Readings: Hayes (APS reader) Chapter 4
Homework: Homework 3 is due before discussion April 26th. You must now use distinctive features).
Term Paper: You should be finding a native speaker to work with and identifying reference sources.

Week 3, Class 2:
Distinctive Features

I. Features for Vowels

1. *Phonetic basis for classifying vowels is to specify height, backness and rounding.*

2. *Horizontal dimension: [back] and [front] – allow three way distinction*

3. *Vertical dimension: [high] and [low]: allow three way distinction*

4. *[round]: produced with a narrowing/protrusion of the lips*

- Usually used for vowels, can be used for secondary articulation of consonants: [k^w, f^w]
- [+round]: [u, o]
- [-round]: [i, e, a]
- Generally, back vowels are [+round] and front vowels are [-round]
- French has a front rounded vowels: [y] $\begin{bmatrix} +\text{syllabic} \\ +\text{high} \\ +\text{front} \\ +\text{round} \end{bmatrix}$

5. *With just [back], [high], [low] and [round] we get a course classification*

	[+front, -back]		[-front, -back]		[-front, +back]	
	[-round]	[+round]	[-round]	[+round]	[-round]	[+round]
[+high, -low]	i	y	ɨ	ʉ	ɯ	u
[-high, -low]	e	ø	ɘ	ɵ	ɤ	o
[-high, + low]	æ	ɶ	a	------	ɑ	ɒ

6. *Spanish, Calabrian/Sicilian, Hawaiian – if you have just five vowels, best to be maximally different in acoustic/articulatory space*

	[+front, -back]		[-front, -back]		[-front, +back]	
	[-round]	[+round]	[-round]	[+round]	[-round]	[+round]
[+high, -low]	i					u
[-high, -low]	e					o
[-high, + low]			a			

7. *Feature redundancy*

- In a system like Spanish, some features are redundant:
  - i. e.g. [+back, +round], all [+back] vowels are also [+round].
  - ii. [+front, - round], all [+front] are also [-round]
  - iii. [+front, -back]. all [+front] are [-back]
  - iv. there are no [-front, -back] vowels; you can just use [+-back]

v. For a system like Spanish, you just need [high], [low] and [back]

	[-back]	+back]
[+high, -low]	i	u
[-high, -low]	e	o
[+ low]	a	

- You can also use [+/- round] instead of [back] (one advantage is that you don't have to decide weather the +low vowel is front or back (may vary in different languages – or according to phonetic environment)

	[-round]	+round]
[+high, -low]	i	u
[-high, -low]	e	o
[+ low]	a	

8. Capturing IPA style vowel height with features

- [high] and [low] distinguish three vowel heights (like in Spanish above)

- What about Standard Italian – four vowel heights
  i. European languages: [tense]
  ii. African languages: [ATR] – advanced tongue root

9. [tense] and [ATR] (advanced tongue root)

- [tense] generally used for European languages: produced with a more deliberate and precise muscular effort/greater muscular tension (the tongue is a big muscle)
  i. There is usually also a 'height' difference, [+tense] vowels are phonetically 'higher'.
  ii. Maybe also a phonetic length difference: [+tense] vowels are longer (
- [lax] you may see this features also, [+lax] = [-tense], [-lax] = [+tense]
- [ATR] used for African languages: advanced tongue root – tense the back of the tongue to push it forward (we don't exactly know what the physical/articulatory correlate it, or if they are the same for all languages said to have [+/- ATR] distinction)

- Standard Italian: [tense] distinction in stressed mid-vowels: [pɛ́ska] 'fish' vs. [pé́ska] 'peach'

	[-back]	[+back]
[+high, -low]	i	u
[-high, -low, +tense]	e	o
[-high, -low, -tense]	ɛ	ɔ
[-high, +low]	a	

- Italian mid vowel constraint: $*\begin{bmatrix} +\text{syl} \\ -\text{high} \\ -\text{low} \\ +\text{tense} \\ -\text{stress} \end{bmatrix}$
- Italian mid-vowel rule: $\begin{bmatrix} +\text{syl} \\ -\text{high} \\ -\text{low} \\ +\text{tense} \end{bmatrix} \rightarrow [-\text{tense}] / \begin{bmatrix} \underline{\quad\quad} \\ -\text{stress} \end{bmatrix}$

