Modeling failure in morphophonological learning

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BACKGROUND

1. SIGMORPHON and morphophonemic learning: the Shared Task

- The Shared Task at SIGMORPHON has long served to guide and focus research.
- Several recent Shared Tasks have involved the **paradigm fill-in** problem:
  - The participants design systems that learn from **large sets of morphologically labeled paradigms**
  - The systems are tested on their ability to provide correct inflected forms for held-out cases.
  - This task requires (at least implicit) **learning** of the morphological and phonological patterns.
  - For scientific purposes, this is a realistic task: humans who speak richly inflected languages take this test every day.
- Toil and inspiration pay off as performance continues to improve.

2. What to do once complete success has been achieved?

- An interesting further challenge would be to have systems that **fail to learn correctly, in the same cases where humans fail**.

3. This talk

- A modest amount is known about human failure, and I will provide a survey here.
- I will also offer very speculative accounts of the types and causes of human failure.

ABOUT HUMAN FAILURE

4. Who is responsible for failure?

- Pretty obviously: children, who are frequently observed producing ungrammatical paradigm fill-in forms.
  - Many English-learning children go through a stage of saying *brung* as the past participle of *bring*.
  - References:
    - — Marcus, Gary F., Steven Pinker, Michael Ullman, Michelle Hollander, T. John Rosen, Fei Xu, and Harald Clahsen. 1992. *Overregularization in language acquisition*.
    - — Xu, Fei, and Steven Pinker. 1995. Weird past tense forms. *J. Child Language* 22:531-556.

5. How we learn about children's errors

- Mostly, classical **diary studies**, now recorded as digital corpora (CHILDES).
- There are nice **experiments**, too; e.g. Do (2018) studies how Korean children perform the paradigm fill-in task.
  - Do, Youngah (2018) Paradigm uniformity bias in the learning of Korean verbal inflections. *Phonology* 35:547-575.

6. Historical change in language as testimony of past child errors

- The established changes that have occurred in the paradigms of languages are generally agreed to be the acquisition errors of children, that somehow spread through the speech community.
- English *helped* is an innovation, replacing earlier *holp*, and matches errors observed in contemporary children, like *goed*.
- Thus, since Kiparsky (1978), historical change has been studied in hopes of learning something about human language acquisition, particularly in phonology.
  - Kiparsky, Paul (1978) *Explanation in phonology*. Dordrecht: Foris.

SOME RELEVANT FINDINGS OF HISTORICAL LINGUISTICS

7. Some references

- A nice textbook is
  - Bynon, Theodora (1977) *Historical Linguistics*. Cambridge: CUP.
- A recent paper that summarizes the points made below and cites the main theoretical literature:
  - Bruce Hayes and James White (2015) Saltation and the P-map. *Phonology* 32:267-302.

8. Phonetic vs. phonological change

- Change in progress— observed in adult or adolescent speakers — tends to be **phonetic**; i.e. gradient.
- As change continues, it often reaches a **tipping point**:

- A new generation of kids **reinterprets** the evolved phonetic pattern, arriving at a novel categorical grammar — which is phonological change.

9. A possible example of restructuring

- The cluster /tr/ (*true*, *treat*, *nutritional*) was originally straightforwardly [tr].
- But it has gradually shifted in its articulation, becoming more like [tʃr].
- The gradual change can be tracked in individuals, who might consider [tr] be a more conservative variant, [tʃr] more casual.
- A new form, which surprised me, suggests that the gradual phonetic change has solidified into a categorical, restructured change:
  - [nutʃ], meaning "nutritional yeast"
  - The [tʃ] is now realized as such, even in the absence of the triggering [r].
  - Whoever made up this form probably "feels" a [tʃ] in *nutritional*.

10. Bigger restructurings produce very noticeable — even catastrophic — language change

- Key idea: extensive, evolved phonetic change poses an acquisition test for a new generation of children — which they may fail, creating a new form of their language.
  - Hence the title of this presentation.
- I will do three cases, each with a different conjectured cause.

I. ODAWA ALTERNATING ST RESS AND VOWEL DROP

11. Background and sources

- Odawa is Algonquian, spoken in the Great Lakes region.
- Bowers, Dustin (2019) The Nishnaabemwin [Odawa] restructuring controversy: New empirical evidence. *Phonology* 36: 187-224.
- Bowers, Dustin (2015) Phonological restructuring in Odawa. M.A. thesis, Department of Linguistics, UCLA.

