Class 2, 1/12/2023: Faithfulness, Factorial Typology, the Rich Base

1. Practical

- Can everyone access the course web site? I believe it is posted ok now.

2. Assignments

- Read: Extract from McCarthy (2003) *A thematic guide to Optimality Theory*. On web site.
- Read: "How to solve phonology problems." On web site.
- Start the first homework, on Ilokano. Download pdf and Word doc from website. It is due in a week, 1/19/23.

WHAT WE HAVE SO FAR

3. Finnish as a canonical OT-case

- Hopefully, complexity from simplicity via ranking

4. Algorithms (implemented in software) can help

- Many people have programmed Recursive Constraint Demotion (enacted last time), and it can check whether your constraints can select the right winner from your candidates.
- It also finds strata that define a set of feasible rankings.
- In some implementations, you can rerun the system eliminating each constraint in turn, testing for necessity.
- I went to my OTSoft program (https://linguistics.ucla.edu/people/hayes/otsoft/) and got some reassurance.

```
Stratum #1
   Align(W,Ft)                          Align(W,Ft)
   *Clash                               *Clash
   FootBin                              FootBin
Stratum #2
   Non-Fin                              Non-Fin
   Dep                                  Dep
Stratum #3
   Lapse                                Lapse
Stratum #4
   *(L H)                               *(L H)
Stratum #5
   All feet L                           All feet L
```

- Note that this defines 12 rankings that work …
- Tableaux:

```
/L H L L L/:
                Align(W,Ft)¦*Clash¦FootBin|Non-Fin¦Dep|Lapse|*(L H)|All feet L
>(L H)(L L)L                ¦      ¦       |       ¦   | 1   |  1   |    2
 (L H) L (L L)              ¦      ¦       |       ¦   | 1   |  1   |    3!
 (L H) L L L                ¦      ¦       |       ¦   | 4!  |  1   |
 (L H)(L L)(L)              ¦      ¦  1!   |  1    ¦   |     |  1   |    6
 (L)(H L)(L L)              ¦  1!  ¦  1    |       ¦   |     |      |    4
 L (H L)(L L)       1!      ¦      ¦       |       ¦   |     |      |    4

etc.
```

- Necessity:

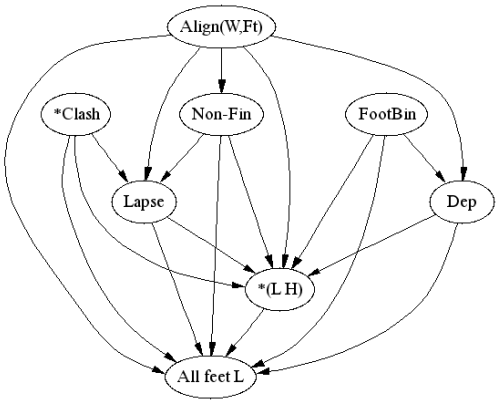
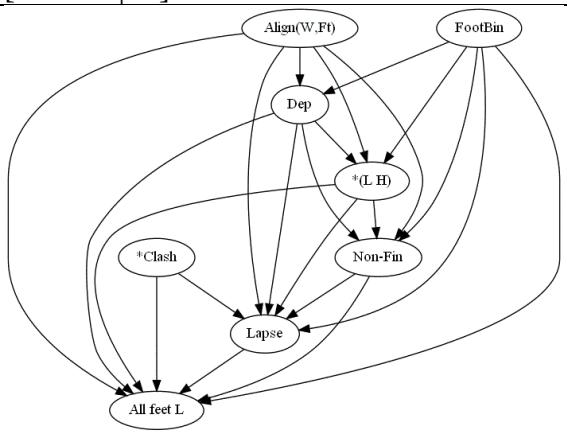
```
Status of Proposed Constraints:  Necessary or Unnecessary

   Align(W,Ft)  Necessary
   *Clash       Necessary
   Non-Fin      Necessary
   Lapse        Necessary
   *(L H)       Necessary
   All feet L   Necessary
   FootBin      Necessary
   Dep          Necessary
```

