Linguistics 201A — Winter 2023
Phonological Theory I — B. Hayes

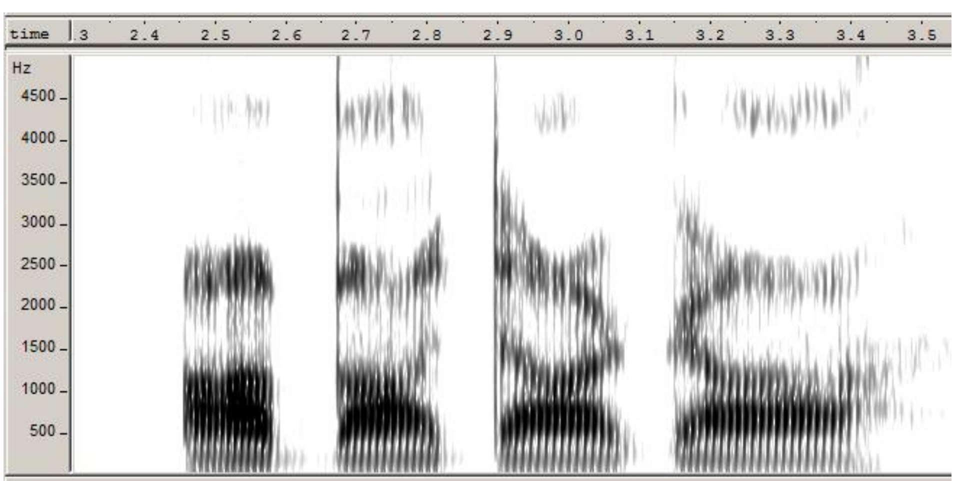
Class 14, 2/23/23: Phonetics in phonology II

1. Current assignments

- MaxEnt phonotactics homeworks — I will need more time to grade them; sorry.
- Web site is *still* down: please visit instead
  - https://www.palisadessymphony.org/temp/index.htm
- Read for next time:
  - White, James (2017). Accounting for the learnability of saltation in phonological theory: A maximum entropy model with a P-map bias. *Language* 93:1-36.
  - No summary required
- Indonesian stress homework is due in class Tues. Feb. 28.

2. Phonetics in phonology: reviewing from last time

- Possible phonetics-based biases
  - Maintain perceptual distance between phonemically-contrasting entities.
  - Maintain perceptual similarity between the allomorphs of a morpheme (P-map)
- So, what is the basis for phonetic similarity?
  - The theory of external vs. internal cues
  - Segments with internal cues (primarily vowels) should be abundant — see below.
  - Segments relying on external cues should be vowel adjacent, so they can be detected by means of coarticulation.



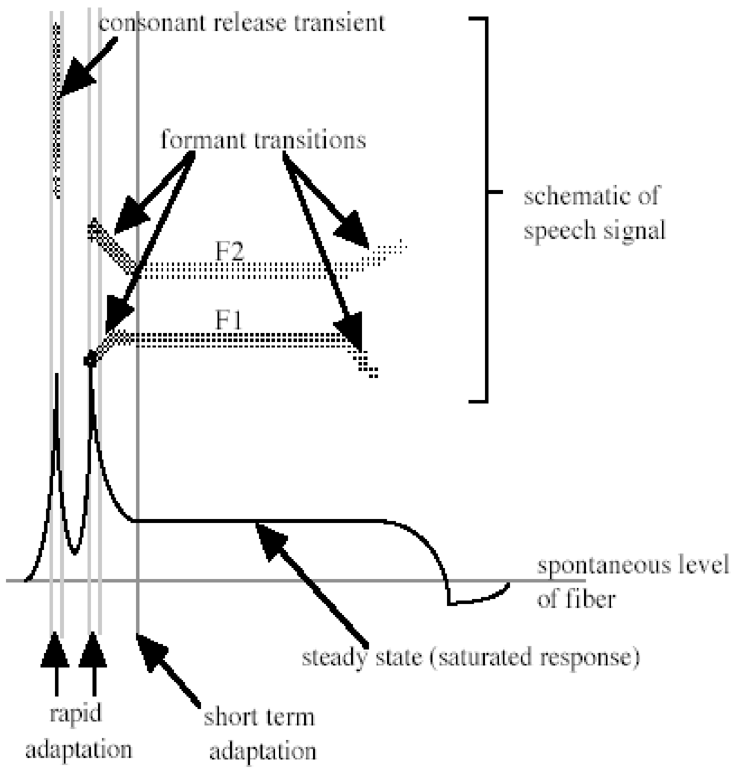
Three semi-voiced stops in the frame / a ___ a ___ a ___ a, speaker BH. What are they?

