Linguistics 219 | Spring 2018
Phonological Theory III | B. Hayes

Class 19, 6/6/2018: Generative Phonetics II; Course Summary

1. Bureaucracy

- Last reading:
  - Flemming and Cho (2017) (harmonic grammar phonetics)
  - on course web site
- If you haven't already, make your appointment to give a talk to me, with handout.
- No office hours Friday (I will be marking the 5K route with Maura.)

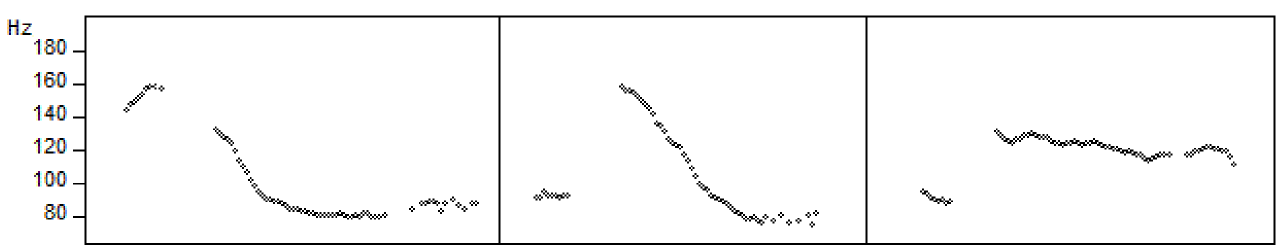
REGISTRAL HIERARCHY AND SHAPE IN F0

2. The concept of autosegmental register

- This can be found in Goldsmith's (1976) dissertation *Autosegmental Phonology*
- In African intonation systems, the downstepping seen in Liberman and Pierrehumbert's "berry" sentences also occurs; usually in alternating H and L: a H after L is not as high as the high that preceded it.
- Hence a *memory device*: "how high was H, the last time I uttered it?"
- The usual phonetic downstep rule is: "Lower the registers at the H-L transition."
- Exercise: deriving the various ways to say /ówà ówà/ in Etsako.[1]

3. Downstep in Japanese

- Seeking precision (since it's not triggered by just any H L transition), Pierrehumbert and Beckman call it *catathesis*.
- It is triggered by a pitch accent (H*+L).
- See figure from last time for the effect of catathesis on the final L boundary tone.



háʃi-o nuɾu	haʃí-o nuɾu	haʃi-o nuɾu
chopsticks-acc. paint	bridge-acc. paint	end-acc. paint
'paint chopsticks'	'paint a bridge'	'paint the end'

[1] Data and discussion from Baruch Elimelech (1978) *A Tonal Grammar of Etsako*, UC Press.

- Downstep is detectible by the minimal pair method: measuring peaks on the same items as they occur after accented or unaccented words.
  - This chart also varies focus.

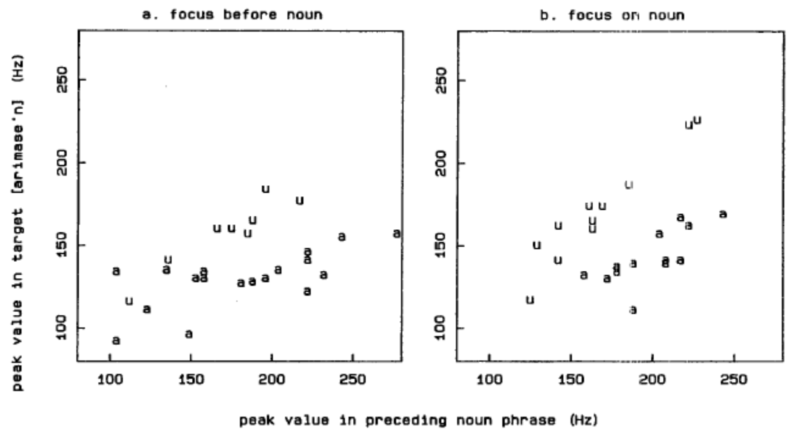
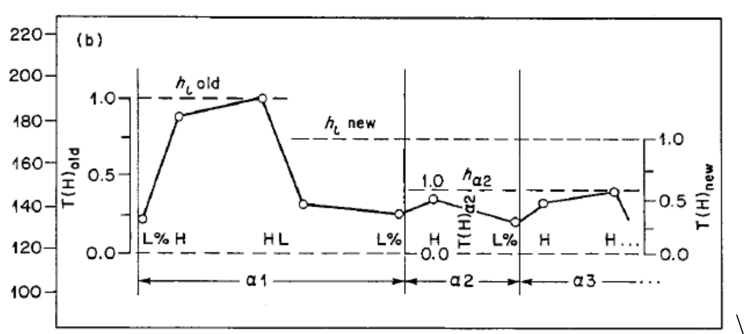