5. Another really helpful algorithm: FreD (Prince and Brasoveanu 2011)

- Ref.: Brasoveanu, Adrian, and Alan Prince. 2011. Ranking & Necessity: the Fusional Reduction Algorithm. *NLLT* 29:1, 3-70.
- This finds all the ranking arguments and makes a Hasse diagram.
- This turns out to be a *big* computational task! For a large problem set an implemented version can run for half an hour.
- It seems that for nontrivial cases human efforts should not be trusted.
- OTSoft output for Finnish:

```
FootBin >> { *(L H), All feet L, Dep }
Dep >> { *(L H), All feet L }
*(L H) >> All feet L
Lapse >> { *(L H), All feet L }
Non-Fin >> { Lapse, *(L H), All feet L }
*Clash >> { Lapse, *(L H), All feet L }
Align(W,Ft) >> { Non-Fin, Lapse, *(L H), All feet L, Dep }
```

- We were curious how an alternative outcome could be derived:

[ˈravinˌtolat] is winner	[ˈravintoˌlat] is winner
	

- You can try comparing these Hasse diagrams (or wait for us to do the same thing with a MaxEnt grammar).

QUICK REVIEW OF FAITHFULNESS CONSTRAINTS

6. Historical note

- In the original OT work, Prince and Smolensky (1993) proposed a system of Faithfulness not well-articulated enough to handle phonology in general
- You will see references to it from time to time but it is not widely employed today.

7. Source for the standard constraints used today

- McCarthy and Prince (1995): Faithfulness and Reduplicative Identity, in *University of Massachusetts Occasional Papers in Linguistics* 18: Papers in Optimality Theory. Ed. by Jill Beckman, Suzanne Urbanczyk and Laura Walsh Dickey. Pp. 249–384.

8. In principle, there are many ways to do Faithfulness

- Faithfulness is based on resemblance.
- Resemblance can be formalized in many ways.
- Conventional *SPE*-representations (sequences of feature matrices) make it easy, but one might also pull in
  - hierarchical structure (phrasing, syllables, feet, autosegmental tiers)
  - actual phonetic form (spectra)
- More on this later.

9. McCarthy and Prince's strategy: *SPE* representations + atomism

- I believe their idea was to find the ways that two representations could differ — allocating constraints to the *smallest possible differences*.

10. Indices

To make the differences explicit, we put an index on every segment (we will see shortly why this is necessary).

- IDENT = differ in one feature value

  /p_1 a_2 k_3/, candidate [b_1 a_2 k_3] violates IDENT(voice)
  /p_1 a_2 k_3/, candidate [m_1 a_2 k_3] violates IDENT(voice) and other constraints

- MAX = an underlying segment of *some natural class* (specified with features) is missing in the surface form.

  /p_1 a_2 k_3/, candidate [p_1 a_2] violates ?? (multiple answers)

- DEP = a surface segment of some natural class (specified with features) is missing in the underlying form.

  /a_2 k_3/, candidate [ʔ$_1$ a_2 k_2] violates multiple DEP constraints.

- LINEARITY, violated when the linear order of any pair of segments is switched. Count the violations here:

  /p_1 a_2 k_3/, candidate [p_1 k_3 a_2] has one violation
  /p_1 a_2 k_3/, candidate [k_3 a_2 p_1] (how many violations?)

  Socrates: What about this candidate: [p_3 a_2 k_1]

- CONTIGUITY, violated when two segments are adjacent in the input but not the output, or vice versa (IO, OI)

- ANCHOR, violated when a segment is adjacent to an edge in the input but not the output.

11. Not a standard Faithfulness constraint

- IDENT(p) "Don't change anything about [p] so it isn't [p] any more."

  - You're welcome to deviate from the "standard" theory — but in the interest of scientific coherence, you need to *label* such deviations.
  - This raises issues of what is your "scientific community", your "community standards"—inevitable in writing up research results.