12. Historical evolution, earliest stage

- Our oldest attestation is from the grammar by Frederic Baraga, 1853.
- His description:
  - Stress is placed on even-numbered syllables, counting from left to right.
  - Stress also falls on long-voweled syllables.

gʊtígʊmínʌgíbınáː	'he rolls someone'
nı-gútıgúmınʌ́gıbínáː	'I roll someone'

13. Next stage of evolution: phonetic change in stressless syllables

- Leonard Bloomfield, 1930's
- His oldest consultants spoke like Baraga's speakers from long before.
- But in his younger consultants, the stressless vowels where **shorter and more reduced**.

Shorten:

gŭtígŭmínʌ́gíbĭná:	'he rolls someone'
nĭ-gútĭgúmĭnʌ́gĭbíná:	'I roll someone'

Reduce:

gə̆tígə̆mínə̆gíbə̆ná:	'he rolls someone'
nə̆-gútə̆gúmə̆nʌ́gə̆bíná:	'I roll someone'

- Indeed, bordering on deletion: the reduced vowels were described as "rapidly spoken and often whispered or entirely omitted".
- It is easy to extrapolate: deletion must have become ever more common.

14. Third stage: children born in the late 1930's

- These speakers were studied in later life by Rhodes (1985a, b) and other scholars.
- They like were exposed to a variety of Odawa in which the reduced vowels were hardly there at all — leading to a tipping point.
- Here is a good guess about what these children were hearing:

gtɪgmɪngɪbna:	'he rolls someone'
ngʊtgʊmnʌgbɪna:	'I roll someone'

- No need to mark stress, since only stressed syllables have survived!

15. The correct textbook-style analysis for the data that these children heard

- **Recapitulate history**; i.e.
- Assume "etymological" underlying representations — all vowels in their correct historical places.
- Assume abstract left-to-right alternating stress, followed by categorical deletion of stressless vowels.

'he rolls someone'	'I roll someone'	
/gʊtɪgʊmɪnʌgɪbɪna:/	/nɪ-gʊtɪgʊmɪnʌgɪbɪna: /	Underlying representation
gʊtígʊmínʌgíbɪná:	nɪgʊ́tɪgʊ́mɪnʌ́gɪbíná:	Left-to-right alternating stress
∅ ∅ ∅ ∅	∅ ∅ ∅ ∅	Deletion of stressless vowels

[gtígmíngíbná:]	[ngútgúmnʌ́gbíná:]	Surface representation
[gtɪgmɪngɪbna:]	[ngʊtgʊmnʌgbɪna:]	(alternative transcription)

16. The tipping point for Odawa

- Per Bowers, the children learn a system radically different from their parents, in both grammar and lexicon.
- The new system:
  - For each stem, roughly, *the isolation form is now the underlying form*.
  - Prefixation is to this form.
  - There is essentially no phonology
- Here are representative forms of what Bowers calls New Odawa:

gtɪgmɪngɪbna:	'he rolls someone'	*unchanged*
ndʌ-gtɪgmɪngɪbna:	'I roll someone'	*novel form*

(earlier 1 sg. form: **ngʊtgʊmnʌgbɪna:**)

- Comparable changes happened throughout the vocabulary.
- The adults of the 1930's must have been very surprised at what their children were saying to them!

17. Where does the "crazy" prefix [ndʌ-] come from?

- **Recutting**. The [n] is part of the old prefix, and the [dʌ] comes from misapprehension of morpheme boundaries in the old alternations.
- Historical derivation:

'hang'	'I hang'	
ʌgo:dʒɪn	nɪ-ʌgo:dʒɪn	original form
—	nɪ**d**ʌgo:dʒɪn	resolve hiatus with [d]
ʌgó:dʒín	nɪdʌ́gó:dʒín	Left to right alternating stress
əgó:dʒín	nədʌ́gó:dʒín	Vowel Reduction
go:dʒɪn	ndʌgo:dʒɪn	Vowel deletion

- The child's straightforward morphological analysis of this, with [ndʌ-] as prefix:

			g	o:	dʒ	ɪ	n	
n	d	ʌ	g	o:	dʒ	ɪ	n	

- Similar prefixes arose from other recut stem material, like [ndɪ-].

