rr} \end{bmatrix} = [t^{\text{f}}, d^{\text{f}}, \text{ʔ}t, \text{ʔ}d, \text{ʈ}, d]$$

$$\begin{bmatrix} \text{st} \\ \text{cr} \\ \text{rr} \end{bmatrix} = [\text{ʈ}]$$

$$\begin{bmatrix} \text{st} \\ \text{cr} \\ \text{rr} \end{bmatrix} = [t^{\text{f}}]$$

$$\begin{bmatrix} \text{st} \\ \text{cr} \\ \text{rr} \\ \text{vc} \end{bmatrix} = [d]$$

$$\begin{bmatrix} \text{st} \\ \text{cr} \\ \text{rr} \\ \text{vc} \end{bmatrix} = [d^{\text{f}}]$$

$$\begin{bmatrix} \text{st} \\ \text{cr} \\ \text{sg} \end{bmatrix} = [t^h]$$

$$\begin{bmatrix} \text{st} \\ \text{cr} \\ \text{sg} \end{bmatrix} = [t^h]$$

$$\begin{bmatrix} \text{st} \\ \text{cr} \\ \text{vc} \end{bmatrix} = [d, \text{ʈ}]$$

$$\begin{bmatrix} \text{st} \\ \text{cr} \\ \text{vc} \end{bmatrix} = [d]$$

$$\begin{bmatrix} \text{st} \\ \text{cr} \\ \text{vc} \\ \text{cg} \end{bmatrix} = [d]$$

$$\begin{bmatrix} \text{st} \\ \text{cr} \\ \text{vc} \\ \text{sg} \end{bmatrix} = [d^h, d^{\text{h}}]$$

$$\begin{bmatrix} \text{st} \\ \text{dr} \end{bmatrix} = [q, g]$$

$$\begin{bmatrix} \text{st} \\ \text{dr} \end{bmatrix} = [q, g]$$

$$\begin{bmatrix} \text{st} \\ \text{dr} \\ \text{cg} \end{bmatrix} = [q', \text{ʔ}q]$$

$$\begin{bmatrix} \text{st} \\ \text{dr} \\ \text{hi} \end{bmatrix} = [k, g, k^{\text{y}}, g^{\text{y}}, k^{\text{u}}, g^{\text{u}}]$$

$$\begin{bmatrix} \text{st} \\ \text{dr} \\ \text{hi} \\ \text{cg} \end{bmatrix} = [k', \text{ʔ}k]$$

$$\begin{bmatrix} \text{st} \\ \text{dr} \\ \text{hi} \\ \text{fn} \end{bmatrix} = [k^j, g^j, \text{ʔ}k, \text{ʔ}g]$$

$$\begin{bmatrix} \text{st} \\ \text{dr} \\ \text{hi} \\ \text{sg} \end{bmatrix} = [k^h, \text{ʔ}k]$$

$$\begin{bmatrix} \text{st} \\ \text{dr} \\ \text{hi} \\ \text{vc} \end{bmatrix} = [g]$$

$$\begin{bmatrix} \text{st} \\ \text{dr} \\ \text{hi} \\ \text{vc} \\ \text{cg} \end{bmatrix} = [g]$$

$$\begin{bmatrix} \text{st} \\ \text{dr} \\ \text{rr} \end{bmatrix} = [q, g]$$

$$\begin{bmatrix} \text{st} \\ \text{dr} \\ \text{rr} \\ \text{vc} \end{bmatrix} = [g, q]$$

$$\begin{bmatrix} \text{st} \\ \text{dr} \\ \text{rr} \\ \text{vc} \\ \text{cg} \end{bmatrix} = [g]$$

SAMPLE SPEECH SOUNDS AND THEIR FEATURES

$\begin{bmatrix} \text{st} \\ \text{dr} \\ \text{sg} \end{bmatrix} = [q^h, {}^h q]$

$\begin{bmatrix} \text{st} \\ \text{dr} \\ \text{vc} \end{bmatrix} = [g, g]$

$\begin{bmatrix} \text{st} \\ \text{dr} \\ \text{vc} \\ \text{cg} \end{bmatrix} = [g']$

$\begin{bmatrix} \text{st} \\ \text{lb} \end{bmatrix} = [p, b]$

$\begin{bmatrix} \text{st} \\ \text{lb} \\ \text{cg} \end{bmatrix} = [p', {}^p p]$