12. Extensions of Faithfulness

- Between a base form and a form derived from it (Benua 1997[1] and much later work)

  heal [ˈhiɬ] *healing* [ˈhiɬɪŋ] compare: *Darjeeling* [dɑɹˈdʒilɪŋ]

  You might try this for the homework.

- Between a reduplicated morpheme and its base (McCarthy and Prince 1994)[2]

DEFINING FACTORIAL TYPOLOGY

13. Assume

- A class of universal inputs
- Some version of GEN
- A set of constraints

then, each ranking of the constraints defines a set of outputs
(many rankings define the same output set, however)

The set of distinct sets of outputs constitutes the **factorial typology** of the system
[called "factorial" because *n* constraints permit *n*! rankings]

14. The appeal of factorial typology

- Proposals can be tested against typological data.
- We can consider them for defects of both undergeneration (instantly fatal) and overgeneration (hard to assess)

15. Some work in factorial typology

- Elenbaas, Nine and René Kager. 1999. Ternary Rhythm and the *LAPSE constraint. *Phonology* 16: 273-330.
- Matthew Gordon (2002) A factorial typology of quantity insensitive stress, *Natural Language and Linguistic Theory* 20, 491-552
- Abigail Kaun (1995) The Typology of Rounding Harmony: An Optimality Theoretic Approach. Ph.D. Dissertation, UCLA. Basis of readings.

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[1] Benua, Laura. Transderivational identity. Ph.D. dissertation, University of Massachusetts Amherst, 1997.

[2] McCarthy, J. and A. Prince 1995 Faithfulness and Reduplicative Identity, *University of Massachusetts Occasional Papers in Linguistics 18: Papers in Optimality Theory*. Amherst, MA: GLSA, University of Massachusetts.

16. How to compute a factorial typology

- Chose an empirical domain (we can't do all of phonology at once).
- Choose constraints: these embody a proposal in phonological theory.
- Choose inputs: they must somehow suffice to illustrate the full range of possible phenomena.
- Choose candidates (ditto)
- Calculate the typology, by hand or with software.

17. Language example: Turkish epenthesis

Nom.	Accus.	1sg poss.	Dative	Nom. Plur.	Ablative	gloss
Idil	idili	idilim	idile	idiller	idilden	'idyll'
vezin	vezni	veznim	vezne	vezinler	vezinden	'meter'
t͡ʃenk	t͡ʃenki	t͡ʃenkim	t͡ʃenke	t͡ʃenkler	t͡ʃenkten	'hand'

- "Epenthesize before a consonant that wouldn't be syllabifiable."
- The idea is that [idil] is /idl/.
- It has to be Epenthesis, not Syncope
  - alternating vowel is always /i/ (or its partners in vowel harmony)
  - /vezin/ doesn't alternate.
- /tʃenk/ has good sonority and makes a good syllable in Turkish

18. Egyptian Arabic

- This language also has /vezn/ for 'meter', but in this language the epenthetic vowel is final: [vezni]

19. Palestinian Arabic

- Like Turkish, but *all* CC sequences are repaired, not just sonority-violating ones:
  /taxt/ → [taxit] 'bed'

20. Sample inputs for factorial typology

/ipl/ Exemplifies a bad-sonority coda
/ilp/ Exemplifies a coda with good sonority profile

21. Reasonable outputs

/ipl/	/ilp/
ipl	ilp
i.pil	i.lip
ip.li	il.pi
i.pli	i.li.pi
i.pi.li	

- Do we have them all?
- If not, what would we include to expand the typology?