3. Factoring in the asymmetries of the auditory system

- Literature review: Wright, Richard (1997) Consonant Clusters and Cue Preservation in Tsou, UCLA dissertation; also Wright (2004), cited above.

- The auditory system goes wild at sudden increases in amplitude, is indifferent to sudden decreases.
  → CV transitions are salient, VC transitions are not
  → a preference for consonants in prevocalic position

4. Response curves (figure from Wright 2004)



5. External cues

- Plausibly, these should be more abundant; e.g. put more vowel contrasts into the long vowels (Hindi), or the stressed vowels (English).
- See, e.g.
  - Crosswhite, Katherine. "Vowel reduction." In Hayes/Kirchner/Steriade *Phonetically based phonology* (2004): 191-231.

SOME CASE STUDIES OF PHONETIC EFFECTS IN PHONOLOGY

6. What is the direction of assimilation in consonant clusters?

- Pre-Steriadian wisdom:
  - ➢ Coda consonants assimilate to onset consonants.
  - ➢ Exceptions: affix consonants assimilate to stem consonants.
  - ➢ Hebrew homework shows both principles, with constraint ranking.

    /it-labeʃ-u/ → [itla**p**ʃu]
    /it-zarez/ → [iz**d**arez]

7. Steriade: reference to syllables is aprioristic; let's look at the cues

- Simple cases: non-prevocalic consonants assimilate to prevocalic ones.
- This follows from two things:
  - The principles just given concerning the salience of external cues.
  - The further principle (a key theme of this course) that alternation tends to be minimally salient perceptually.
- Let us consider a canonical case, found all over the world: /an+pa/ → [ampa]
  - Try three candidates: faithful, [ampa], [anta]

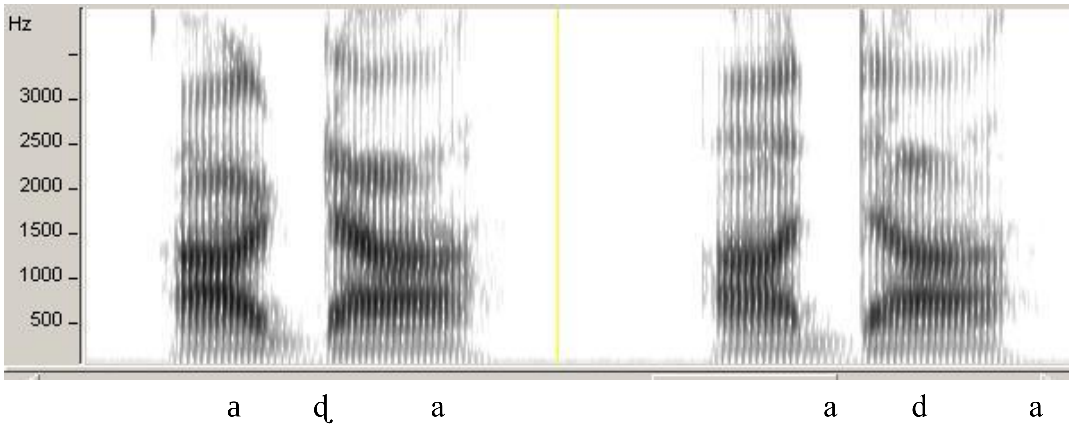
8. Steriade's *Paradebeispiel*:[1] retroflex/alveolar contrasts

- Retroflexes are common in the languages of Australia and India
- There is enough information to obtain typological preferences.
- Strikingly, they tend to be backward:
  - In retroflex-alveolar or alveolar-retroflex sequences, we normally get *progressive* assimilation (/atʈa/ → [atta], /aʈta/ → [aʈʈa]).
  - Why should these be different?