- These prefix allomorphs now compete with one another, with a non-etymological distribution, and much free variation (Bowers).

18. Upshot

- The phonetic drift of Vowel Reduction into full deletion induced a catastrophe:
  - massive stem reshaping
  - loss of the stress system
  - novel prefix system

- Bowers: dating of the sources suggests that the changes occurred essentially the very moment that reduction crossed the line to deletion.

19. Explaining the catastrophe

- Usually, the response to phonetic change is less dramatic (see below).
- What could explain such a massive change?

20. Bowers's proposal

- The data pattern that the restructuring Odawa children encountered, unusually, requires **genuine serial derivation** for its analysis.
- You must *first* assign stress, to know where to delete the vowels." After the vowels are dropped, the alternating count that governed stress is no longer present.
- But maybe phonology isn't serial? Many scholars today opt for the all-at-once derivations that hold in standard Optimality Theory (Prince and Smolensky 1993 *et seq.*)
- Standard OT works just fine for pre-vowel-drop Odawa, and falls flat for the pattern that parents presented to their children in the 1930's.
- Given that acquisition failed, this may be an **explanatory virtue** of standard Optimality Theory, contra its serialist critics (e.g., McCarthy 2008).

21. Upshot

- I present Bowers's account of Odawa as a vivid instance of failure in human morphophonological learning.
- I offer one possible account (again from Bowers) for why failure occurred: phonological grammar does not include the serial computations that would be needed to continue the old system.
- The posited complete inability of humans to deal with the patently-serial Odawa pattern explains the extreme response of the Odawa children who were confronted with that pattern.

II. SEEDIQ PARADIGMS AND THE SINGLE-SURFACE-BASE HYPOTHESIS

22. Language information and sources

- Seediq is Austronesian, eastern Taiwan
- Kuo, Jennifer (2020) Evidence for base-driven alternation in Tgdaya Seediq. M.A. thesis, Department of Linguistics, UCLA.

23. The classical "cobbling" tradition in phonological analysis

- Phonological processes *neutralize* (wipe out information) in *every* member of the paradigm.
- To find an analysis, scan throughout the paradigm, finding the information we need to make an informationally-adequate underlying representation — "cobbling" the UR together.
- Yang (1976), working in classical generative phonology, offered a cobbled analysis for Seediq.
  - Yang, Hsiu-fang (1976). The phonological structure of the Paran dialect of Sediq. *Bulletin of the Institute of History and Philology Academia Sinica* 47(4). 611-706.

24. An Seediq example of a cobbled underlying form

/umal/ 'to increase'

- This underlying form is *never* pronounced as such.
- It surfaces as [ˈuman] when alone.
- It surfaces as [ˈmal-an] when followed by the suffix [-an].
- We arrive at /umal/ by reasoning backwards, based on the known phonological rules of Seediq.

25. Deriving the non-suffixed form

/umal/	Underlying representation
ˈumal	Penultimate Stress Assignment
n	Final Coronal Neutralization: $l \rightarrow n$ / ___ $]_{word}$
[ˈuman]	Surface representation

26. Deriving the suffixed form

/umal-an/	Underlying representation
uˈmal-an	Penultimate Stress Assignment
—	Final Coronal Neutralization: $l \rightarrow n$ / ___ $]_{word}$
∅	Delete unstressed vowels at the beginning of a word.
[ˈmalan]	Surface representation

27. Further justification: contrasting forms

- The underlying /l/ is needed because there are stems that have [n] across the board:

  [ˈduru**n**], [duˈru**n**-an] ‘entrust’

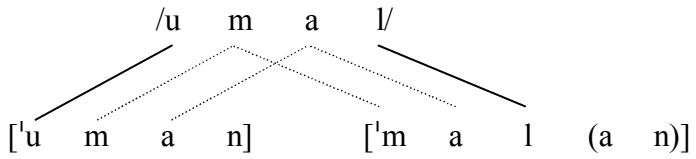
  - ➢ so a rule like n → l could never work.

- The underlying /u/ is needed because there are also stems that are monosyllabic across the board:

  [ˈreq], [ˈreq-an] ‘to swallow’

  - ➢ so a rule inserting /u/ could never work.

28. /umal/ is cobbled together



- Bold lines: correct UR segment obtainable only from this source.
- Dotted lines: either source would suffice.

