Teaching Fellow: Jack Isaac Rabinovitch
jrabinovitch@g.harvard.edu

Discussion Section: Boylston Hall, Room 335
Section 1: Thursdays 3:00–4:00
Section 2: Thursdays 4:30–5:30

Office Hours: Boylston Hall, Room G03
Mondays 12:15–1:15

Discussion Handout 6

November 4, 2021

(1) Today:
   a. Phonemes, Allophones, and Rules
   b. Universal Feature System
   c. Rule Denotation
   d. Rule Ordering and Interactions

1 Phonemes and Allophones

(2) Phonemes
   a. Phonemes are abstract units of contrastive information.
   b. Languages store the forms of words and morphemes as strings of phonemes.
   c. Languages differ in what phonemes they use (phonemic inventory).

(3) Phones
   a. Realizations of a phoneme in a given context.
   b. A single Phoneme can correspond to different phones: these are called 'allophones'.
   c. Allophones can occur in complementary distribution (consistent based on context) or free variation (can differ within the same context).
   d. All the phones of a language make the phonetic inventory (different from phonemic inventory).

Free variation and complementary distribution are theory-neutral; they refer to what we observe in the language:

(4) "[h] and [ɦ] are in complementary distribution in Estonian." means that:
   a. [h] and [ɦ] are both in the phonetic inventory of Estonian, and
   b. [h] and [ɦ] never appear in the same environment in Estonian.

(5) "[v] and [ʋ] are in free variation in Faroese." means that:
   a. [v] and [ʋ] are both in the phonetic inventory of Faroese, and
   b. [v] and [ʋ] may be freely interchanged within Faroese words without changing their meaning.

Discussion of which phones are allophones of what phonemes is more theory specific; we make theories based on our observations:

(6) "[t] and [t^h] are allophones of /t/ in English." means that:
   a. [t] and [t^h] are both in the phonetic inventory of English,
   b. /t/ is in the phonemic inventory of English, and
   c. /t/ is realized sometimes as [t] and sometimes as [t^h]

(7) "[t^h] is underlyingly /t/ in English." means that:
   a. The phone [t^h] corresponds to the phoneme /t/.

(8) "/u/ surfaces as [ʊ] after uvular consonants in Manchu" means that:
   a. The phoneme /u/ is realized as [ʊ] in contexts where /u/ follows a uvular consonant.

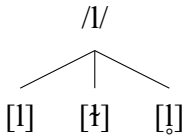
We theorize that the brain stores simpler forms (with units as phonemes), and these forms undergo rules into pronunciation (in the form of phones).

2 Rules, Elsewhere Conditions, and Neutralization

(9) English /l/ allophones:
   a. [ɬ] occurs in rime position (either coda or nucleus of a syllable)
   b. [l̥] occurs after a voiceless plosive
   c. [l] occurs in all other positions:
      (i) When the first segment in a syllable,
      (ii) When following voiced plosives, and
      (iii) When following non-plosive sounds.

Because [l] shows up in multiple contexts, which cannot be unified as a single context, it is the elsewhere condition; we assume it has undergone no change:

(10)



Neutralization:

(11) German /d/ devoicing:
   a. In German [d] and [t] are both phones.
   b. [d] never occurs word-finally.
   c. Segments which surface as [d] when not word final surface as [t] when word final. (cf. [rat] vs. [rad-əs])

/t/ surfaces as [t] always, /d/ surfaces as either [t] or [d] depending on context. Because two phonemes correspond to one phone in a certain context, these phonemes are neutralized in that context.

(12) /t/ /d/

[t] [d]

3 Universal Feature Theory

(13) Claim: Rather than phonemes as the basic building blocks of phonology, features (attributes of phonemes) are.

a. Our brain cares not about arbitrary labels like /p/, but rather the things which define /p/ (bilabial, voiceless, oral, stop)
b. Phonemes (and phones) are sets or bundles of features
c. Features have a binary structure: they represent the engagement of some muscle or attribute of sound and so they are either "on" or "off".
d. We can thus distinguish how similar two sounds are: what features do they share?