9. The phonetics of retroflex articulation

- There is forward tongue movement during retroflexes:
  - at release, they are almost alveolars
  - cues are mostly in preceding vowel [aɖa] [ada]
  - characteristic preferred position of retroflexes is **postvocalic**, even in codas
  - Thus: neutralization (usually to alveolar) in initial and postconsonantal position
  - progressive assimilation of retroflexion in consonant clusters, rather than the normal regressive assimilation
- This shows up on a spectrogram, and indeed is (I think) plainly audible, at least for retroflexes as I articulate them:
  - [ad] [aɖ], [da], [ɖa]
  - see spectrogram

[1] German, 'parade example'. A favorite word of Indo-Europeanists.



10. Consequence

- In coronal sequences with retroflexes, phonetic salience of alternation is minimized by progressive assimilation.
- Again, try an informal tableau with /atʈa/: faithful, regressive, progressive

11. Steriade's theoretical proposal: the P-map

- Children accumulate phonetic experience in perceptual and articulatory maps (Steriade readings).
  - ➢ Here is a sample P-map from Steriade:

	V_V	V_#	V_C	#_V	C_V	C_C
s/ʂ	s/ʂ	s/ʂ	s/ʂ	s/ʂ	s/ʂ	s/ʂ
t/ʈ	t/ʈ	t/ʈ	t/ʈ	t/ʈ	t/ʈ	t/ʈ
n/ɳ	n/ɳ	n/ɳ	n/ɳ	n/ɳ	n/ɳ	n/ɳ

- They use this as a learning bias; favoring phonetically sensible constraints.
- For Steriade this is a set of universal a prior rankings on a set of highly-detailed Faithfulness constraints.
- Colin Wilson (2006, *Cognitive Science*) built on this, developing a "soft UG" version with μ's for the weights of each Faithfulness constraint, derived from the P-map.

12. Further: Jun (2004)

- Other factors affecting perceptibility of place also affect assimilation.
- Nasals obscure the formants of neighboring vowels; are weakly cued for place, assimilate more easily.
  - ➢ Jun, Jongho. "Place assimilation." In Hayes/Kirchner/Steriade *Phonetically based phonology* (2004): 58-86.

- Assimilation of place in nasals implies assimilation of place in stops, etc.

13. Let us do a couple of tableaux for place assimilation.

Try: np → mp, not *nt
ʈt → ʈʈ, not *tt

Set up the constraints with *Articulation, *Map constraints.
Relate what you find to the P-map.

For *Articulation, we might appeal to the "radical autosegmentalism", often expressed as "feature geometry", of the 1980s and 1990s.

14. Similar patterns in hiatus resolution

- Remember Ilokano: /i/ is happy to become [j], /e/ is willing to become [j], /a/ is unwilling to become [j].

15. The "Too many solutions" problem

- Reference: Steriade readings
- This has long been noticed as a peril of OT.
- Language characteristically fix
  - b] by devoicing it
  - np by assimilating the n
  - VV by gliding, inserting [ʔ]
- BUT: use your imagination, how else might these problems be fixed? Of course, all these solutions are included in GEN.
- Steriade suggests that languages favoring the perceptually least salient repair, per P-map, and (for us) preferred weightings of *Map constraints.

16. In favor of a "soft" answer to the Too Many Solutions problem

- I'm personally happy with this, since of course typology does give us cases where multiple solutions occur cross-linguistically.
  - See Zuraw, Kie and Yu-An Lu (2009). Diverse repairs for multiple labial consonants. *Natural Language and Linguistic Theory* 27. Pp. 197-224.
- This relates to the question of unnatural phonology, dished up by accidents of history.