- English: the [-high, -low, +tense] are offglides

	[-back]	[+back]	
[+high, -low, +tense]	i	u	[bid] 'bead', [but] 'boot'
[+high, -low, -tense]	ɪ	ʊ	[bɪd] 'bid', [fʊt] 'foot'
[-high, -low, +tense]	e	o	[beɪd] 'bayed', [boʊt] 'boat'
[-high, -low, -tense]	ɛ	ɔ	[bɛd] 'bed', [bɔt] 'bought
[-high, +low]	æ	ɑ [also -round]	[bæd] 'bad', [fɑθɚ] 'father'

10. **Feature redundancy is language specific**

- Maasai: [ATR] – symbols for [+/-ATR] and [+/-tense] vowels are the same
- [+low] and [-ATR] are redundant in Maasai(because there is no [+low] [+ATR] vowels), nevertheless harmony systems requires specification.
- [ɑ] must be [-ATR]: it doesn't trigger [+ATR] harmony
- All vowels in a word have to be either [+ATR] or [-ATR] (relatively common in African languages – e.g. Yoruba)
- [ɑ] acoustic and phonological evidence requires [+back] analysis

	[-back]	[+back]
[+high, -low, +ATR]	i	u
[+high, -low, -ATR]	ɪ	ʊ
[-high, -low, +ATR]	e	o
[-high, -low, -ATR]	ɛ	ɔ
[-high, +low, -ATR]		ɑ [also -round]

Summary of vowel features	[+front, -back]		[-front, -back]		[-front, +back]	
	[-round]	[+round]	[-round]	[+round]	[-round]	[+round]
[+high, -low, +tense]	i	y	ɨ	ʉ	ɯ	u
[+high, -low, -tense]	ɪ	ʏ	------	------	------	ʊ
[-high, -low, +tense]	e	ø	ɘ	ɵ	ɤ	o
[-high, -low, -tense]	ɛ	œ	ə	ɞ	ʌ	ɔ
[-high, + low]	æ	ɶ	a	------	ɑ	ɒ

- There are some divergences from the IPA chart – review pg. 81 of the Hayes reader
- Not every slot has an IPA symbol; not every IPA symbol has a slot.
- IPA symbols allow for finer distinctions than what is needed for phonological classification.

11. Other features for vowels: [stress], [nasal], [long]

- [+stress], [-stress]: caveat – some phonologists consider stress to be a property of entire syllables, not just vowels. Nonetheless, was needed for Calabrian vowel raising rule
- [+nasal][-nasal]: Used for nasalized vowels, like in French
- [+long], [-long]: used for vowel length difference, like Papago

II. Review: Manner features

12. Manner features distinguish 'manner of articulation': degree of constriction in the vocal tract (how close the articulators get)

13. Sonority Hierarchy: It is useful to arrange the manners of articulation into a hierarchy based loosely on the acoustic sonority (loudness) of sounds.

most sonorous (loudest) **least sonorous**

	vowels	glides	liquids	nasals	obstruents
[syllabic]	+	-	-	-	-
[consonantal]	-	-	+	+	+
[approximant]	+	+	+	-	-
[sonorant][1]	+	+	+	+	-

- Generally, for major classes of sounds, the following holds (we will discuss complications): you can use these features do define each class.
  i. vowels: [+syllabic]
  ii. consonants: [-syllabic]
  iii. glide: [-syllabic, -consonantal]
  iv. liquid: [+consonantal, +approximant]
  v. Nasal: [-approximant, + sonorant]
  vi. obstruents (except the nasal stops): [-sonorant]

III. Obstruents: Stops, affricates and fricatives

14. [continuant]: produced with continuous airflow in the vocal tract

- [+continuant]: fricatives, liquids, glides and vowels
- [-continuant]: involves full closer in the vocal tract, stops, affricates
  i. stops, affricates
  ii. nasals are [-continuant]; vocal tract is obstructed

15. [delayed release]: produced with delayed release of oral obstruction (this "delay" produces frication)

- [+delayed release]: fricatives and affricates
- [-delayed release]: stops
- only used with obstruents – 0 value for other sounds

IV. Place Features for Consonants

16. Major Articulator Features: refer to the active articulator

- [+ labial]: articulated with the lips (includes bilabials and labiodentals)
  i. e.g. [p, b, ɸ, β, m, f, v, ɱ]
- [+ coronal]: articulated with the tongue blade and/or tip
  i. e.g. [t, d, θ, ð, s, z, n, l, r, ʃ. ʒ]
  ii. [+coronal] generalized over both alveolar/dental and palato-alveolar places of articulation
- [+dorsal:] articulated wit the tongue body
  i. e.g. [k, g, x, ɣ, ŋ,]
- [+radical]: consonants made with the tongue root (more rare): pharyngeals and epiglottals (a consonant that is articulated with the epiglottis against the back of the pharynx – extremely rare)
  i. [ʕ] pharyngeal fricative (Hebrew)
  ii. [ʔ] epiglottal stop, [ʜ] voiceless epiglottal fricative, [ʢ] voiced epiglottal fricative (Agul is a Nakho-Dagestanian language (Samurian subgroup of the Lezgian family) of the northeast Caucasus)

