
Week 2 – Features and Natural Classes

September 16, 2008

1 Feature Theory

- (1) Features are properties of speech sounds. An important theme in the theory of phonology is that these properties are the level at which generalizations are made.
- (2) Feature Theory is the theory whose subject is this subsegmental structure. Major issues include:
 - a. How are features defined?
 - b. What are the relevant features?
 - c. What values can features take?
 - d. Are there dependency relations between features and if so what are they?
 - e. What is the role of feature underspecification?
 - f. Where do features come from?
 - g. How do we find answers to these questions?
- (3) Goals of Distinctive Feature Theory:
 - a. Determine which units can be minimally contrastive in the world's languages
 - (i) The idea is each language draws its distinctive features from this universal set
 - b. Another idea is that the features bridge the gap between the abstract symbol and the physical realization of the sound—they are concrete instructions to articulators, for example.
- (4) Of course there is always a tension:
 - a. The more features posited, the more phonetic detail is accounted for, and potentially more phonological processes can be explained with appeal to phonetic naturalness
 - b. However, smaller inventories are simpler and make describing phonological processes easier
- (5) The methodology:
 - a. If two sounds contrast minimally in some way in some language, then a feature must be posited to account for the difference.

- b. If a phonological process applies to some class of sounds then those sounds ought to have something in common
- c. The more common the distinction is used across languages, the more languages which refer to the same class of sounds, is evidence for that feature and/or natural class.
- d. Consequently, the phonemic inventories and phonological processes found in the world's languages constitute the major sources of evidence for distinctive feature theory.
- e. Increasingly detailed phonetic work providing articulatory (via ultrasound or other more-invasive means) or acoustic measures can help clarify which speech sounds meet which definitions.

1.1 What are features?

- (6) The central idea behind features is that each segment is actually definable in terms of a set of properties. These properties are the features and this set is often called a *feature bundle*.
- (7) Thus words, which we often think of as a string of segments, can actually be represented as a string of feature bundles. Here is one set of features we might use to illustrate this idea with the word *pen*.

$$[p\tilde{e}n] = \begin{bmatrix} -syllabic \\ -sonorant \\ -continuant \\ -nasal \\ +LABIAL \\ -CORONAL \\ -voice \\ \dots \end{bmatrix} \begin{bmatrix} +syllabic \\ +sonorant \\ +continuant \\ +nasal \\ -LABIAL \\ -CORONAL \\ +voice \\ -low \\ -high \\ +front \\ -tense \\ \dots \end{bmatrix} \begin{bmatrix} -syllabic \\ +sonorant \\ -continuant \\ +nasal \\ -LABIAL \\ +CORONAL \\ +voice \\ \dots \end{bmatrix}$$

- (8) The features can be thought of as
 - a. the phonetic properties which combine to form the speech sounds of language, or/and
 - b. the instructions the articulators need to produce a particular sound
- (9) The feature bundle representation of the word *pen* above is intended to be complete in the sense that the feature bundles are specified for every feature.
 - a. In other words, the bundles above are intended to represent vectors because they all ought to have the same length (a value for every feature is specified, even if it is 0).

- ★ Which features are redundant and can be removed because they are predictable by rule to get a phonemic representation (=distinctive features)? Which of these rules are perhaps universal and which are language-specific?

- (10) Where do the features come from?
- It is standardly assumed that they are universal and innate (which would explain why the same distinctions and processes are found in so many unrelated languages).
 - However it has recently been argued that features are emergent, i.e. learned and are not innate (Mielke 2004).
- (11) In principle, features can be defined articulatorily or acoustically.
- It is of some debate whether some features are best defined one way or another.
 - When deciding whether a sound has a particular feature, check the definition of the feature!
- (12) Phonological rules appear to apply to classes of sounds, which follows naturally from defining a segment as complexes of properties.
- It has already been pointed out that the feature system provides us with a means not only for designating individual speech sounds, but also for designating particular classes of speech sounds. (p. 185) (Halle 1972).
- (13) The group of sounds a particular set of features picks out are called **natural classes**.

1.2 So what feature system should we use?

- (14) There have been three major proposals:
- Preliminaries to Speech Analysis (Jakobson et al. 1952)
 - SPE (Chomsky and Halle 1968)
 - Unified Feature Theory (Clements and Hume 1995)
- (15) ... but see also (Avery and Idsardi 2001) and Durvasala's upcoming thesis
- (16) Note that SPE and Preliminaries use the linear feature model outlined above, however more recent feature theories employ a non-linear, or 3-dimensional, approach to features, called feature geometry (we may spend time on this at the later in the semester).
- Among other things, feature geometry encodes dependencies between features.
- (17) Caution: There are many more theories of features and there is disagreement. On the one hand, you need to understand the issues. On the other, you need to become familiar with a particular system so that you can use it comfortably. We will use Hayes' feature system from your reading for this course.