17. Some non-P-map compliant phonology of diachronic origin

- A compendium of cases involving epenthesis: Bert Vaux (2002) Consonant epenthesis and the problem of unnatural phonology (2002). Never published but available on line.
- The most famous case is non-rhotic English, which diachronically restructured to give epenthesis of (for heaven's sake) [ɹ].
- History:

law	*lore*	*the law is*	*the lore is*	
lɔ	lɔɹ	ðə lɔ ɪz	ðə lɔɹ ɪz	ancient (preserved in non-rhotic dialects)
—	lɔ	—	—	loss of nonprevocalic /r/
—	—	ðə lɔɹ ɪz	—	restructuring as epenthesis

- Comparable restructurings have led to a surprising zoo of epenthetic consonants. Here is Vaux's list:

  t Axininca, Korean, French, Maru, (Danish?)
  d French aphasic
  n Korean, Greek, Sanskrit, Dutch, Swiss German, (Armenian, Mongolian, English)
  ŋ Buginese (Trigo-Ferre 1988, Lombardi 1997:14)
  r English, German, Uyghur, Zaraitzu Basque (Hualde and Gaminde 1998:42), (Japanese)
  l Bristol, Midlands American, Motu, Polish
  y Turkish, Uyghur, Greenlandic, various Indic (Masica 190), Arabic (Heath 1987:48)
  w Guajiro, Greenlandic, Arabic (Heath 1987:48), Abajero Guajiro
  v Marathi (Masica 190)
  b Basque (Markina, Urdiain, Etxarri, Lizarraga; Hualde and Gaminde 1998:42)
  ʃ Basque (Lekeito/Deba, Zumaia; Hualde and Gaminde 1998:42)
  ʒ Cretan and Mani Greek (Newton 1972:56), Basque dialects (Hualde and Gaminde 1998:42)
  g Mongolian, Buryat
  s/z French, Land Dayak, Dominican Spanish
  x Land Dayak

  The [l] case in Midlands English is like *The crow is* [kɔ-l-ɪŋ], homophonous with *calling.*

18. More non-p-map compliant phonology

- Phonologists are struck by the fact that Korean repairs final /tʃ/ as [t] in paradigmatic alternation, but as [tʃi] in loanwords ("lunchie").
- Plausibly (can't prove it): the paradigm case is telescoped history; loanword adaptation is fresh and P-map compliant.

WHITE ON SALTATION

19. References

- White, J. (2017). Accounting for the learnability of saltation in phonological theory: A maximum entropy model with a P-map bias. *Language*, 93(1), 1–36.
- Hayes, B. & White, J. (2015). Saltation and the P-map. *Phonology*, 32(2), 1–36.
- White, J. & Sundara, M. (2014). Biased generalization of newly learned phonological alternations by 12-month-old infants. *Cognition*, 133(1), 85–90.
- White, J. (2014). Evidence for a learning bias against saltatory phonological alternations. *Cognition*, 130(1), 96–115.

20. Ur-reference, inventing the method

- Wilson, Colin. "Learning phonology with substantive bias: An experimental and computational study of velar palatalization." Cognitive science 30, no. 5 (2006): 945-982.

21. Basic scheme

- This is an Artificial Grammar Learning experiment, modeled on Campadanian — is the saltatory pattern hard to learn?
- Stimuli (singular-plural of pictures)

	p	b
	f	v
A.	ap	avi
B.	ab	abi

22. Key results

- Participants tend to generalize [ap] ~ [av-i] to [ab] ~ [av-i], when not exposed to [ab].
- They do this to some extent even when trained explicitly on [ab] ~ [ab-i].
- A followup on 12-month-old infants yielded similar results.

23. You can train a MaxEnt grammar to be a White-participant

(11) Calculating predicted probabilities in tableaux

a. Input /VpV/ in experiment 1, potentially saltatory condition

/VpV/	*V[−voice]V 2.20	*MAP(p, v) 2.17	*V[−cont]V 1.86	*MAP(b, v) 1.30	Penalty score	$e^{(-\text{penalty})}$	Predicted prob.
VvV		1			2.17	.1142	.87
VpV	1		1		4.06	.0172	.13

b. Input /VbV/ in experiment 1, potentially saltatory condition

/VbV/	*V[−voice]V 2.20	*MAP(p, v) 2.17	*V[−cont]V 1.86	*MAP(b, v) 1.30	Penalty score	$e^{(-\text{penalty})}$	Predicted prob.
VvV				1	1.30	.2725	.64
VbV			1		1.86	.1557	.36

24. Levels of modeling

- Flat-out data matching
- Learning influenced by a UG prior, grounded in phonetics.