(14) /d/ undergoes devoicing word finally in German, why does it become [t] rather than [p]?

$$[\text{d}] = \begin{bmatrix} + & \text{VOI} \\ + & \text{COR} \\ - & \text{LAB} \\ & \dots \end{bmatrix} \quad [\text{t}] = \begin{bmatrix} - & \text{VOI} \\ + & \text{COR} \\ - & \text{LAB} \\ & \dots \end{bmatrix} \quad [\text{b}] = \begin{bmatrix} + & \text{VOI} \\ - & \text{COR} \\ + & \text{LAB} \\ & \dots \end{bmatrix} \quad [\text{p}] = \begin{bmatrix} - & \text{VOI} \\ - & \text{COR} \\ + & \text{LAB} \\ & \dots \end{bmatrix}$$

a. Devoicing replaces $\begin{bmatrix} + & \text{VOI} \end{bmatrix}$ with $\begin{bmatrix} - & \text{VOI} \end{bmatrix}$
b. [t] is just [d] with the $\begin{bmatrix} - & \text{VOI} \end{bmatrix}$ instead of $\begin{bmatrix} + & \text{VOI} \end{bmatrix}$

We can define sets of segments as natural classes: sets of feature bundles which describe the entire group of segments.

(15) $\begin{bmatrix} - & \text{NAS} \\ + & \text{VOI} \end{bmatrix}$ = voiced oral segments

These feature sets typically refer to all of the members of a given phonemic/phonetic inventory which have those features.

(16) $\begin{bmatrix} - & \text{VOI} \\ - & \text{CONT} \end{bmatrix}$ = voiceless stops and affricates:

a. English: {p, t, k, tʃ, (and p^h, t^h, k^h)}
b. Burmese (Myanmar): {p, p^h, t, t^h, k, k^h, tʃ, tʃ^h, m̥, n̥, ɲ̊, ŋ̊}
c. West Greenlandic (Kalaallisut): {p, t, k, q}

Natural classes, and feature sets in general, are intersective: no "or" statements.

(17) a. OK: $\begin{bmatrix} - & \text{VOI} \\ - & \text{CONT} \end{bmatrix}$ = all segments which are both $\begin{bmatrix} - & \text{VOI} \end{bmatrix}$ and $\begin{bmatrix} - & \text{CONT} \end{bmatrix}$

b. NOT OK: all segments which are either $\begin{bmatrix} - & \text{VOI} \end{bmatrix}$ or $\begin{bmatrix} - & \text{CONT} \end{bmatrix}$

4 The Features

(18) Laryngeal Features determine properties of the larynx during the production of a sound:

a. VOI: voicing: whether the sound is voiced
   (i) + = voiced
   (ii) − = voiceless

b. SG: spread glottis: whether the glottis is spread (vocal folds are held apart)
   (i) + = spread glottis: [h], [ɦ], [ʍ], aspirated segments, and breathy voicing
   (ii) − = not spread glottis: all other segments

c. CG: constricted glottis: whether the glottis is constricted (vocal folds are adducted)
   (i) + = constricted glottis: [ʔ], glottalized segments, ejectives, creaky voicing
   (ii) − = not constricted glottis: all other segments

(19) Major class features:

a. SYL: syllabic: whether the segment is the nucleus of a syllable.
   (i) + = syllabic: vowels and syllabic consonants
   (ii) − = other segments

b. CONS: consonantal: whether the vocal tract audibly constricts.
   (i) + = consonantal: obstruents, nasals, liquids, and trills.
   (ii) − = non consonantal: glides, vowels, laryngeal segments (such as [h], [ɦ])

c. APPROX: approximant: whether air flows without turbulence through the oral cavity.
   (i) + = vowels, glides, liquids
   (ii) − = obstruents (stops, affricates, fricatives), nasal stops

d. SON: sonorant: whether there is a pressure differential in the oral cavity: whether air flows without turbulence.
   (i) + = vowels, glides, liquids, nasals
   (ii) − = obstruents (stops, affricates, fricatives)