22. Should we include [i.lpi] among the outputs?

- Proposal: to keep the problem under control, you can assume some constraints to be undominated (i.e. "we are considering only the class of languages that don't allow sonority-reversed codas").
- Often, this leaves enough languages under consideration to make the problem still worthwhile.
- Thus, let's avoid, for /ilp/: i.lpi, il, ip, lip, pli, ilu (p becomes u).
  - Undominated: *HORRIBLE ONSET, MAX(C), LINEARITY, IDENT(syl)

23. Proposed constraints

Name	
1. DEP(i)	Penalizes insertion of vowels; quality ignored here.
2. *BAD SONORITY CODA	Should be suitably formalized; violated by final [pl].
3. *CC CODA	Violated by [ilp] as well.
4. *CODA	Inviolable in Hawaiian, Bantu languages, etc.
5. *BRANCHING ONSET	i.e. *[$_{\sigma}$ CC
6. CONTIGUITY	one violation for each pair of segments adjacent input but not output — penalizes *internal* epenthesis
7. ANCHOR	one violation for each segment adjacent to a particular word edge in the input but not in the output — penalizes *external* epenthesis

24. Some outputs we need never consider

/ipl/ → [ip.il]
[i.pi.li.i.i.i]

These bad outputs are **harmonically bounded** and (in classical OT) can never win.
[Socrates: take a look at the tableau rows.]

25. Harmonic bounding

Candidate A **harmonically bounds** candidate B if A has a strict subset of B's violations.

26. A software-derived factorial typology of epenthesis

Method employed: keep adding inputs, run Constraint Demotion over and over, regain all combos that have a feasible ranking.

	Output #1	**Output #2**	**Output #3**	**Output #4**
/ipl/:	[ipl]	[i.pil]	[i.pil]	[ip.li]
/ilp/:	[ilp]	[ilp]	[i.lip]	[ilp]
	faithful outcomes; Persian (*vœzn, tœxt*)	Turkish	Palestinian Arabic	I know no case; = Egyptian-Turkish blend

	Output #5	**Output #6**	**Output #7**	**Output #8**
/ipl/:	[ip.li]	[i.pli]	[i.pli]	[i.pli]
/ilp/:	[il.pi]	[ilp]	[i.lip]	[il.pi]
	Egyptian Arabic	French, at least in some speaking styles		I know no case; = Egyptian-French blend

	Output #9	**Output #10**
/ipl/:	[i.pli]	[i.pi.li]
/ilp/:	[i.li.pi]	[i.li.pi]
		Japanese loan adaptation: *tax* → [takusu]

27. Basics of Factorial Typology interpretation

- **Undergeneration:** real case that the constraint system can't get under any ranking; indubitably bad
- **Overgeneration**: hypothetical case that the linguist feels could never occur. How bad?

- Linguists differ greatly in how seriously to take the argument "gosh, I've never seen a case of this kind". A forceful statement of skepticism of this kind of thinking may be found in:
  - McCollum, Adam., Eric Baković, Anna Mai, and Eric Meinhardt. 2020. Unbounded circumambient patterns in segmental phonology. *Phonology* 37:215-255.

  Perhaps some day we will use some form of statistical analysis to authenticate our gaps.

28. Sometimes the missing case walks in the door

- **Majority-rule vowel harmony**[3]: "Harmonize a suffix in backness with which ever kind of vowel (back or front) occurs more often in the stem." (Linda Lombardi[4]; for a remedy see Baković 1999[5].)

[3] Unless Margit is right…

[4] Lombardi, Linda. 1996. Positional Faithfulness and Voicing Assimilation in Optimality Theory. Ms., University of Maryland, College Park

[5] http://roa.rutgers.edu/files/340-0899/roa-340-bakovic-2.pdf

- But Margit Bowler's work suggests this happens in Warlpiri.
- I believe that "cases walking in the door" are fairly frequent — so many languages, so little analysis.

29. Typological work

- You can mine libraries (Noah Elkins, 2021 UCLA MA thesis; my 1995 book *Metrical Stress Theory*
- UCLA has a fantastic descriptive collection (stroll one minute north to YRL, fourth floor, roughly PK-PL).
- Interlibrary Loan has gotten more efficient (on my desk, a book from Harvard)
- And the internet has more resources

30. Interpretation of factorial typology: T-orders

- We examine the factorial typology, and compile all true statement of the following form:

> In all grammars in which Output A_m is derived from Input A, Input B must yield Output B_n.