25. The effort made at biased modeling

- Obtain a P-map: take a confusion matrix, and set up an artificial MaxEnt grammar: "If I hear [*x*], what is probability that I perceive [*y*]?"
- Here is one confusion matrix that White employed, from Cutler et al. (2004, *JASA*):

TABLE V. Confusion matrix for initial consonants at 0 dB SNR categorized by the Dutch listeners. Percentages of correct responses have been pooled over participants and vowel contexts.

	Response																					
	pie	tie	car	far	thin	see	she	chin	hi	be	do	go	very	there	zoo	joke	yell	my	no	lie	row	win
Stimulus	p	t	k	f	θ	s	ʃ	tʃ	h	b	d	g	v	ð	z	dʒ	j	m	n	l	r	w
p	**30.8**	3.3	9.2	9.6	2.9			0.4	19.2	11.7	1.3	1.3	2.9	1.7	0.4		0.8	0.8	1.3	1.3		1.3
t	24.6	**14.2**	12.5	7.5	7.9	0.8		2.9	11.3	7.1	0.4	2.1	1.3	1.7				2.1	3.3	0.4		
k	25.0	7.9	**25.8**	3.8	4.2	0.4	0.8	0.4	13.8	4.2	1.3	3.8	1.3	0.8	0.4	0.4	1.3	0.4	1.7	1.3	0.4	0.8
f	24.6	2.1	9.2	**15.0**	7.1		0.4	0.4	9.2	15.0	1.7	2.9	5.4	4.2		0.4	0.4	0.4	0.4		0.4	0.8
θ	18.8	6.3	3.8	13.3	**12.1**	0.4	0.4	0.4	7.1	14.2	2.5	1.7	2.9	7.5			0.4	1.3	2.9	2.9		0.8
s	0.4	2.5	0.4	12.5	24.6	**30.4**	0.8	0.4		0.8	1.3		3.3	7.9	14.6							
ʃ		0.4			1.3	6.7	**72.5**	18.3									0.8					
tʃ	3.3	4.2	1.3	2.1	2.5	1.3	4.6	**70.8**	1.3	1.3	0.4		0.4	0.8		5.4	0.4					
h	26.3	4.6	12.1	11.3	5.0	0.4	0.4	0.8	**17.9**	8.3	1.3	0.4	4.6	1.7	0.4		0.8		0.8	1.7	0.8	0.4
b	7.5	0.4	5.8	9.2	1.7	0.4		0.4	12.5	**28.3**	2.5	0.4	4.6	2.1			2.9	7.1	2.9	5.0	1.3	5.0
d	2.5	2.1	1.3	1.3	5.4				8.8	12.1	**10.8**	2.5	2.1	12.9	0.4	0.4	6.3	4.2	12.5	12.5		1.7
g	3.3	1.3	9.2	2.9	2.5		0.4	1.3	9.2	10.0	5.0	**17.1**	1.7	3.3		0.8	24.2	0.8	2.5	2.5	0.4	1.7
v	7.5	2.9	2.5	8.8	5.0	0.4			6.7	30.0	1.3	1.7	**9.6**	7.9			2.1	3.8	1.7	0.4	2.5	5.4
ð	2.5	1.3	2.5	1.7	14.6	2.1	0.4	0.8	2.1	17.1	10.0		1.3	**18.8**	1.3	1.7	1.3	1.3	3.3	12.1	0.8	2.9
z		0.8	1.3	1.3	9.6	3.3	0.4	1.3		7.9	5.0		2.5	23.8	**27.1**	1.3	2.5	2.1	5.0	0.4	0.8	3.8
dʒ	4.2	0.4	2.5	0.4	2.1		0.8	18.3	2.1	2.1	6.7	2.1		7.5		**40.4**	5.8	0.4	1.3	2.9		
j	1.3		0.8	0.8	0.8		0.8	0.4	2.1	4.2	2.5	1.3	0.4	1.3	0.4	4.6	**69.6**	2.5	4.2	1.3		0.8
m	3.8	0.8	2.5	2.9	0.4				2.1	9.6	0.8		2.5					**50.0**	10.0	5.0	5.4	4.2
n					0.4				2.1	1.7	1.3					0.8	0.4	12.9	**73.8**	4.6	0.4	1.7
l	5.8	1.3	1.7	1.3	1.3			0.4	2.1	8.3	1.7	0.8	2.5	3.3			1.3	10.0	4.2	**46.7**	2.1	5.4
r	2.5	1.3	1.7	2.1				0.4	5.8	14.6	0.8	2.1	1.3	0.8				0.8	0.4	0.4	**58.3**	6.7
w	1.7		0.4	0.4	0.4	0.4			1.7	5.8	0.8		2.1	0.4				5.8	0.8	2.5	1.7	**75.0**