(20) Manner features:

a. CONT: continuant: whether airflow is continuous through the oral cavity
   (i) + = vowels, glides, liquids, fricatives
   (ii) − = plosives, nasal stops, affricates

b. DELREL = delayed release: whether release of segment is delayed (such as to create frication); this is assumed as a subfeature of obstruents (specified when segment is −SON)
   (i) + = affricates and fricatives
   (ii) − = plosives

c. NAS: nasal: whether velum is lowered
   (i) + = nasal stops, nasal vowels
   (ii) − = other segments

d. ROUND: rounding: whether lips are rounded
   (i) + = rounded vowels, labialized (not labial) consonants like [k^w], denoted with superscript 'w', [w], [ʍ], [ɥ]
   (ii) − = unrounded vowels, non-labialized consonants

e. TENSE: whether the segment is tense or lax

(i) + = tense vowels, glides, consonants pronounced with advanced tongue root
(ii) − = lax vowels, consonants pronounced without advanced tongue root

f. LAT: lateral: whether airflow aims through the side of the mouth
(i) + = airflow through side, laterals: [l], [ɬ], [ʎ], [tɬ] etc.
(ii) − = all else

g. TRILL: whether the segment is a trill

h. TAP: whether the segment is a tap or flap

i. LONG: whether the segment is long or short (many theories reject this as a feature)

j. STRESS: whether the segment is in a stressed syllable (many theories reject this as a feature)

(21) Place features:

a. LAB: labial: whether segment engages lower lip in articulation
(i) + = labials: bilabials, labiodentals, labiovelars
(ii) − = all else

b. LABIODENT: labiodental: whether segment engages upper teeth and lower lip in articulation (subfeature of LAB)
(i) + = labiodentals
(ii) − = all else

c. COR: coronal: whether the segment engages the front of the tongue in articulation
(i) + = coronals: interdentals to retroflex, palatoalveolars, alveopalatals
(ii) − = all else

d. ANT: anterior: whether the tongue engages the front of the mouth in articulation (subfeature of COR)
(i) + = dentals, alveolars
(ii) − = all else

e. DIST: distributed: whether the tongue blade engages in articulation (subfeature of COR)
(i) + = tongue blade is used: in English any coronal other than alveolars
(ii) − = tongue tip is used: in English, alveolar sounds

f. STRID: strident: whether the segment is a sibilant (subfeature of COR)
(i) + = sibilants: {s, z, ʃ, ʒ, tʃ, dʒ} etc.
(ii) − = all else (including non-sibilant coronal fricatives like [θ] and [ð])

g. DOR: dorsal: whether the segment is produced with the body of the tongue (dorsum)
(i) + = dorsal sounds: palatal, velar, uvular consonants, and vowels and glides (and labiovelar sounds)
(ii) − = all else

(22) Dorsal Specific Features:

a. HI: high: whether tongue body placement is high in mouth/jaw is closed
(i) + = high vowels, velar consonants, palatal consonants
(ii) − = all else

b. LOW: low: whether tongue body placement is low in mouth/jaw is open
(i) + = low vowels, pharyngeal consonants
(ii) − = all else

c. FRONT: front: whether tongue placement is in front of mouth
   (i) + = front vowels, palatal consonants
   (ii) − = all else

d. BACK: front: whether tongue placement is in back of mouth
   (i) + = front vowels, uvular consonants, pharyngeal consonants
   (ii) − = all else

(23)

	Major Place	Minor Place	
Bilabial	[+ LAB]	[− LABIODENT]	
Labiodental		[+ LABIODENT]	
Interdental/Dental	[+ COR]	[+ ANT]	[+ DIST]
Alveolar			[− DIST]
Palatoalveolar		[− ANT]	[+ DIST]
Retroflex			[− DIST]
Palatal	[+ DOR]	see below	
Velar			
Uvular			
Pharyngeal	None		
Laryngeal		None	

Minor place features for dorsals and pharyngeals are also height and backness features for vowels:

(24)

		Front [+ FRONT, − BACK]	Central [− FRONT, − BACK]	Back [− FRONT, + BACK]
High	[+ HI, − LOW]	palatals	velars	
Mid	[− HI, − LOW]			uvulars
Low	[− HI, + LOW]			pharyngeals

(25) Coarticulated sounds may have multiple positive major place features:

Labiovelars: [w], [ʍ], [k͡p] = [+ LAB, − COR, + DOR, …]

(26)