1.3 How do we define features?

- (18) Reasons to think features ought to be defined articulatorily:
- The rules that we propose refer to natural classes which are best defined with articulatory features as opposed to acoustic ones.
 - Some acoustic gestures have unclear acoustic correlates.
 - Some acoustic gestures have different acoustic correlates depending on their environment.

1.4 Few comments on feature values

- (19) Most features are binary valued i.e. +/-.
- (20) Some are considered to be monovalued, typically [+nasal]. The idea is here is that non-nasals do not seem to form a natural class in any language.
- (21) Features which are dependent on other features (e.g. the features [distributed] which is dependent on the [CORONAL]) may have a zero value in non-coronal segments.
- It can be interpreted as phonetic indifference. I.e. the value of [distributed] will be determined by other factors (“filled-in” by context for example)

- ★ Can you think of a domain where it might be natural to have more than two values for a feature?

2 Hayes’ Features (Chapter 4)

2.1 Major Class Features

- (22) We have been introduced to the following terms as designating certain groups of similar sounds: vowels, glides, liquids, nasals, fricatives, affricates, and stops.

vowels	glides	liquids	nasals	fricatives	affricates	stops
+syllabic	-syllabic					
-consonantal		+consonantal				
+approximant			-approximant			
+sonorant				-sonorant		
+continuant					-continuant	

- (23) Bruce Hayes defines these features in terms of sonority, an acoustic measure, which roughly corresponds to acoustic loudness.
- Think of ‘sonority’ as ‘singability’.

- b. There is no clear single acoustic correlate of sonority.
 - c. Note that further distinctions can be made. I.e. lower vowels are said to be more sonorous than higher vowels.
 - d. Others define these sonority-based features in terms of STRICTURE, i.e. how much airflow is allowed to pass through the oral cavity. Different articulations constrict the flow of air in different ways contributing to different degrees of sonority.
- (24) Although we could use a feature system with features like [+stop], this misses the point that these different groups of sounds pattern together in many rules in natural language.

★ Can you give an example from anything discussed in class or in your HW?

- (25) We can reconstruct the categories above with the following features:

vowel	=	[+syllabic]	(but see below)
glide	=	[-syllabic, -consonantal]	
liquid	=	[+consonantal, +approximant]	
nasal	=	[-approximant, +sonorant]	
fricative	=	[-sonorant, +continuant]	
affricate	=	[-continuant, +delayed release]	(we add [delayed release] to
stop	=	[-continuant, -delayed release]	distinguish affricates from stops)

- (26) Syllabic fricatives and stops are quite rare (they occur in Berber languages), but can be defined analogously. (We remarked earlier that English has syllabic nasals and consonants.)
- (27) Thus, strictly speaking, [syllabic] is outside of the system given above since all of the categories in the set [glide, liquid, nasal, fricative, stop] can be [+syllabic].
- a. However, in the majority of the world's languages, only vowels can be syllabic segments, and in these languages it is reasonable to take [+syllabic] as defining the extreme sonorous end of the hierarchy.

2.2 The Sonority Hierarchy

- (28) This feature system, with cut-off points along a continuum, is a way of formally characterizing the so-called sonority hierarchy, which is precisely the continuum shown in (22).
- (29) The features corresponds to cut-off points in the continuum.
- a. Thus [-consonantal] means “at least as sonorous as a glide”
 - b. [+approximant] means “at least as sonorous as an approximant”
 - c. [+sonorant] means “at least as sonorous as a nasal”

- d. [+continuant] means “at least as sonorous as a fricative”
- (30) One major source of evidence for the above feature system comes from examining which segments may be syllabic peaks.
- (31) Typologically, in many languages, syllabic sounds must be vowels. But there are some languages, like Czech and Serbo-Croatian, in which syllabic sounds may be vowels or liquids, but no other sound. English allows vowels, liquids, and nasals to be syllabic, but no other sound. Some Berber languages allow absolutely any sound to occur as a syllabic nucleus.
- (32) This is called an implicational hierarchy: if in a given language, a segment of a certain type can be a syllabic nucleus, then all segments of greater sonority may also serve as a syllabic nucleus.

★ How do the proposed features capture this implicational hierarchy?