Figure 3.1
Value of the f_0 peak in *arimase'n* plotted against the peak in the preceding noun in utterances from the "amaimame" set produced by speaker TS. Plotting characters: "a" = accented noun *mame'*, "u" = unaccented noun *ame*. Panel (a) shows tokens with focus on the adjective preceding the accented or unaccented noun and (b) tokens with focus on the noun itself.

4. The key finding for scaling in Japanese

- *Every* tone is downstepped after an accent, each in suitable proportion.
- How to get this result? Basically, *downstep must change the Amana, not the tones*.
  - The metaphor of stretchable graph paper, scaled 0 - 1, on which each tone is plotted with its own inherent number.
  - e.g., if, one such graph paper, accented H* is 1 Amana, unaccented H is .9 Amanas, and L is .3 Amanas, the basic shape of pitch patterns in accentual phrases will remain the same.



- Hence, it appears that phonetics has hidden structure, like the other components of the grammar.

5. Shapes in generative phonetics

- There are older intonational traditions (O'Connor and Arnold; t'Hart and Cohen) that set up whole gestalts, shapes as theoretical entities.
- The same might be said for Articulatory Phonology, where a "gesture" is a mass-spring system that imposes a whole contour when run on its default settings.
- Might a stretch of graph paper, with its local tones and scaling, be thought of as a shape?
- The key counterargument is the meaningful compositionality of the tunes into tones, as argued for instance in Pierrehumbert and Hirschberg (1990).
  - Janet Pierrehumbert; Julia Bell Hirschberg (1990) The meaning of intonational contours in the interpretation of discourse. In Philip R. Cohen, ed., *Intentions in Communication.*
- You need both the parts (meaningful tonal morphemes) and the whole (the framework that organizes their phonetic implementation).

CROWDED SYSTEMS; GENERATIVE PHONETICS WITH HARMONIC GRAMMAR

6. Focus

- The systems that arise when targets are close by (the norm), forcing imperfect achievement of the target values.

7. The pervasiveness of compromise in crowded-environment phonetics

- Two elements inherently articulated in different places receive output values that moves them toward each other (see below on loci).
- Duration of segments reflects a compromise of effects based on
  - inherent duration
  - number of segments in syllable or rhyme
  - phrasal position
  - etc.
- A key goal is to set up grammatical systems that achieve these compromises in a simple and natural way.
- Harmonic Grammar seem to be a viable method to pursue.

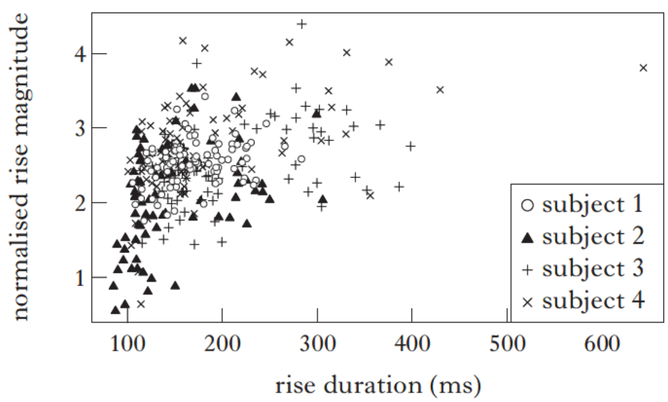
8. Basics of running a phonetic grammar in a Harmonic-Grammar framework

- Constraint violations: these will penalize *quantitative* deviations from a target.
  - Not "how many times", but "how much"
- Violations need not be integers.
  - Nothing in the math of harmonic grammar or maxent would demand this in any event.
- Asserting winners: two possibilities
  - a non-stochastic system with a single winner: the most harmonic candidate

- a stochastic system, using maxent or Noisy Harmonic Grammar, deriving a probability distribution over outputs.