	SYL	CONS	APPROX	CONT	SON
Vowels	+	−	+	+	+
Glides	−	−	+	+	+
(Non-syllabic) Liquids	−	+	+	+	+
(Non-syllabic) Fricatives	−	+	−	+	−
(Non-syllabic) Affricates	−	+	−	−	−
(Non-syllabic) Plosives	−	+	−	−	−
(Non-syllabic) Nasal Stops	−	+	−	−	+

(27) CONT VS. SON (VS. APPROX):

a. CONT cares about continuous airflow through the oral passage.
b. SON cares about non-turbulent airflow (through any passage).
c. Fricatives have continuous (but turbulent) airflow through the oral passage: [+CONT], [−SON]
d. Nasal stops have continuous non-turbulent airflow; only through the nasal passage: [−CONT], [+SON]
e. APPROX cares about both non-turbulent airflow and airflow through the oral passage: Nasal stops and fricatives are both [−APPROX]

(28) Obstruents [−SON]:

	CONT	DELREL
Fricatives	+	+
Affricates	−	+
Plosives	−	−

(29) VOT in features:

		VOT	VOI	SG
Voiced (Unaspirated)	[d]	Negative	+	−
Voiceless Unaspirated	[t]	Zero	−	−
Aspirated (Voiceless)	[t^h]	Positive	−	+

5 Rule Notation

(30) Target → Structural Change / Context

a. Target: A natural class which undergoes change
b. Structural Change: The features which this natural class gains in a certain context
c. Context: The context in which the Target changes, where "__" represents the target
d. Read as: [Target] becomes [Structural Change] when [Context].

(31) Special symbols:

a. # represents a word boundary (either the beginning or ending of a word):
__# means that the target is word final.
b. $[_\sigma$ and $]_\sigma$ represents the beginning and ending of a syllable:
__$]_\sigma$ means that the target is syllable final.
c. Ø represents null (nothing):
(i) X → Ø represents deletion of X
(ii) Ø → X represents epenthesis of X
d. C represents consonants, V represents vowels
e. X_n^m means any number of X segments between n and m. If no upper bound is listed, assume infinite.
f. Greek letters: α, β, γ, etc. represent variable values.
g. PLACE represents any place features (major or minor).
h. FEAT represents all features.

Examples:

(32) a. $\left[+ \ \text{CONT}\right] \rightarrow \left[+ \ \text{COR}\right] / \_\_ \left[+ \ \text{COR}\right]_2$
Read as: Continuants become coronal before two or more (consecutive) coronal segments.

b. $\begin{bmatrix} + & \text{VOI} \\ - & \text{SON} \end{bmatrix} \rightarrow \left[\alpha \ \ \text{PLACE}\right] / \_\_ \begin{bmatrix} \alpha & \text{PLACE} \\ + & \text{NAS} \\ - & \text{SYL} \end{bmatrix} \#$
Read as: Voiced obstruents (non-sonorants) assimilate in place with (become the same place as) following nasal consonants word finally

6 Universal Feature Theory in Rule Writing

(33) Some varieties of Spanish:
a. /b/ becomes [β] between vowels (intervocalically)
b. /d/ becomes [ð] between vowels (intervocalically)
c. /g/ becomes [ɣ] between vowels (intervocalically)

Do we want three rules to explain this? Do Spanish speakers process this as three different processes?

(34) Generalization:
Voiced plosives become fricatives intervocalically.

We want a single rule which explains all of these processes.

(35) First try, just names, no features:
Voiced Plosive → Fricative / Vowel __ Vowel

Let's find which (smallest number of) features define each of these groups.

(36) a. Voiced Plosives $= \begin{bmatrix} + & \text{VOI} \\ - & \text{SON} \\ - & \text{DELREL} \end{bmatrix}$

b. Difference between plosives and fricatives $= \begin{bmatrix} + & \text{DELREL} \\ + & \text{CONT} \end{bmatrix}$

c. Vowels $= \begin{bmatrix} + & \text{SYL} \\ - & \text{CONS} \end{bmatrix}$, or just V

Then plug in:

(37) Second try, features:
$\begin{bmatrix} + & \text{VOI} \\ - & \text{SON} \\ - & \text{DELREL} \end{bmatrix} \rightarrow \begin{bmatrix} + & \text{DELREL} \\ + & \text{CONT} \end{bmatrix} /\text{V}\_\_\text{V}$

Do we need to specify $[-\text{SON}]$ in the previous analysis?