J. Acoust. Soc. Am., Vol. 116, No. 6, December 2004 Cutler *et al.*: Native and non-native phoneme confusion 3673

- The artificial MaxEnt grammar gives the default weights for *MAP() constraints.

26. White's method for biased learning

- Taken from Wilson (2006), with improvements.
- Here is the MaxEnt formula from Goldwater and Johnson (2003):

$$\log \mathrm{PL}_{\bar{w}}(\bar{y}|\bar{x}) - \sum_{i=1}^{m} \frac{(w_i - \mu_i)^2}{2\sigma_i^2}$$

  - First part: log likelihood of the batch of candidates *y* given their UR *x*.
  - Second part: the prior, which implements the bias

27. Key part of the prior

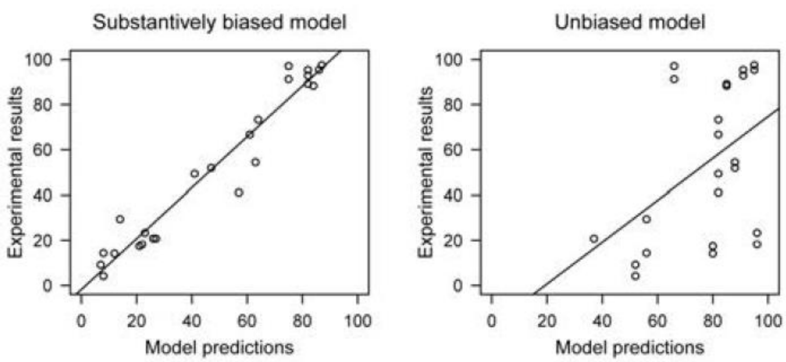
- Find the difference between the weight being solved for, and its ideal values, μ.

- Square it
- Rescale it
    - ➢ You could just multiply it by something, but instead one divides by twice sigma squared. I will briefly tell you why.

28. The point of doing this

- The grammar learned emerges as a compromise between matching the learning data and matching "UR" in the form of the prior.
- Socrates:
    - ➢ If σ is enormous, what do you match?
    - ➢ If σ is tiny, what do you match?

29. The method worked well for White



- It would appear that the participants actually didn't pick up much from the data themselves!
- They respond heavily influenced by the similarity prior.
- Real-life learners of Campidanian had a far better chance to overcome their prior.

DISPERSION AND CONTRAST IN PHONOLOGY

30. Some references

- Flemming, Edward (2002) *Auditory representations in phonology*, Routledge.
- Flemming, Edward (2004) Contrast and Perceptual Distinctiveness. In Bruce Hayes, Robert Kirchner, and Donca Steriade, eds., *Phonetically-Based Phonology*, Cambridge University Press (readings)
- Work of Jaye Padgett, UC Santa Cruz, a guide posted at https://humweb.ucsc.edu/jayepadgett/wp/research
- Work of Juliet Stanton, NYU, posted at https://julietstanton.github.io/
- Work of Paul Boersma and colleagues, noted below

31. Dispersion

- The contrasting forms of a language should sound *different from each other*.
- This is completely sensible a priori, given the demands of speech perception.
- It means that the "goodness" of a form depends on the other forms that are present in the language.
- This ends up falsifying the hypothesis of "harmonic completeness," as defined below.

32. Harmonic completeness

- The **harmonic completeness** property (Prince and Smolensky 1993, §9.2.1) holds when:

  - If Segment A has a subset of the markedness violations of Segment B, then any inventory that includes B must include A.

- It's very tricky to deduce harmonic completeness from OT (depends on Faithfulness constraints) — can't cover it here.
- Flemming: harmonic completeness as an *empirical prediction* is very far from the truth.
  - Not due to random weird cases, perhaps with a historical origin.
  - Rather, false on a principled basis; we should *expect* it to be false.