$\begin{bmatrix} \text{st} \\ \text{lb} \\ \text{cr} \end{bmatrix} = [t]$

$\begin{bmatrix} \text{st} \\ \text{lb} \\ \text{cr} \\ \text{vc} \end{bmatrix} = [d]$

$\begin{bmatrix} \text{st} \\ \text{lb} \\ \text{dr} \end{bmatrix} = [q\hat{p}]$

$\begin{bmatrix} \text{st} \\ \text{lb} \\ \text{dr} \end{bmatrix} = [q\odot]$

$\begin{bmatrix} \text{st} \\ \text{lb} \\ \text{dr} \\ \text{hi} \end{bmatrix} = [k\hat{p}]$

$\begin{bmatrix} \text{st} \\ \text{lb} \\ \text{dr} \\ \text{hi} \end{bmatrix} = [\odot, k\odot]$

$\begin{bmatrix} \text{st} \\ \text{lb} \\ \text{dr} \\ \text{hi} \\ \text{vc} \end{bmatrix} = [g\hat{b}]$

$\begin{bmatrix} \text{st} \\ \text{lb} \\ \text{dr} \\ \text{hi} \\ \text{vc} \end{bmatrix} = [\odot, g\odot]$

$\begin{bmatrix} \text{st} \\ \text{lb} \\ \text{dr} \\ \text{rr} \end{bmatrix} = [q\odot]$

$\begin{bmatrix} \text{st} \\ \text{lb} \\ \text{dr} \\ \text{rr} \\ \text{vc} \end{bmatrix} = [g\odot]$

$\begin{bmatrix} \text{st} \\ \text{lb} \\ \text{dr} \\ \text{vc} \end{bmatrix} = [g\odot]$

$\begin{bmatrix} \text{st} \\ \text{lb} \\ \text{fn} \end{bmatrix} = [p^j, b^j, {}^j p, {}^j b]$

$\begin{bmatrix} \text{st} \\ \text{lb} \\ \text{hi} \end{bmatrix} = [p]$

$\begin{bmatrix} \text{st} \\ \text{lb} \\ \text{hi} \end{bmatrix} = [p^v, b^v, {}^v p, {}^v b, p^u, b^u, {}^u p, {}^u b]$

$\begin{bmatrix} \text{st} \\ \text{lb} \\ \text{hi} \\ \text{vc} \end{bmatrix} = [b]$

$\begin{bmatrix} \text{st} \\ \text{lb} \\ \text{rd} \end{bmatrix} = [p^w, b^w, {}^w p, {}^w b]$

$\begin{bmatrix} \text{st} \\ \text{lb} \\ \text{rr} \end{bmatrix} = [p^f, b^f, {}^f p, {}^f b, p, b]$

$\begin{bmatrix} \text{st} \\ \text{lb} \\ \text{rr} \end{bmatrix} = [p]$

$\begin{bmatrix} \text{st} \\ \text{lb} \\ \text{rr} \\ \text{vc} \end{bmatrix} = [b]$

$\begin{bmatrix} \text{st} \\ \text{lb} \\ \text{sg} \end{bmatrix} = [p^h]$

$\begin{bmatrix} \text{st} \\ \text{lb} \\ \text{vc} \end{bmatrix} = [b, p]$

$\begin{bmatrix} \text{st} \\ \text{lb} \\ \text{vc} \\ \text{cg} \end{bmatrix} = [b]$

$\begin{bmatrix} \text{st} \\ \text{lb} \\ \text{vc} \\ \text{cg} \end{bmatrix} = [b]$

$\begin{bmatrix} \text{st} \\ \text{lb} \\ \text{vc} \\ \text{sg} \end{bmatrix} = [b, b^h, b^{\hat{h}}]$

$\begin{bmatrix} \text{st} \\ \text{lt} \\ \text{cr} \end{bmatrix} = [t^l, d^l, {}^l t, {}^l d]$

$\begin{bmatrix} \text{st} \\ \text{lt} \\ \text{cr} \\ \text{dr} \end{bmatrix} = [q\parallel]$

$\begin{bmatrix} \text{st} \\ \text{lt} \\ \text{cr} \\ \text{dr} \\ \text{hi} \end{bmatrix} = [\parallel, k\parallel]$

$\begin{bmatrix} \text{st} \\ \text{lt} \\ \text{cr} \\ \text{dr} \\ \text{hi} \\ \text{vc} \end{bmatrix} = [\parallel, g\parallel]$