(38) Parsimony:

a. Express classes and rules with the fewest number of symbols
b. Generalize as much as the data permits
c. Why? Because that is what people tend to do with phonological data:
   (i) Learners make the broadest generalizations unless given data which contradicts the generalizations they make.
   (ii) Acquisition tends to go through stages of overgeneralization, cf. 'goed'

7 Kinds of Sound Change

(39) Assimilation and Dissimilation

a. Features change to be similar (assimilation) or dissimilar (dissimilation) with surrounding segments.
b. Progressive: conditioner precedes target (feature spreads rightwards): preserve feature and change late.
c. Regressive: conditioner follows target (feature spreads leftwards): anticipate feature and change early.
d. Vowel Harmony: feature change only occurs to vowels, intervening consonants are ignored.
e. When writing rules: use greek letter variables: e.g. $[\alpha\text{PLACE}]$, in both structural change and condition.

(40) Deletion and Epenthesis:

a. Deletion or Creation (Epenthesis) of a segment.
b. When writing rules: use Ø, in target for epenthesis, in structural change for deletion.

(41) Metathesis:

a. Two segments switch ordering.
b. When writing rules: subscripts to represent different orderings:
c. $\begin{bmatrix} - & \text{SON} \end{bmatrix}_a \begin{bmatrix} + & \text{SON} \\ - & \text{SYL} \end{bmatrix}_b \rightarrow C_b C_a$

(42) Reasons to have sound change:

a. Ease of articulation:
   (i) Changing between segments with different features means moving muscles for each different feature!
   (ii) Consonant clusters can be hard to pronounce!
   (iii) Too many syllables means too much time spent talking!
b. Ease of perception:
   (i) Too many similar sounds make it difficult to distinguish repetition from unique words (did he say 'go-go' or did he just say 'go' twice by accident?)
   (ii) Consonant clusters can be hard to hear clearly!

8 Ordering of Multiple Rules

(43) Languages don't just have one sound change rule!

a. Processes may require multiple rules to describe accurately
b. However, the output of one rule might be the context for the input of another rule.
c. How do we determine the ordering of rules? Do rules need orderings?

(44) If two sound changes deal with completely different targets and contexts, then they may not ever influence the other:

a. For all inputs:
input > Rule A > Rule B is the same as
input > Rule B > Rule A
Then there is no strict ordering.
b. This must be the case for all inputs in order to hold true!

(45) There are four kinds of interactions:

a. Feeding
b. Bleeding
c. Counterfeeding
d. Counterbleeding

(46) TL;DR:

	A > B (Reality)	B > A (Could've been)
A Feeds B	B applies	B does not apply
A Bleeds B	B does not apply	B applies
B Counterfeeds A	A does not apply	A applies
B Counterbleeds A	A applies	A does not apply

8.1 Feeding

(47) Feeding is about what was enabled to happen "downstream":
Rule A feeds Rule B if:

a. Rule A applies before Rule B,
b. There is a word to which Rule A and Rule B apply, and
c. For that word, if Rule A did not apply first, the context for Rule B to apply would not exist.

In Tagalog, there is a word /ganap-in/ → [gampin] such that both deletion and assimilation apply, and if deletion did not apply, the context for assimilation would not exist.

(48) Feeding in Tagalog:

a. What it is:

	/kapit-in/	/ganap-in/	/banig-in/
V → Ø / VC__CV	[kaptin]	[ganpin]	[bangin]
$[+\ \text{COR}] \rightarrow [\alpha\ \text{PLACE}] / \_\_ \begin{bmatrix} \alpha & \text{PLACE} \\ - & \text{SYL} \end{bmatrix}$	—	[gampin]	[baŋgin]

b. What could've been:

	/kapit-in/	/ganap-in/	/banig-in/
$[+\ \text{COR}] \rightarrow [\alpha\ \text{PLACE}] / \_\_ \begin{bmatrix} \alpha\ \text{PLACE} \\ -\ \text{SYL} \end{bmatrix}$	—	—	—
V → Ø / VC__CV	[kaptin]	[ganpin]	[bangin]

8.2 Bleeding

(49) Bleeding is about what was prevented "downstream":
Rule A bleeds Rule B if:

a. Rule A applies before Rule B,
b. There is a word to which Rule A applies, and
c. For that word, if Rule A did not apply first, the context for Rule B to apply would exist.