9. A characteristic empirical pattern in crowded systems

- Flemming and Cho's clouds of points (readings) are pudgy-snakes like Pierrehumbert's, but they are **curved**, not straight.[2]
- This is because one end of the range is constrained by other factors and cannot continue in a straight line.
- Look right-to-left along this plot of Mandarin rising tones (Tone 2): as you shorten, it becomes impossible to rise that much.



10. Don't forget knobs

- Surely their effects are at least as powerful in phonetics as anywhere else.
- Flemming and Cho found that one speaker liked to use a big pitch range for *medium* speaking rate only; and just normalized this out. (p. 18)

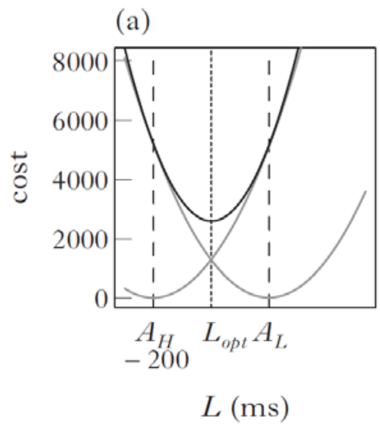
11. The mechanism of compromise in phonetic harmonic grammars (Flemming)

- It is essential that violations *be taken to some power greater than one* (he and others use 2).
- Only in this way do you get
  - compromise outcomes
  - compromise outcomes favoring the stronger constraint

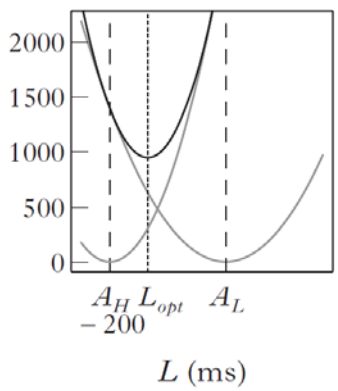
12. Schematic example from Flemming and Cho: An equal compromise

- Vertical axis: Harmony penalty
- Horizontal axis: timing of L target

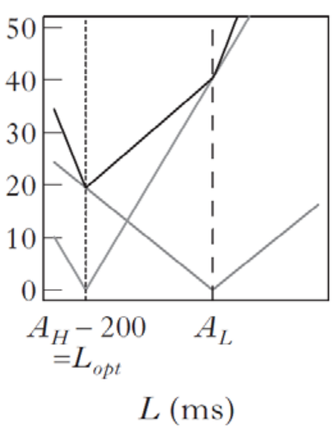
[2] Inevitably, given the complexity of crowded-target phonetics, they are pudgier.



13. An unequal compromise: higher-weighted constraint has stronger influence



14. The bad result with power-of-one rather than power-of-two: winner-take-all



FUNDAMENTALS OF HARMONIC GRAMMAR PHONETICS: FLEMMING'S EARLY RESULT ON LOCI

15. Source

- Flemming, Edward (2001) Scalar and categorical phenomena in a unified model of phonetics and phonology. *Phonology* 18: 7-44.
- I see this as the urtext of Harmonic Grammar phonetics, though Flemming doesn't call it that.

16. The scheme

- You have a consonant, like /t/, and a vowel, like /a/.
  - /t/ wants F2 to be 1800
  - /a/ wants F2 to be 1100.
- The system wants to avoid a severe, mousetrap-like transition at release.
- It turns out that both the consonant and the vowel contribute to the compromise.

17. The existing findings of experimental phonetics

- The outcome is always a compromise.
- The target for the consonant — unobservable, inferred — is called its *locus*.
- This was worked out, with equations, by phoneticians Bjorn Lindblom, Harvey Sussman and others.
  - Lindblom, Björn (1963). Spectrographic study of vowel reduction. JASA 35:1773-1781.
  - Sussman, H. M., K. A. Hoemeke & F. S. Ahmed (1993). A cross-linguistic investigation of locus equations as a phonetic descriptor for place of articulation. JASA 94.1256-1268.
  - Sussman, H. M., H. A. McCaffrey & S. A. Matthews (1991). An investigation of locus equations as a source of relational invariance for stop place categorization. JASA 90.1309-1325.
- The standard "locus equation" for consonants as expressed by Flemming:

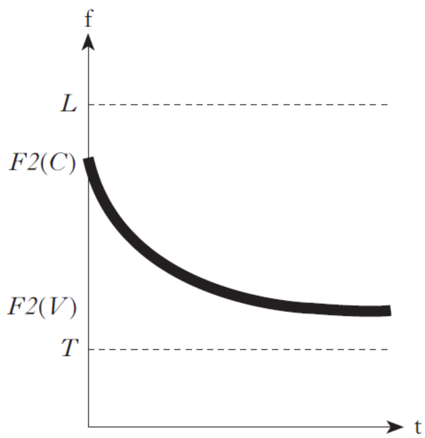
  $$F2(C) = k_1(F2(V) - L) + L$$

  - I.e., the F2 of the consonant at release is basically its locus L, but deviating from L by an amount based on how far away the target for the vowel (F2(V)) is.
  - Note that in Flemming's diagram, the vowel itself compromises a bit, deviating from its target.
- Adding in the equation for the vowel:

  $$F2(V) = k_2(F2(C) - T) + T$$

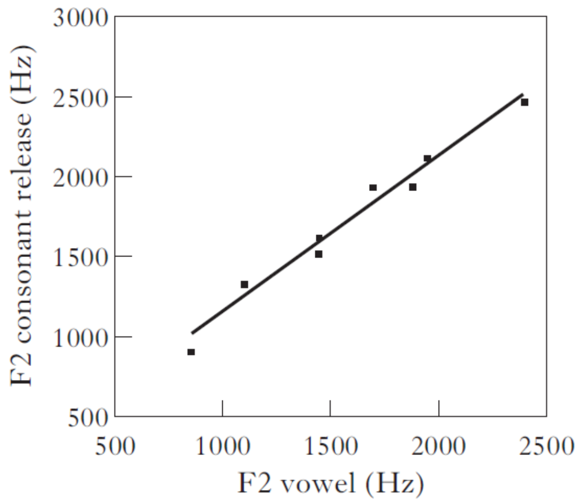
  - which is just the same equation going in the opposite direction.

- Flemming puts the two patterns together in a schematic graph:



18. Locus theory works

- [g] followed by a variety of vowels (Flemming's data):



- Socrates: what is the slope of the line and why?

19. Flemming's Harmonic Grammar analysis

- Constraints (note squared deviation penalty, per above)

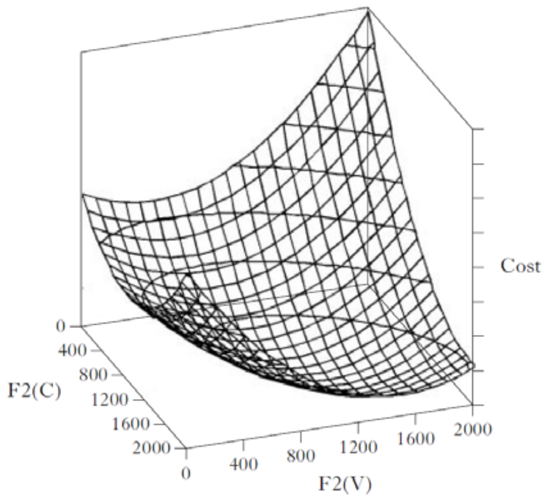
	Constraint	*Cost of violation*
IDENT(C)	$F2(C) = L$	$w_c(F2(C) - L)^2$
IDENT(V)	$F2(V) = T$	$w_v(F2(V) - T)^2$
MINIMISEEFFORT	$F2(C) = F2(V)$	$w_e(F2(C) - F2(V))^2$

- Calculating harmony — this is the standard formula, sumproduct() with weights.

$$cost = w_c(F2(C) - L)^2 + w_v(F2(V) - T)^2 + w_e(F2(C) - F2(V))^2$$

- Finding the best candidate.

- It is the F2(V) and F2(C) coordinates of the *minimum* of a beautiful parabolic harmony-bowl:



- You don't need the Solver for this! Flemming dredged up his high school calculus; a minimum is where the slope along every axis is zero.
- The answer is:

$$F2(C) = u_c(L-T)+L \quad \text{where} \quad u_c = \frac{w_e w_v}{w_e w_c + w_v w_c + w_e w_v}$$