[1] You may notice that there is a type in the sonority hierarchy in the Hayes reader on page 74. The vowels, glides, liquids, nasals should be [+sonorant] not [-sonorant]

17. Complex segments: two articulators involved

- labio-velar [k͡p]: involves both lips and tongue body [+labial, +dorsal]

18. Consonants with no articulators

- glottal stop [ʔ]: [-labial, -coronal, -dorsal]

V. Features subdividing coronals

- [+coronal]: includes alveolar/dental and palato-alveolar places of articulation
  - i. e.g. [t, d, s, z, ʃ, ʒ, n, ɲ]
  - ii. there are more kinds of [+coronal] (tongue tip or blade) consonants than for any other articulator

19. [anterior]: towards the front

- [+anterior]: articulated at the alveolar ridge or more forward
  - **i.** (inter-)dentals, alveolars
  - **ii.** e.g. [t, t̪, d, d̪, θ, ð, t͡s, d͡z]
  - **iii.** labials and lingualabials (rare) have 0 value for [anterior] (only distinguishes coronals)

- [-anterior]: articulated behind the alveolar ridge or more back
  - **i.** palato-alveolars, retroflexes
  - **ii.** e.g. [ʃ, ʒ, t͡ʃ, d͡ʒ]

20. [distributed]: refers to part of tongue which makes contact in coronal sounds

- [+distributed]: tongue blade: contact is long, measured from the front to back
  - **i.** when the tongue blade is used, there is inevitably more contact
  - **ii.** laminals and dentals (or lamino-dentals)
  - **iii.** palato-alveolars: [t͡ʃ, d͡ʒ, ʃ, ʒ]
- [-distributed]: tongue tip: contact is short, measured from the front to back
  - **i.** retroflexes
  - **ii.** apico-alveolars: [t, d, t͡s, d͡z, s, z]

- This features distinguishes the apical vs. laminal distinction we saw in Maasai
- Phonetic charts classify sounds by the place of articulation (e.g. alveolar): both Maasai sounds had an alveolar place of articulation.
- This features refers to the moving articulator: e.g. place on the tongue)

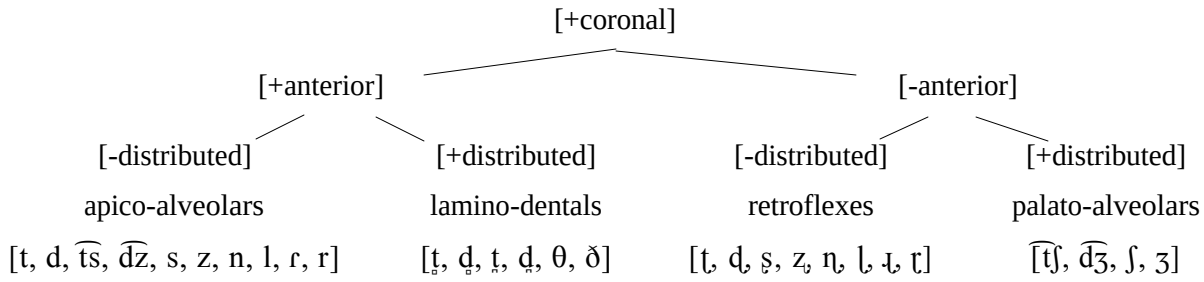
- [d̻] apical = [+consonantal, -continuant, -delayed release, +coronal, +anterior, -distributed, +voice]
- [d̪] laminal [+consonantal, -continuant, -delayed release, +coronal, +anterior, +distributed, +voice]

- Distributed also distinguishes the Bengali dental vs. alveolar sounds

- [t] alveolar = [+consonantal, -continuant, -delayed release, +coronal, +anterior, -distributed]
- [t̪] dental [+consonantal, -continuant, -delayed release, +coronal, +anterior, +distributed]

- Maasai apical sounds have same features as Bengali alveolars
- Maasai laminal sounds have same features as Bengali dentals
- Phonetic description requires specification
- Very unlikely that there is a language that distinguishes both apical vs. laminal and dental vs. alveolar (if there is one we need more features)

21. Four basic types of [+coronal] sounds



22. [strident]: air channeled through a groove in the tongue, resulting in a stream of air blown at the teeth.