29. Seediq, analyzed classically, needs a lot of cobbling

- Pretonic vowels delete when initial (as above), otherwise get merged together as [u].

ˈg**e**daŋ	g**u**ˈdaŋ-an	‘die’	/e/
ˈb**i**ciq	b**u**ˈciq-an	‘decrease’	/i/ → [u]
ˈb**a**rah	b**u**ˈrah-an	‘rare’	/a/
ˈb**u**rah	b**u**ˈrah-an	‘new, create’	/u/

- Posttonic vowels, under slightly different conditions, get merged as [u].

ˈrem**u**x	ruˈm**u**xan	‘enter’	/u/
ˈpem**u**x	puˈm**e**xan	‘hold’	/e/ → [u]
ˈdoʔ**u**s	doˈʔ**o**s-an	‘kind of metal’	/o/

- l → n / ___]$_{word}$ is only one of a set four final consonant neutralization rules.

  /p/, /b/, /k/ → [k]
  /d/, /t/, /ts/→ [ts]
  /m/, /ŋ/ → [ŋ]

/l/,/n/ → [n]

30. Odawa is cobbled too, of course

- But it seems a more drastic case.
- Odawa's phonetic changes led to catastrophe.
- As we will see, Seediq has responded much more moderately, changing one word at a time and gradually evolving its lexicon.
- The Seediq pattern does not require serialism, so the catastrophe-inducing mechanism found in Odawa is not present in Seediq.

31. What might explain Seediq? The Single Surface Base Hypothesis

- In a series of papers, Adam Albright has argued that kids don't cobble. Rather:
- They find the slot in the paradigm (Yiddish 1st person sg., Lakhota 2nd pers., etc.) that is most **informationally nutritious** — best permits the other forms to be predicted.
- They favor this slot, perhaps exclusively, for synthesizing novel forms.
- Where derivation from the favored slot fails, speakers lexically list the unpredictable form.
- As with this talk, the hypothesis is supported by data from language change.
- Refs.:
  - Albright, Adam (2010). Base-driven leveling in yiddish verb paradigms. *Natural Language & Linguistic Theory* 28.475-537.
  - Albright, Adam C (2002). The identification of bases in morphological paradigms. PhD dissertation, UCLA.
  - Albright, Adam. (2002) A restricted model of UR discovery: Evidence from Lakhota.

32. The Single Surface Base Hypothesis works really well for Seediq

- The privileged base for Seediq turns out to be the **isolation form**.
- Kuo's work demonstrates this rigorously with machine-implemented grammars that predict either:
  - the suffixed form from the isolation base form: 78% correct
  - the isolation form from the suffixed form: 23% correct
- Why does the isolation form work so well? Conjecture:
  - Already, generations of Sediiq children, adopting the isolation-form base, have committed errors of learning, on a word-by-word basis, recreating the suffixed form.
  - Each of these individual errors makes the isolation-base analysis work even better.
  - In related languages (Maori; Hale 1973), the gradual repair process is essentially complete, making suffixed forms fully predictable.

33. Watching Seediq change, per Albright/Kuo

- The paradigm [ˈuman] ~ [ˈmal-an], given earlier, was elicited from consultants born ca. 1940.

- Kuo's own consultants, were born ca. 1960, and say ['uman] ~ ['ma**n**-an].
- This is just what is expected from the Single Surface Base Hypothesis, given that "[n]-across-the-board" is more common than "[n]-alternating-with-[l]".
- I.e., the children born ca. 1960 synthesized the new form ['manan], following the dictates of their Albrightian bases.
- The speakers born ca. 1940 probably had the same grammar, but listed ['mal-an] as a lexical entry.

34. Upshot: conjectured mechanism

- Seediq does not involve serialism, and has experienced no catastrophes.
- But the superior choice of the isolation form as the Single Surface Base has gradually led to an ironing out of the suffixed forms, making them ever more predictable.

III. SERBO-CROATIAN PARADIGMS AND PHONETIC SIMILARITY

35. Background and source material

- South Slavic, Bosnia/Croatia/Serbia/Montenegro
- Harry Bochner (1981) The l → o rule in Serbo-Croatian. In George N. Clements, ed., *Harvard Studies in Phonology II*; Indiana University Linguistics Club.