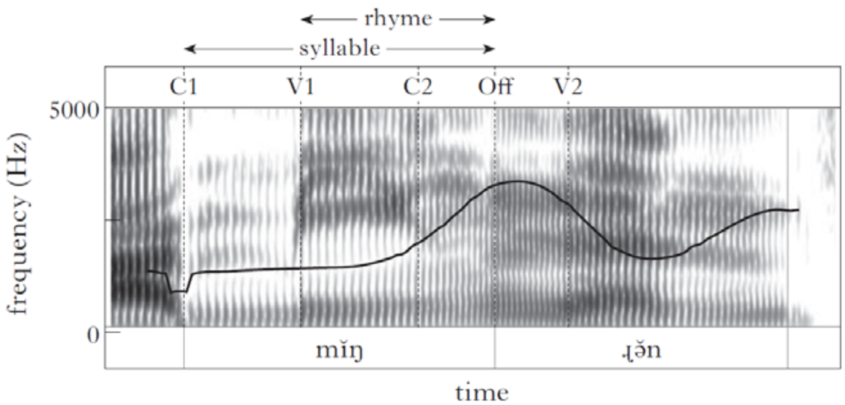
$$F2(V) = u_v(L-T)+T \quad \text{where} \quad u_v = \frac{w_e w_c}{w_e w_c + w_v w_c + w_e w_v}$$

- These equations are indeed the Lindblom/Sussmann locus equations, with coefficients derived from the constraint weights. QED!

COMPROMISING IN THE REALIZATION OF MANDARIN SECOND TONE

20. Second tone

- Following fairly standard assumptions, treated as LH.
- Here is "famous person", first syllable is LH.



21. The four-way compromise

- L wants to be in a segmental spot (some distance into the vowel)
  - ➢ It might have to move leftward as a compromise, when speech is fast.
- H wants to be in a segmental spot (rather late in the syllable)
  - ➢ It might have to move rightward as a compromise, when speech is fast.
- Each tone has a pitch target, too, so we want there to be a pitch rise, H − L.
  - ➢ It might have to be less as a compromise, when speech is fast.
- Slope is a cue to second tone, so there is a best-slope target [controversy]
  - ➢ It might have to be less, or more, as a compromise.

22. Formalizing as constraints in Harmonic Grammar

target	constraint	cost of violation
magnitude	$M = T_M$	$w_M(M - T_M)^2$
slope	$S = T_S$	$w_S(M/(H - L) - T_S)^2$
L alignment	$L = A_L$	$w_L(L - A_L)^2$
H alignment	$H = A_H$	$w_H(H - A_H)^2$

- the only non-trivial part is defining slope violations; be sure you follow what is being calculated here.
- Again, we multiple violations by weights to obtain harmony (a.k.a. cost):

$$Cost = w_M(M - T_M)^2 + w_S\left(\frac{M}{H-L} - T_S\right)^2 + w_L(L - A_L)^2 + w_H(H - A_H)^2$$

23. This is much harder than the locus-analysis was

- Finding the best weights requires a search of a non-convex space to fit the data, and they try lots of starting points to make sure the system is reasonably consistent.

- Deciding how to read the time values of the L and H targets is non-trivial; they use fitting of line segments, a method also used by Pierrehumbert and Beckman (1989).
- Deciding how well the model works against noisy experimental data is also hard.
- I admire the paper partly as an example of disciplined, thoughtful addressing of these hard problems.
- In the end, they seem to get a reasonably decent model.

24. The big theoretical result

- The model requires that we assign a target for Slope.

25. Where does this put Autosegmental Phonology?

- This is a now-challenged consensus: since the 1970's all dynamic entities in phonology have been represented analytically as double-target sequences.
- I'm inclined to keep this view, I guess, given the lack of insight provided by primitive dynamic features.
- Key addition is Steriade's view: OO-correspondence is not just phonemic elements, but deduced phonetic elements, of which Slope is perhaps one.

OTHER APPLICATIONS OF HARMONIC GRAMMAR IN PHONETICS I:
PARADIGM UNIFORMITY

26. Work of Aaron Braver

- Braver, Aaron (2013) Degrees of incompleteness in neutralization: Paradigm uniformity in a phonetics with weighted constraints. Rutgers Ph.D. dissertation.
- Example case
  - Japanese /CV/ → [CVˑ], not quite as long as underlying /CVː/.
  - /fu/ 'gluten' is [kiˑ] alone, [fu ga] with suffix.
  - /fuː/ 'seal' is [fuː] alone.
- Example:
  - /fu/ alone wants to be bimoraic to satisfy a word-minimum.
  - It wants to be shortish to resemble the base form (seen before a suffix, as in *fu ga*)
- Theory is wonderfully simple:
  - derived forms are tied to their bases by weak, weighted constraints that penalize differences in phonetic parameters.
  - this is done with Harmonic Grammar, with Flemmingian squared derivations from constraints TARGETDUR=x, OOFAITH(Dur)

27. Braver's Law of Incomplete Neutralization

- All incomplete neutralizations are compromises between the observed values in paradigms.