- Arto Anttila, in various papers[6] emphasizes this kind of implication (i.e. a complete set of them) as a way of diagnosing the structure of a factorial typology.
- For a brief intro see http://www.stanford.edu/~anttila/research/torders/t-order-manual.pdf

31. The T-order for the epenthesis typology (complete)

If this input	has this output	then this input	has this output
/ipl/	[ipl]	/ilp/	[ilp]
/ipl/	[i.pi.li]	/ilp/	[i.li.pi]

THE RICH BASE, PHONOTACTICS AND ALLOPHONY

32. Phonotactics

- = phonological legality, grammaticality
- Chomsky and Halle (1965, *Journal of Linguistics*):

[bɹɪk]	is possible and exists
[blɪk]	is possible and doesn't exist
*[bnɪk]	is impossible

- Phonotactic well-formedness is gradient (?[pɔ͡ɪk]), but (since we are working with classical OT) we will idealize for the moment to a grammatical/ungrammatical distinction.

[6] e.g. http://www.lingref.com/cpp/wccfl/26/paper1655.pdf

- Phonotactics is learned in the absence of negative evidence: from what we do hear, we figure out what would should never expect to hear.

33. Why do we have phonotactic knowledge?

- One theory is that it helps guide speech perception: we prefer phonotactically well-formed interpretations of the waveform.
- A famous paper:
  - Massaro, Dominic W., and Michael M. Cohen (1983) Phonological context in speech perception. *Perception & psychophysics* 34: 338-348.
  - A synthesized [r]-[l] F3 continuum is biased to be heard as [r] after [t], as [l] after [s].

34. The standard OT account of phonotactics: the Rich Base (Prince and Smolensky 1993[7])

- Assume that the set of possible inputs is *every conceivable phonological representation*.
- An adequate grammar converts any unpronounceable input into a pronounceable one — thus expressing the phonotactics.

35. Pseudo-derivations in Rich Base theory

- For bad things: Markedness outranks at least one Faithfulness constraint whose violation could repair an input that is bad.
- This assumes fictional "derivations", like English /qæt/ → [kæt]
  - (BH recite the Parable of the Space Aliens.)
- Such grammar is often (harmlessly, I think) indeterminate — we don't know what repair "would be" used.[8]
- Socrates: what other Faithfulness constraints could be violated in repairing /qæt/?

36. The fundamental principle for phonotactics in Rich Base theory

- The higher-ranked the Faithfulness constraints, the more things emerge from the grammar.
  - Intuition: without Faithfulness, we could say only [ta] (or perhaps nothing).
- This basic point can be elaborated into a typology of phonotactics, based on ranking
  - illegality
  - phonemicness
  - allophony
  - contextually-limited contrast (two ways to do it)

[7] They attribute the idea to David Stampe, who thought of it for his theory of Natural Phonology, a rule-based precursor to OT (univeral rule set!).

[8] Though we can make an educated guess (work of Steriade, later): default is repair to the phonetically closest legal entity.

WORKING THROUGH RICHNESS OF THE BASE WITH MINI-TABLEAUX

37. Case I: Illegality

- As above, for /qæt/

38. Case II: Phonemicness

- A feature will be phonemic if the faithfulness constraint for it dominates the conflicting markedness constraint.

IDENT([voice])	(Faithfulness)
*[–sonorant, +voice]	(Markedness; cf. Hawaiian)

39. Case III: Allophony

- This is: two conflicting Markedness constraints, special one with context, general one ranked second, both above Faithfulness.

Special markedness
↓
General Markedness
↓
Faithfulness

VTV	*[–son, –voice] / V ___ V	(cf. Korean, Yidiɲ, various Australian)
*D	*[–sonorant, +voice]	(Hawaiian)
IDENT	IDENT([voice]) in obstruents	

- Socrates: How does this ranking distribute [t] and [d]?

40. Case IV: contextually limited contrast by the Markedness Sandwich

- Assume:

IDENT([voice] in obstruents / ___ [+sonorant])
*[–sonorant, +voice]
IDENT([voice] in obstruents)

- Describe the resulting distibution of [t] and [d], justifying your answer with little tableaux.
- General recipe: SPECIAL FAITHFULNESS >> MARKEDNESS >> GENERAL FAITHFULNESS

41. Socrates

- What is the factorial typology of the three constraints we're working with?