SAMPLE SPEECH SOUNDS AND THEIR FEATURES

$$\begin{bmatrix} \text{st} \\ \text{lt} \\ \text{cr} \\ \text{dr} \\ \text{rr} \\ \text{vc} \end{bmatrix} = [\text{gll}]$$

$$\begin{bmatrix} \text{st} \\ \text{lt} \\ \text{cr} \\ \text{dr} \\ \text{vc} \end{bmatrix} = [\text{gll}]$$

$$\begin{bmatrix} \text{st} \\ \text{lt} \\ \text{dr} \end{bmatrix} = [\text{q}^{\text{l}}, \text{g}^{\text{l}}, \text{q}^{\text{l}}, \text{g}^{\text{l}}, \text{q}^{\text{l}}, \text{g}^{\text{l}},$$

$$\text{q}^{\text{l}}, \text{g}^{\text{l}}]$$

$$\begin{bmatrix} \text{st} \\ \text{lt} \\ \text{dr} \end{bmatrix} = [\text{q}^{\text{l}}, \text{g}^{\text{l}}, \text{q}^{\text{l}}, \text{g}^{\text{l}}, \text{q}^{\text{l}}, \text{g}^{\text{l}},$$

$$\text{q}^{\text{l}}, \text{g}^{\text{l}}]$$

$$\begin{bmatrix} \text{st} \\ \text{lt} \\ \text{dr} \\ \text{hi} \end{bmatrix} = [\text{k}^{\text{l}}, \text{g}^{\text{l}}, \text{k}^{\text{l}}, \text{g}^{\text{l}}, \text{k}^{\text{l}}, \text{g}^{\text{l}},$$

$$\text{k}^{\text{l}}, \text{g}^{\text{l}}]$$

$$\begin{bmatrix} \text{st} \\ \text{lt} \\ \text{lb} \end{bmatrix} = [\text{p}^{\text{l}}, \text{b}^{\text{l}}, \text{p}^{\text{l}}, \text{b}^{\text{l}}]$$

$$\begin{bmatrix} \text{st} \\ \text{lt} \\ \text{ns} \\ \text{cr} \\ \text{dr} \\ \text{hi} \end{bmatrix} = [\text{ll}, \text{ll}]$$

$$\begin{bmatrix} \text{st} \\ \text{lt} \\ \text{ns} \\ \text{cr} \\ \text{dr} \\ \text{hi} \\ \text{vc} \end{bmatrix} = [\text{ll}, \text{ll}]$$

$$\begin{bmatrix} \text{st} \\ \text{ns} \\ \text{cr} \end{bmatrix} = [\text{t}, \text{t}]$$

$$\begin{bmatrix} \text{st} \\ \text{ns} \\ \text{cr} \\ \text{ps} \\ \text{lm} \end{bmatrix} = [\text{c}]$$

$$\begin{bmatrix} \text{st} \\ \text{ns} \\ \text{cr} \\ \text{ps} \\ \text{lm} \\ \text{vc} \end{bmatrix} = [\text{c}]$$

$$\begin{bmatrix} \text{st} \\ \text{ns} \\ \text{cr} \\ \text{vc} \end{bmatrix} = [\text{d}, \text{d}]$$

$$\begin{bmatrix} \text{st} \\ \text{ns} \\ \text{dr} \end{bmatrix} = [\text{q}, \text{q}]$$

$$\begin{bmatrix} \text{st} \\ \text{ns} \\ \text{dr} \\ \text{hi} \end{bmatrix} = [\text{k}, \text{k}]$$

$$\begin{bmatrix} \text{st} \\ \text{ns} \\ \text{dr} \\ \text{hi} \\ \text{vc} \end{bmatrix} = [\text{g}, \text{g}]$$

$$\begin{bmatrix} \text{st} \\ \text{ns} \\ \text{dr} \\ \text{rr} \end{bmatrix} = [\text{q}, \text{q}]$$

$$\begin{bmatrix} \text{st} \\ \text{ns} \\ \text{dr} \\ \text{rr} \\ \text{vc} \end{bmatrix} = [\text{G}, \text{G}]$$

$$\begin{bmatrix} \text{st} \\ \text{ns} \\ \text{dr} \\ \text{vc} \end{bmatrix} = [\text{G}, \text{G}]$$

$$\begin{bmatrix} \text{st} \\ \text{ns} \\ \text{lb} \end{bmatrix} = [\text{p}, \text{p}]$$