- (33) Another application of the Sonority Hierarchy involves sonority sequencing within the syllable. In a language which permits clusters of consonants to occur at the margins of syllables, typically the situation will be this: the most sonorous segment in the syllable serves as its nucleus. Then, proceeding outwards from the nucleus towards the edges of the syllable, one tends to encounter segments of progressively decreasing sonority.

★ What are some counter-examples to the Sonority Sequencing Principle in English?

3 Vowels

- (34) Phonologists generally agree on the features [high], [low], [front], [back], [round].
- (35) It is worth noting that there are both articulatory and acoustic definitions for these sounds and that these definitions lead to the same conclusions.
- Vowel height is directly correlated with jaw opening and inversely correlated with F1.
 - Vowel backness is directly correlated with tongue position and inversely correlated with F2.
 - Rounding is correlated with lip rounding and correlates with a lowering of F3.
 - F1, F2 and F3 (“first formant, second formant, third formant”) are acoustic measures of certain harmonics boosted by resonances somewhere in the vocal tract, and can be visually inspected in a spectrogram.

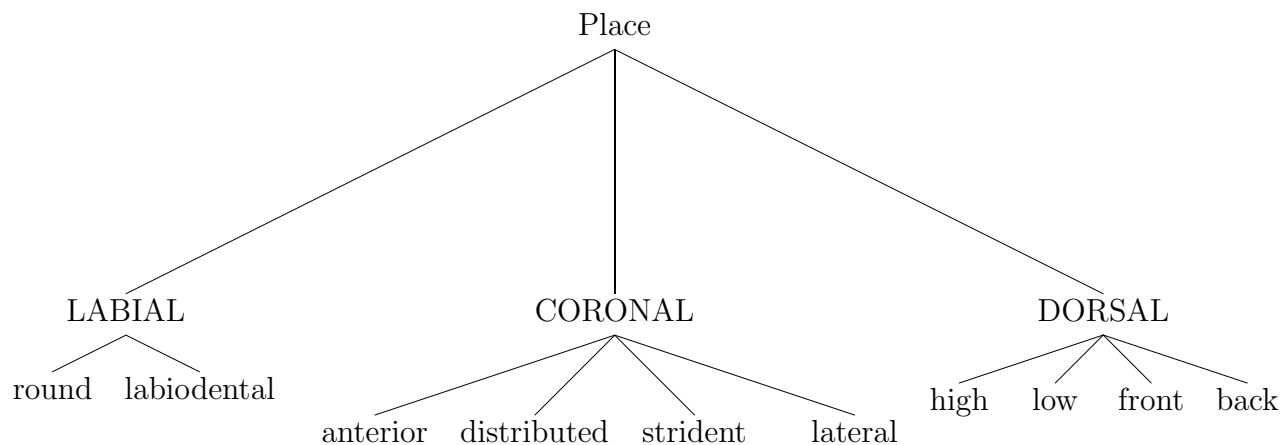
- (36) Sometimes people use Advanced Tongue Root [ATR] instead of [tense].
- (37) Sometimes people use the feature [long] to indicate vowel length (we will discuss alternatives later)
- (38) Until we discuss otherwise, we will use the feature [stress] to distinguish between stressed and unstressed vowels.

4 Consonants

- (39) Place of articulation

LABIAL	CORONAL	DORSAL
round	anterior	high
labiodental	distributed	low
	strident	front
	lateral	back

- (40) The fact that certain features depend on values of other features (i.e. [+labiodental] iff [+labial]) suggests that the features might be organized hierarchally.



- (41) For now, we encode this simply by assigning irrelevant features the value 0. So non-labial sounds may have a 0 assigned for lip-rounding.
- (What about [f] in English vs. Japanese?)
- (42) Note although [anterior] is presented here as being dependent on the feature CORONAL, some people still use it independently (Kenstowicz 1994 does this for example).
- There [+anterior] is defined to be any sound formed with a constriction forward of the alveolar ridge, including labials.
 - Similarly, [-anterior] to be any sound formed with a constriction posterior of the alveolar ridge, including velars, etc.
- (43) If in doubt, define the features you are using! If it helpful to have a feature which

groups all sounds formed forward of the alveolar ridge for example, then you can say you are adopting this definition of the feature [anterior].