33. Flemming's general argument: the "excluded center"[2]

Perceptual distance scale:

←————————————————————→

A	B	C
marked	unmarked	marked

where A and C are marked for articulatory reasons (greater effort, excursion of articulators)

and the language uses A and C, but not B.

- This is problematic for OT!
- Suppose we adopt a constraint banning B — this would be very bad, because: B is what occurs when there is no contrast on the dimension.

34. Excluded center I: Russian Palatalization

- It is marked for consonants to be palatalized or velarized. But Russian has only palatalized and velarized consonants (Padgett 2001).[3]

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[2] This helpful term due to Boersma and Hamanns, discussed later.
[3] Padgett, Jaye (2001) "Constrast dispersion and Russian palatalization," in Hume, Elizabeth and Keith Johnson, *The role of speech perception in phonology*.

- And many languages like English or Spanish use non-palatalized, non-velarized consonants.

35. Excluded center II: vertical vowel systems

- Examples:
  - Marshallese
  - Kabardian and other Caucasian languages
  - Ndu languages (New Guinea)

- long vowel subsystem is normal; short vowel subsystem is "vertical":

ɨ
ə
a

- Caveat: all such systems have substantial allophony, triggered by (secondary articulations on) neighboring consonants.

36. Vertical vowel subsystems

- In some dialects of English, the reduced vowels (medial position) are

ɨ *roses*
ə *Rosa's*

or *American* [əˈmɛɹɨkən]

37. Completing the picture

- [ɨ] normally occurs in a high vowel row only where [i] and [u] are already present.

38. Excluded-center cases are ordinary — what theoretical account could predict their normality?

- Synchronic — within phonological theory: Flemming and his successors.
- Diachronic — via a theory of phonetic acquisition: Boersma and Hamann, others

THE ANALYSIS OF THE EXCLUDED CENTER IN BRIEF

39. Flemming's dispersion theory

- Flemming, Edward. "Contrast and perceptual distinctiveness." *Phonetically based phonology* 232 (2004): 276.

40. The functionalist basis of the constraints

1. It is good to minimize articulatory effort.
2. It is good to keep contrasting entities perceptually distinct.
3. It is good to have contrasts, forming the basis of distinct words.

- These principles conflict with each other
  - ☞ explain 1-2, 1-3, 2-3

41. Analysis I: The F2 perceptual continuum

i ɨ u
←→
high low

and similarly for various other continua

42. Analysis II: Constraints banning bad contrasts

MINDIST=F2:2 ‘Don’t allow contrasting entities to differ by less than 2 on the F2 scale”

- Violated when the inventory includes both [i] and [ɨ], or [ɨ] and [u].
- Let’s hold off for a moment on what representations MINDIST constraints apply to …

43. Analysis III: constraint requiring enough contrasts

MAXIMIZE CONTRASTS (perhaps along some particular dimension)

- MAXIMIZE CONTRASTS constraints award **check marks**, rather than penalizing with asterisks. One ✓ for each contrasting entity.

44. Analysis IV: effort-based markedness constraint

“*HIGH EFFORT” cover term for a constraint that bans the production of peripheral vowels in short time frame. [i] and [u] are peripheral; [ɨ] is not.

45. The factorial typology of these constraints

a. **Vertical System**: *HIGH EFFORT is on top (possibly tied with MINDIST).

	*HIGH EFFORT	MINDIST=F1:2	MAXIMIZE CONTRASTS
☞ [ɨ]			✓
*[i]	*!		✓
*[u]	*!		✓
*[i-ɨ]	*!	*	✓✓
*[ɨ-u]	*!	*	✓✓
*[i-u]	*!*		✓✓
*[i- ɨ -u]	*!*	**	✓✓✓

[☞ What candidates are harmonically bounded? Specify the bounders.]

b. **Polarized system**

E.g. Spanish, with the peripheral vowels [i - u].
[☞ What is the ranking under which [i-u] wins?]

- *This is claimed to be a case of the excluded center!*
  - ➢ But no one had realized this before, because this ranking is so common across languages.

c. **Rich system**: Hopi, with [i ɨ u]

[☞ What is the ranking for this?]