- *[+strident]: Used to classify sibilants*
  - [s, z, t͡s, d͡z, ʃ, ʒ, t͡ʃ, d͡ʒ]
- *sounds with high/medium range frication; generally louder (the sounds you hear when somebody is whispering)*

23. [Lateral]: tongue is compressed laterally, so that contact at the edges is incomplete. Air passes laterally around the tongue

- [+lateral] distinguishes [l] from other coronal liquids: e.g. [r, ɾ, ɽ]

24. [trill], [tap]

- Distinguish types of "r" sounds
- [+tap]: [ɾ]
- [+trill]: [r]

VI. Features used to subdivide labials

25. [round]: articulated by rounding the lips

- [round] is a secondary articulation
- rounded bilabials
  i. [pʷ, bʷ, mʷ, βʷ]
- rounded labiodentals
  i. [fʷ, vʷ]
- secondary rounding on velars and coronals also
  i. [kʷ, gʷ, xʷ]
  ii. [tʷ, dʷ, sʷ, zʷ]

26. [labiodental]: articulated by touching the lower lip to the upper teeth

- marginal feature, distinguishes [ɸ] vs. [f], [β] vs. [v]
- Most languages either have one or the other, not both
    i. Japanese has [ɸ] but not [f]
    ii. Peninsular Spanish as [b, β] but no [v]
    iii. Greek has phonemes /b/ and /v/ but no [β]
- California Spanish said to have /β/ vs. /v/ distinction

VII. Features for Subdividing Dorsals

27. vowel features for dorsals

- Dorsals can be described using the features of voels produced with similar articulations
- Dorsals and vowels both involve the tongue body

- Fronted/advanced velars (i) = [+high, -low, +front, -back]
    i. [k̟, g̟, x̟, ɣ̟]
- Central velars (ɨ): [+high, -low, -front, +back]
    i. [k, g, x, ɣ]
- Back velars (u): [+high, -low, -front, +back]
    i. [k̠, g̠, x̠, ɣ̠]
- Uvulars (ʌ): [-high, -low, -front, +back]
    i. [q, ɢ, χ, ʁ]
- pharyngeals (ɑ): [-high, +low, -front, +back]
    i. [ħ, ʕ]

28. Evidence for vowel features for consonants

- English velars become fronted before high vowels
- Eskimo lowers high vowels to mid vowels before uvulars
- Maltese Arabic lowers /i/ to [a] before pharyngeals

29. True palatals

- Judged to involve simultaneous participation of both tongue blade and tongue body/
- [+coronal, -anterior, +distributed, +dorsal, +high, -low, +front, -back]
    i. [c, ɟ, j, ɲ]

30. Secondary articulations – also involve vowel features

- palatalization: add [+dorsal, +high, -low, +front, -back]
    i. [p^j, t^j, k^j]
- velarization: add [+dorsal, +high, -low, -front, +back]
    i. [^{ɣ}]
- labialization: add [+labial, +round]
    i. [p^w, t^w, k^w]

31. Place assimilation

- many features refer to the place of articulation

- some phonological rules manipulate all place features at once
- Spanish: nasals contrast word initially
  i. /n/ vs. /m/: [náða] 'nothing', [mápa] 'map'
  ii. /n/, /m/, /ɲ/: [ponér] 'to put', [bámos] 'we go', [espáɲa] 'Spain
- contrast is neutralized before another consonants

Spanish Nasal Place Assimilation

labial	coronal	velar
[r:ómpo]	[kansáðo]	[θíŋko]
[ámbos]	[ánda]	[óŋgo]
[imbíta]	[kánta]	

- nasal place assimilation rule

$$n \rightarrow [place_i] / \_\_\_ \begin{bmatrix} \text{-syllabic} \\ place_i \end{bmatrix}$$

32. Alpha variable notation for assimilation

- *"α" is also often used as a variable also (commonly for place)*

$$n \rightarrow [\alpha place] / \_\_\_ \begin{bmatrix} \text{-syllabic} \\ \alpha place \end{bmatrix}$$

- use alpha variable(s) when you want to say that the + or – value of a feature is linked to whether or not the value for some of other features is + or -.