4.1 Consonantal features

- (44) Laryngeal features
 - a. voice (some break this up to [stiff vocal cords] and [slack vocal cords])
 - b. constricted glottis (glottalized sounds, ejectives)
 - c. spread glottis (aspirated sounds)

aspirated consonants	plain consonants	glottalized consonants
C ^h	C	Cʔ
+spread glottis	-spread glottis	
-constricted glottis		+constricted glottis

- (45) CORONAL
 - a. anterior (sounds that are produced more front of the alveolar ridge)
 - b. distributed (more contact of tongue blade)
 - c. strident (sibilants, noisy, grooved tongue)
 - d. lateral (basically distinguishes [l] from other coronals)

★ Which features can distinguish the fifteen coronal obstruents of Bengali? Data from Khan (2006) (see also references therein)

	Dental	Alveolar	Post-alveolar
Plosive	t̪ d̪ t̪ʰ d̪ʱ	t d tʰ dʱ	
Affricate			tʃ dʒ tʃʰ dʒʱ
Fricative		s z	ʃ

Table 2. The coronal obstruents of East Bengali.

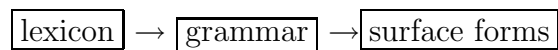
- (46) LABIAL: [round], [labiodental]
- (47) DORSAL: [back], [front], [high], [low]
- (48) Other features: [trill], [tap] (flap), [ejective], [implosive]

5 Morphophonemic Analysis

- (49) This refers to an analysis that addresses the morphological alternations in the context of a phonemic analysis.
- (50) Questions to keep in mind:
- What are the phonemic representations of the morphemes?
 - How are the morphemes arranged—i.e. prefixes or suffixes, etc?
 - What is the null hypothesis? If I stick two morphemes together, ought there be an alternation at all?
 - What is predictable and what is not?

5.1 The basic theory

- (51) Lexical representations use only the distinctive features as predictable information is stored in rules in the grammar. These are also called **underlying forms**.
- (52) A feature bundle with only distinctive features is incomplete in the sense that it does not have all the instructions that tell the articulators what to do.
- (53) Thus the underlying form gets passed through a system of rules which “fill it out”. This system of rules may be phonological or phonetic (and possibly interact with the morphology)
- (54) The output of the system of rules is the **surface form**.



- (55) Explanation of terms:
- The lexicon stores the idiosyncratic information
 - The grammar stores the rules which represents the productive knowledge speakers have
 - The surface forms is a complete (but still abstract) representation of what you say and hear

5.2 Exercise

Kasem Class C noun plurals (Based on discussion in SPE Ch. 8, data originally from Callow, plus additional discussion in Halle 1978.)

	<i>singular</i>	<i>plural</i>	
a	bakada	bakadi	‘boy’
b	sada	sadi	‘grass mat’
c	mimina	mimini	‘thin’
d	fala	fali	‘white man’
e	tula	tuli	‘granary’
f	kukuda	kukudi	‘dog’
g	fana	fani	‘knife’
h	čana	čani	‘moon’
i	bakala	bakali	‘shoulder’
j	kambia	kambi	‘cooking pot’
k	pia	pi	‘yam’
l	buga	bwi	‘river’
m	diga	di	‘room’
n	malaa	male	‘chameleon’
o	kabaa	kabe	‘slave’
p	zizaa	zize	‘grass roof’
q	laŋa	le	‘song’
r	naga	ne	‘leg’
s	pia	pe	‘sheep’ (cf. ‘yam’)
t	babia	babe	‘brave’
u	nanjua	nanjwe	‘fly’
v	yua	ywe	‘hair’
w	koga	kwe	‘back’
x	čoŋa	čwe	‘path’

References

- Avery, Peter and William Idsardi. 2001. Laryngeal dimensions, completion and enhancement. In *Studies in Distinctive Feature Theory*, edited by T. A. Hall and U. Kleinhanz. Berlin: Mouton de Gruyter, pages 41–70.
- Chomsky, Noam and Morris Halle. 1968. *The Sound Pattern of English*. Harper & Row.
- Clements, G.N. and Elizabeth V. Hume. 1995. The Internal Organization of Speech Sounds. In *The Handbook of Phonological Theory*, edited by John Goldsmith. Cambridge, Mass.: Blackwell, pages 246–306.
- Halle, Morris. 1972. Theoretical Issues in Phonology in the 1970’s. In *Proceedings of the Seventh International Congress of Phonetic Sciences*, edited by André Rigault and René Charbonneau. Mouton, The Hague, pages 179–205.

Jakobson, Roman, C. Gunnar, M. Fant, and Morris Halle. 1952. *Preliminaries to Speech Analysis*. MIT Press.

Khan, Sameer ud Dowla. 2006. Similarity Avoidance in East Bengali Fixed-Segment Echo Reduplication. In *Proceedings of the Western Conference on Linguistics 2006*.

Mielke, Jeffrey. 2004. The Emergence of Distinctive Features. Ph.D. thesis, Ohio State University.