42. Case V: contextually limited contrast by the Faithfulness Sandwich

- Here, what's different is that we put the context into the Markedness constraint, not Faithfulness.
- Assume:

*[–sonorant, +voice] in codas	special markedness
IDENT([VOICE]	Faithfulness
*[–sonorant, +voice]	general markedness

- Describe the resulting distribution of [t] and [d] , justifying your answer with little tableaux.

RICHNESS OF THE BASE, ALLOPHONES, AND CONCRETE URS

43. Often, many URs are compatible with a given SR

Socrates: suggest some URs for [kʰæ̆t̚] 'cat'

44. One way to resolve: Lexicon Optimization (hypothesis of Prince and Smolensky 1993)

- All else being equal, learned morphemes are represented in the lexicon in whatever way minimizes their constraint violations (necessarily, of Faithfulness).
- The "all else being equal" is a pretty broad loophole…
- [Socrates: what would lead you to list something different from phonetic form?]

45. Good old allophones

- Beginners to this day are taught to collect sounds that are phonetically similar and in complementary distribution (e.g. for /t/: [tʰ], [t], [ʔt], [t̪]).
  - Socrates: dredge up your memory of where these allophones of /t/ are distributed.
- Standard OT *provides no basis for this actually happening*. Why?
  - Old theory: constraints on underlying forms included phoneme inventory.
  - But if the constraints all apply at the surface there is no such thing, only a phone inventory.
- Nonstandard OT? Perhaps we relax Lexicon Optimization, permitting underlying-surface disparities to minimize the number of categories in UR.

46. *Should* phonemes be unified?

- For experiments suggesting that native speakers sometimes hear allophones as "the same sound", see
  - Jaeger, Jeri J. (1980) "Testing the psychological reality of phonemes," *Language and Speech* 23, 233-253
  - Bruce Derwing, Terrance M. Nearey, and Maureen L. Dow (1986) "On the phoneme as the unit of the 'second articulation," *Phonology Yearbook* 3:45-70.

- Likewise, experiments teaching people how to read: what letter do they pick for an allophone untaught to them? Gudschinsky, Popovich, and Popovich (1970)[9], who got a untutored speaker to spell [k̟] as *kk*, [k̟] being the contextual allophone of /k/.
- Anecdote: my son, when little, trained to string-reverse words by sound: *cat* [kʰæʔt] → [tʰæʔk], but *fill* [fɪɬ] → [ɬɪf]

47. Can phonemes be unified under standard OT?

- Some may be unified at a pre-symbolic, categorization level—creation of categories by the warping of perceptual space. References:
  - Guenther, Frank and Marin N. Gjaja (1996) The Perceptual Magnet Effect as an Emergent Property of Neural Map Formation, *Journal of the Acoustical Society of America* 100: 1111-1121.
  - Jessica Maye, Janet F. Werker, and LouAnn Gerken (2002) Infant sensitivity to distributional information can affect phonetic discrimination. *Cognition* 82:101–111.
  - UCLA dissertations of Ying Lin, Kristine Yu, on our web site
- More interesting are allophones that are not in a cloud, but discrete, e.g. [ɾ] and [χ] as allophones (putative) of "/r/" in Portuguese.
- OT opts for "invariance":[10]
  - For every phoneme, there is a set of feature values shared by all allophones of that phoneme and by none of allophones of any other phoneme.

  To my knowledge, no one has published anything on invariance-violating phonemes in OT …

[9] Gudschinsky, Sarah C., A. Harold Popovich, and Frances B. Popovich. 1970. "Native reaction and phonetic similarity in Maxakalí phonology." *Language* 46: 77-88

[10] Origin: Noam Chomsky, *Current issues in linguistic theory* (The Hague: Mouton, 1964). pp. 75-95. N.B. Chomsky puts forth invariance as a straw-man position.