In English, there is a word /glæs-z/ → [glæsɪz] such that epenthesis applies to it, and if epenthesis did not apply, the context for voice assimilation would exist, but because epenthesis did apply, the context for voice assimilation no longer exists.

(50) Bleeding in English:

a. What it is:

	/kæt-z/	/glæs-z/	/dɔg-z/
$Ø \rightarrow \text{ɪ} / [+\ \text{STRID}] \_\_ [+\ \text{STRID}]$	—	[glæsɪz]	—
$[+\ \text{STRID}] \rightarrow [-\ \text{VOI}] / [-\ \text{VOI}] \_\_$	[kæts]	—	—

b. What could've been:

	/kæt-z/	/glæs-z/	/dɔg-z/
$[+\ \text{STRID}] \rightarrow [-\ \text{VOI}] / [-\ \text{VOI}] \_\_$	[kæts]	[glæss]	—
$Ø \rightarrow \text{ɪ} / [+\ \text{STRID}] \_\_ [+\ \text{STRID}]$	—	[glæsɪs]	—

8.3 Counterfeeding

(51) Counterfeeding is about what could've been enabled "downstream":
Rule B counterfeeds Rule A (Rule A is counterfed by Rule B) if:

a. Rule A applies before Rule B,
b. If Rule B applied before Rule A, then Rule B would feed Rule A.

In Catalan, there is a word /sant/ → [san] such that nasal deletion does not apply to it, but if cluster reduction occurred before nasal deletion, then nasal deletion would apply to it.

(52) Counterfeeding in Catalan:

a. What it is:

	/san/	/sant/	/əskerp/
n → Ø / __#	[sa]	—	—
$\begin{bmatrix} -\ \text{SYL} \\ -\ \text{LAB} \end{bmatrix} \rightarrow Ø / C\_\_\#$	—	[san]	—

b. What could've been:

	/san/	/sant/	/əskerp/
$\begin{bmatrix} - & \text{SYL} \\ - & \text{LAB} \end{bmatrix} \rightarrow \text{Ø}/\text{C}\_\_\#$	—	[san]	—
$\text{n} \rightarrow \text{Ø} \ / \ \_\_\#$	[sa]	[sa]	—

8.4 Counterbleeding

(53) Counterbleeding is about what could've been prevented "downstream":
Rule B counterbleeds Rule A (Rule A is counterbled by Rule B) if:

a. Rule A applies before Rule B,
b. If Rule B applied before Rule A, then Rule B would bleed Rule A

In Polish, there is a word /ʒwob/ → [ʒwup] such that raising applies to it, but if devoicing applied before raising, then raising would not have applied to it.

(54) Counterbleeding in Polish:

a. What it is:

	/ʒwob/	/ʒwobi/	/trud/
$\begin{bmatrix} + & \text{BACK} \\ - & \text{LOW} \end{bmatrix} \rightarrow \begin{bmatrix} + & \text{HI} \end{bmatrix} .\_\_ \begin{bmatrix} - & \text{SYL} \\ + & \text{VOI} \end{bmatrix} \#$	[ʒwub]	—	—
$\begin{bmatrix} - & \text{SON} \end{bmatrix} \rightarrow \begin{bmatrix} - & \text{VOI} \end{bmatrix} / \_\_\#$	[ʒwup]	—	[trut]

b. What could've been:

	/ʒwob/	/ʒwobi/	/trud/
$\begin{bmatrix} - & \text{SON} \end{bmatrix} \rightarrow \begin{bmatrix} - & \text{VOI} \end{bmatrix} / \_\_\#$	[ʒwop]	—	[trut]
$\begin{bmatrix} + & \text{BACK} \\ - & \text{LOW} \end{bmatrix} \rightarrow \begin{bmatrix} + & \text{HI} \end{bmatrix} .\_\_ \begin{bmatrix} - & \text{SYL} \\ + & \text{VOI} \end{bmatrix} \#$	—	—	—

Note!! For /ʒwob/, both Rule A and Rule B apply, doesn't that mean that Rule A feeds Rule B? No: Rule B would apply without Rule A, so it is not considered a feeding configuration.