- Example: there could never be a German′ in which /rad/ surfaces as slightly "more voiceless" than /rat/.

COMPROMISE IN DURATIONAL HIERARCHIES

28. References

- Katz, Jonah (2010) Compression effects, perceptual asymmetries, and the grammar of timing. MIT dissertation.
- Lefkowitz, Michael (2017) Maxent Harmonic Grammars and Phonetic Duration, UCLA dissertation.
- Hayes, Bruce and Russell Schuh (in progress) Metrical structure and sung rhythm of the Hausa Rajaz, ms.

29. Key idea

- Segments have preferred durations
- Syllables and other higher-level units have preferred durations.
- The durations we observe are a compromise, metaphorized by Katz thus:

  "A useful metaphor for understanding the logic of the formalism is the problem of trying to fit partially-malleable objects into a partially-malleable container."

- The Flemmingian model can be applied, setting up harmony penalties for deviations at both segmental and syllabic levels.
- Hayes and Schuh also include targets for musical rhythm, to model singing data.
- Hayes and Schuh do their harmonic grammar in the maxent fashion, outputting probability distributions rather than single optima.

COURSE SUMMARY

30. A quick overview

Tracking the evolving field:
    phonology as effort to predict behavior, as opposed to rationalizing a corpus
Maxent
    probability as the basis for rational inductive thought
    why the maxent formula is as it is
    finding the weights
    practical experience with medial clusters
The framework bazaar and how to decide among frameworks
    harmonically bounded partial-winners

- constraint ganging
- Bias
  - frequency matching as default; but there is also also non-veridical learning, the result of bias
  - modeling bias with priors in maxent
  - paradigm uniformity as a particularly fruitful application of the concept of bias
- Model evaluation
  - quantitative models need serious methodology to evaluate one analysis against another
  - Wilson and Obdeyn
    - trashing of Observed/Expected as foolish ad hockery
    - glory for principles maxent, which actually reconstructs the inventor's intent in artificial examples
    - empirical domain: root cooccurrence restrictions on consonants
- Knobs and variation
  - "Knobs" are control elements outside the constraint system itself.
  - 4 knobs: style, rate, emphasis, lexical frequency
  - process-lockstep (Miriam Of The Lower East Side) as evidence for knobs
  - The Coetzee-Kawahara approach; teasing out its predictions
  - register conflict as a means of accessing process-lockstep (ways to say *mountain*)
- Acquisition
  - the Mennian two-grammar, two-lexicon model
  - Phenomena: avoidance, near-neutralization, opacity
  - Two topics related to learning the parental system:
    - Bayesian distributional learning of segmentation, to get started
    - learning hidden structure as an unsolved problem; the exterminationist response
- Paradigm Uniformity
  - examples
  - mechanisms: OO correspondence and others
  - phonotactic liberality in paradigms relative to stems
  - evidence from historical change, experiments, acquisition
  - funny bases for paradigms:
    - quirky derivation: *communication* → *communicable*, *-ism/-istic*
    - Steriade's inflectional-paradigm bases for derivation
    - lexical conservatism (Steriade) and multiple-choice bases
  - what can be inherited with OO? Not just contrastive properties
    - Steriade on French
    - Turk and others on *bacon* ≠ *bakin'*
    - Kenstowicz on syllabic affiliation in Spanish
  - The higher the grammatical/phrase level, the stronger the degree of inheritance
- Syllable weight
  - apparent phonetic basis — onset-biased energy integral (Gordon)
  - weight is process-specific, not language-specific (Gordon)
  - weight criteria selected by combination of phonetic sensibleness and formal simplicity (Gordon)
  - Ryan's Law:

in stochastic contexts, all criteria of weight enter in (meter, Kelly's English study)
capturing this by combining gradient and categorical constraints in the same grammar

Lexical variation (Kie)
pure token variation, type variation, mixed variation
theoretical approaches, including lexically indexed variation

Generative phonetics
target-and-interpolation theories
arithmetic as the language of phonetic interpretation
phonologically-guided experimentation as the key to finding phonetic generalizations
crowded systems with compromise, analyzed with Harmonic Grammar

31. Course evaluations