33. Laryngeal Features: [Voice], [spread glottis], [constricted glottis]

- [+voice]: vocal cords vibrating
  i. distinct is phonemic mostly only in obstruents
  ii. Sonorant consonants and vowels are by default voiced, but can be voiceless as allophones (Japanese has voiceless vowel allophones)
- [+spread glottis]: vocal cords relatively wide apart, allowing air flow
  i. usually voiceless sounds (because vocal folds must be closed for voicing)
  ii. /h/

- English Aspiration Rule

$$\begin{bmatrix} \text{-continuant} \\ \text{-voice} \end{bmatrix} \rightarrow [\text{+spread glottis}] / [_{word}\_\_\_\_\_$$

- [+constricted glottis]: adduction of the vocal cords, making a narrow or closed glottis.
  i. glottal stops
  ii. Ejectives
  iii. preglottalized sounds: word final voiceless stops in English
  iv. creaky voice, creaky vowels

- most speech sounds are [-spread glottis], [-constricted glottis]

34. Alpha variable for voicing assimilation

- consonant assimilates to the voicing value of the following consonant, whether + or -

$$[\text{-syl}] \rightarrow [\alpha\text{voice}] / \_\_\_ \begin{bmatrix} \text{-syllabic} \\ \alpha\text{voice} \end{bmatrix}$$

35. Bulgarian obstruent voicing assimilation

$$[\text{-sonorant}] \rightarrow [\alpha\text{voice}] / \_\_\_ \begin{bmatrix} \text{-sonorant} \\ \alpha\text{voice} \end{bmatrix}$$

Prefix /ot-/	[otivam]	'go, depart'
	[otkrivam]	'open'
	[odgovarjam]	'answer'
Preposition /pod/	[pod igoto]	'under the Yoke'
	[pod grada]	'under the city'
	[pot kʌʃtata]	'under the house'

- suffix [ATR] harmony and alpha variables

$$[\text{+syll}] \rightarrow [\alpha\text{ATR}] / \ [\alpha\text{ATR}]]_{\text{root}} \_\_\_\_\_]_{\text{suffix}}$$

36. Features in writing rules

- a fully explicit analysis would use only features – refer directly to the mental representations – this is what the real rule are claimed to do
- Sometimes it is easier to use symbols – like when you are dealing with the change of just one sound
- You need to use features to capture a natural class
- Indonesian /ŋ/ Deletion before nasals, liquids and glides
    - symbol for the change of a single segment
    - features for an entire natural class

$$/\eta/ \rightarrow \varnothing / \_\_\_\_ \begin{bmatrix} \text{-syllabic} \\ \text{+sonorant} \end{bmatrix}$$

- *To capture assimilation: a segment adopts the feature value of an adjacent segment*

Velar Fronting

$$\begin{bmatrix} \text{-+dorsal} \\ \text{+consonantal} \end{bmatrix} \rightarrow \begin{bmatrix} \text{+front} \\ \text{-back} \end{bmatrix} / \ \_\_\_\_ \begin{bmatrix} \text{+syllabic} \\ \text{+front} \end{bmatrix}$$

- two show that the change is minor
    i. instead of /p/ → [b], p → [+voice]

37. Feature practice

- The Arabic definite article /al-/ assimilates to the following segment
- How can these assimilating segments be defined using features
- Which ones doesn't assimilate, and why

1.	[albajt]	'the house'	2.	[atta:dʒir]	'the merchant'
3.	[alkita:b]	'the book'	4.	[addarsa]	'the lesson'
5.	[alqalam]	'the pen'	6.	[atˤtˤa:lib]	'the student'
7.	[alʔumma]	'the mother'	8.	[adˤdˤaba:b]	'the fog'
9.	[alfaqi:r]	'the poor person'	10.	[aθθawb]	'the garment'
11.	[alxa:l]	'the maternal uncle'	12.	[aððahab]	'the gold'
13.	[alɣurfa]	'the room'	14.	[assu:q]	'the market'
15.	[alha:l]	'the situation'	16.	[azzawdʒ]	'the husband'
17.	[alʕayn]	'the eye'	18.	[asˤsˤaba:h]	'the morning'
19.	[alhadijja]	'the gift'	20.	[azˤzˤuhr]	'the midday prayer'
21.	[almalik]	'the king'	22.	[aʃʃajʔ]	'the thing'
23.	[alwalad]	'the boy'	24.	[annabi:]	'the prophet'
25.			26.	[alluɣa]	'the language'
27.			28.	[arradʒul]	'the man'

- Polish: C → C^j / _____ [i, e, j]
  i. [stiv] 'Steve (borrowed name)
  ii. [$stiv^je$]
- Stop deletion in Indonesian: /p, t, k,/ → ∅ / [+nasal] ___
  i. [b, d, dʒ, g, tʒ, f] don't delete