36. Serbo-Croatian offers a lovely problem set

a.	zelén	zelen-á	zelen-ó	zelen-í	'green'
b.	béo	bel-á	bel-ó	bel-í	'white'
c.	mío	mil-á	mil-ó	mil-í	'dear'
d.	veseo	vesel-a	vesel-o	vesel-i	'gay'
e.	jásan	jasn-á	jasn-ó	jasn-í	'clear'
f.	dóbar	dobr-á	dobr-ó	dobr-í	'kind'
g.	múkao	mukl-á	mukl-ó	mukl-í	'hoarse'

37. The correct answer, in brief

a. **Epenthesis**: Break up word-final consonant clusters with an inserted [a].
b. **L-Vocalization**: turn /l/ at the end of a syllable into [o]

/bel/	/bel-a/	/jasn/	/jasn-a/	/mukl/	/mukl-a/	Underlying representations
—	—	jasan	—	mukal	—	Epenthesis
beo	—	—	—	mukao	—	L-Vocalization
[beo]	[bel-a]	[jasan]	[jasna]	[mukao]	[mukla]	Surface representations

38. Probable history of this pattern: gradual phonetic change of [l] to [o]

- In many languages, English included, [l] at the end of a syllable is "**dark**" = pronounced with backed tongue-body position.
  - Compare light [l] in *let* [lɛt] with dark [ɬ] in *tell* [tɛɬ].
- Dark [ɬ] is partway to [o], relative to light [l].
- Subsequent phonetic change removes the tongue-blade movement, adds lip rounding, and makes the result syllabic.

39. That problem set was *heavily* edited!

- Bochner's contribution is to show that, with in-depth knowledge of the language, we find a huge amount of exceptionality and irregularity.
- Below is just a selection of the data mess that Bochner bravely wades through.

40. Lexical exceptions

val	'wave-nom. sg.'	not *[vao]
val-a	'wave-gen. sg.'	
kal	'mud-nom. sg.'	not *[kao]
kal-a	'mud-gen. sg.'	
ogledalo	'mirror'	
oglecalce	'mirror-diminutive'	not *[oglecaoce]
sedl-o	'seat'	
sedal-ce	'seat-diminutive'	not *[sedaoce]

41. Doublets with varying meaning

selo	'village'
seoce	'pertaining to villages in general' (used in poetic or literary contexts)
selce	'pertaining to some specific village'

- There are about 12, and in all, the more transparent meaning is the productive one.

42. Implications of the doublets

- This is important: opaque meanings imply memorization, so the innovative form is that one that keeps [l] and *does not alternate.*
- So non-alternation is probably the productive pattern.

43. Why has Serbo-Croatian /l/ to [o] experienced partial breakdown?

- There are many possible explanations, of which my favorite is:
  - **Language disfavor phonetically extreme alternation.**
  - i.e. [l] is phonetically very different from [o]
- There is independent evidence supporting the principle just given.
  - Historical changes that reduce alternation distance (Kiparsky 1978)
  - Psycholinguistic experimentation in the Artificial Grammar Learning paradigm: phonetic distance makes alternations hard to learn (Wilson 2006, White 2013, 2014, Skoruppa et al. 2011)
- Refs.
  - Wilson, Colin (2006). Learning phonology with substantive bias: an experimental and computational investigation of velar palatalization. *Cognitive Science* **30**. 945–982
  - White, James (2013). *Bias in phonological learning: evidence from saltation*. PhD dissertation, UCLA.
  - White, James (2014). Evidence for a learning bias against saltatory phonological alternations. *Cognition* **130**. 96–115.
  - Skoruppa, Katrin and Sharon Peperkamp. 2011. Adaptation to novel accents: Feature-based learning of context-sensitive phonological regularities. *Cognitive Science* 35:348-366.

SUMMING UP

44. The three cases of restructuring discussed here and their conjectured origin

I. Odawa: Mislearning because human grammars are (conjectured to be) **non-serial** — can't match the result of a sequenced historical change.
II. Seediq: Mislearning because human grammars are constrained by the **Single Surface Base Hypothesis**.
III. Serbo-Croatian: Mislearning because human grammars learning is biased to **resist phonetically extreme alternation**.

45. There are probably many other factors that result in acquisition error, e.g.

- Complexity, unpredictability, low frequency
- A great deal of research remains to be done.
- This research might benefit greatly from computational participation: explicit, implemented models that predict acquisition failure in all its forms.

46. End

- Thanks for listening, and I look forward to your questions.