$$\begin{bmatrix} \text{st} \\ \text{ns} \\ \text{lb} \\ \text{dr} \\ \text{hi} \end{bmatrix} = [\text{c}, \text{c}, \text{c}]$$

$$\begin{bmatrix} \text{st} \\ \text{ns} \\ \text{lb} \\ \text{dr} \\ \text{hi} \\ \text{vc} \end{bmatrix} = [\text{c}, \text{c}]$$

$$\begin{bmatrix} \text{st} \\ \text{ns} \\ \text{lb} \\ \text{vc} \end{bmatrix} = [\text{b}, \text{b}]$$

$$\begin{bmatrix} \text{st} \\ \text{rd} \\ \text{cr} \end{bmatrix} = [\text{t}, \text{t}, \text{t}]$$

$$\begin{bmatrix} \text{st} \\ \text{rd} \\ \text{cr} \\ \text{ps} \\ \text{lm} \end{bmatrix} = [\text{c}, \text{c}]$$

$$\begin{bmatrix} \text{st} \\ \text{rd} \\ \text{cr} \\ \text{vc} \end{bmatrix} = [\text{d}, \text{d}, \text{d}]$$

$$\begin{bmatrix} \text{st} \\ \text{rd} \\ \text{dr} \end{bmatrix} = [\text{q}, \text{q}, \text{q}]$$

$$\begin{bmatrix} \text{st} \\ \text{rd} \\ \text{dr} \\ \text{hi} \end{bmatrix} = [\text{k}, \text{k}, \text{k}]$$

SAMPLE SPEECH SOUNDS AND THEIR FEATURES

$$\begin{bmatrix} \text{st} \\ \text{rd} \\ \text{dr} \\ \text{rr} \end{bmatrix} = [q^w, \text{ʒ}^w, {}^wq, {}^w\text{ʒ}]$$

$$\begin{bmatrix} \text{st} \\ \text{rd} \\ \text{dr} \\ \text{rr} \\ \text{vc} \end{bmatrix} = [G^w, q^w, {}^wG, {}^wq]$$

$$\begin{bmatrix} \text{st} \\ \text{rd} \\ \text{dr} \\ \text{vc} \end{bmatrix} = [G^w, q^w, {}^wG, {}^wq]$$

$$\begin{bmatrix} \text{st} \\ \text{rh} \\ \text{cr} \end{bmatrix} = [t^r, \text{d}^r, t^r, \text{d}^r, {}^1t, {}^1\text{d}, {}^1t,$$

$$\begin{bmatrix} \text{st} \\ \text{rh} \\ \text{dr} \\ \text{hi} \end{bmatrix} = [k^r, \text{ʒ}^r, {}^rk, {}^r\text{ʒ}, k^1, \text{ʒ}^1,$$

$$\begin{bmatrix} \text{st} \\ \text{rh} \\ \text{lb} \end{bmatrix} = [p^r, \text{b}^r, p^1, \text{b}^1, {}^rp, {}^rb,$$

$$\begin{bmatrix} \text{st} \\ \text{rt} \\ \text{dr} \end{bmatrix} = [q^r, \text{ʒ}^r, {}^rq, {}^r\text{ʒ}, q^1, \text{ʒ}^1,$$

$$\begin{bmatrix} \text{st} \\ \text{sd} \\ \text{cr} \end{bmatrix} = [t^s, \text{ts}]$$

$$\begin{bmatrix} \text{st} \\ \text{sd} \\ \text{cr} \\ \text{cg} \end{bmatrix} = [t^s, \text{ts}, {}^2t^s, {}^2\text{ts}]$$

$$\begin{bmatrix} \text{st} \\ \text{sd} \\ \text{cr} \\ \text{ps} \\ \text{lm} \\ \text{fn} \end{bmatrix} = [t^e, t^{\text{ej}}, \text{te}, \text{te}^j]$$

$$\begin{bmatrix} \text{st} \\ \text{sd} \\ \text{cr} \\ \text{ps} \\ \text{lm} \\ \text{fn} \\ \text{sg} \end{bmatrix} = [t^{\text{eh}}, t^{\text{ejh}}, \text{te}^h, \text{te}^{\text{jh}}]$$

$$\begin{bmatrix} \text{st} \\ \text{sd} \\ \text{cr} \\ \text{ps} \\ \text{lm} \\ \text{fn} \\ \text{vc} \end{bmatrix} = [d^z, d^{\text{zj}}, \text{dz}, \text{dz}^j]$$

$$\begin{bmatrix} \text{st} \\ \text{sd} \\ \text{cr} \\ \text{ps} \\ \text{lm} \\ \text{hi} \end{bmatrix} = [t^f, \text{tf}]$$

$$\begin{bmatrix} \text{st} \\ \text{sd} \\ \text{cr} \\ \text{ps} \\ \text{lm} \\ \text{hi} \\ \text{cg} \end{bmatrix} = [t^f, \text{tf}]$$

$$\begin{bmatrix} \text{st} \\ \text{sd} \\ \text{cr} \\ \text{ps} \\ \text{lm} \\ \text{hi} \\ \text{sg} \end{bmatrix} = [t^{\text{fh}}, \text{tf}^h]$$

$$\begin{bmatrix} \text{st} \\ \text{sd} \\ \text{cr} \\ \text{ps} \\ \text{lm} \\ \text{hi} \\ \text{vc} \end{bmatrix} = [d^z, \text{dz}]$$

$$\begin{bmatrix} \text{st} \\ \text{sd} \\ \text{cr} \\ \text{sg} \end{bmatrix} = [t^{\text{sh}}, \text{ts}^h]$$

$$\begin{bmatrix} \text{st} \\ \text{sd} \\ \text{cr} \\ \text{vc} \end{bmatrix} = [d^z, \text{dz}]$$

$$\begin{bmatrix} \text{st} \\ \text{sd} \\ \text{dr} \\ \text{hi} \end{bmatrix} = [k^x]$$

$$\begin{bmatrix} \text{st} \\ \text{sd} \\ \text{lb} \end{bmatrix} = [p^f]$$

$$\begin{bmatrix} \text{st} \\ \text{sd} \\ \text{lb} \\ \text{rd} \end{bmatrix} = [p^{\text{fw}}]$$

$$\begin{bmatrix} \text{st} \\ \text{sd} \\ \text{lb} \\ \text{vc} \end{bmatrix} = [b^v]$$

$$\begin{bmatrix} \text{st} \\ \text{sd} \\ \text{ns} \\ \text{cr} \end{bmatrix} = [{}^nt^s]$$

$$\begin{bmatrix} \text{st} \\ \text{sd} \\ \text{ns} \\ \text{cr} \\ \text{vc} \end{bmatrix} = [{}^nd^z]$$

SAMPLE SPEECH SOUNDS AND THEIR FEATURES

$$\begin{bmatrix} \text{st} \\ \text{cr} \\ \text{ps} \\ \text{lm} \\ \text{dr} \end{bmatrix} = [q^\dagger, \dagger q]$$

$$\begin{bmatrix} \text{st} \\ \text{ns} \\ \text{cr} \\ \text{lm} \\ \text{dr} \\ \text{hi} \end{bmatrix} = [\tilde{l}, \eta l]$$

$$\begin{bmatrix} \text{st} \\ \text{ns} \\ \text{cr} \\ \text{lm} \\ \text{dr} \\ \text{hi} \\ \text{vc} \end{bmatrix} = [\eta \downarrow]$$

$$\begin{bmatrix} \text{st} \\ \text{ns} \\ \text{cr} \\ \text{ps} \\ \text{dr} \\ \text{hi} \\ \text{vc} \end{bmatrix} = [\tilde{r}, \eta g!]$$

$$\begin{bmatrix} \text{st} \\ \text{ns} \\ \text{cr} \\ \text{ps} \\ \text{lm} \\ \text{dr} \\ \text{hi} \end{bmatrix} = [\tilde{r}, \eta \dagger]$$

$$\begin{bmatrix} \text{st} \\ \text{ns} \\ \text{cr} \\ \text{ps} \\ \text{lm} \\ \text{dr} \\ \text{hi} \\ \text{vc} \end{bmatrix} = [\eta \dagger]$$

$$\begin{bmatrix} \text{st} \\ \text{sd} \\ \text{cr} \\ \text{ps} \\ \text{lm} \\ \text{dr} \end{bmatrix} = [\dagger \chi]$$

$$\begin{bmatrix} \text{vc} \\ \text{sg} \end{bmatrix} = [\hbar, \hbar]$$

$$[\text{cg}] = [\gamma, \gamma]$$

$$[\text{fv}] = [h, \hbar]$$

$$[\text{lo}] = [\hbar, \hbar]$$

$$[\text{sg}] = [h, \hbar]$$

$$[\text{st}] = [\gamma, \gamma]$$

$$[\text{vc}] = [\vartheta, \vartheta, \vartheta]$$

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