Language Acquisition and a Process-Centered View of Language Change

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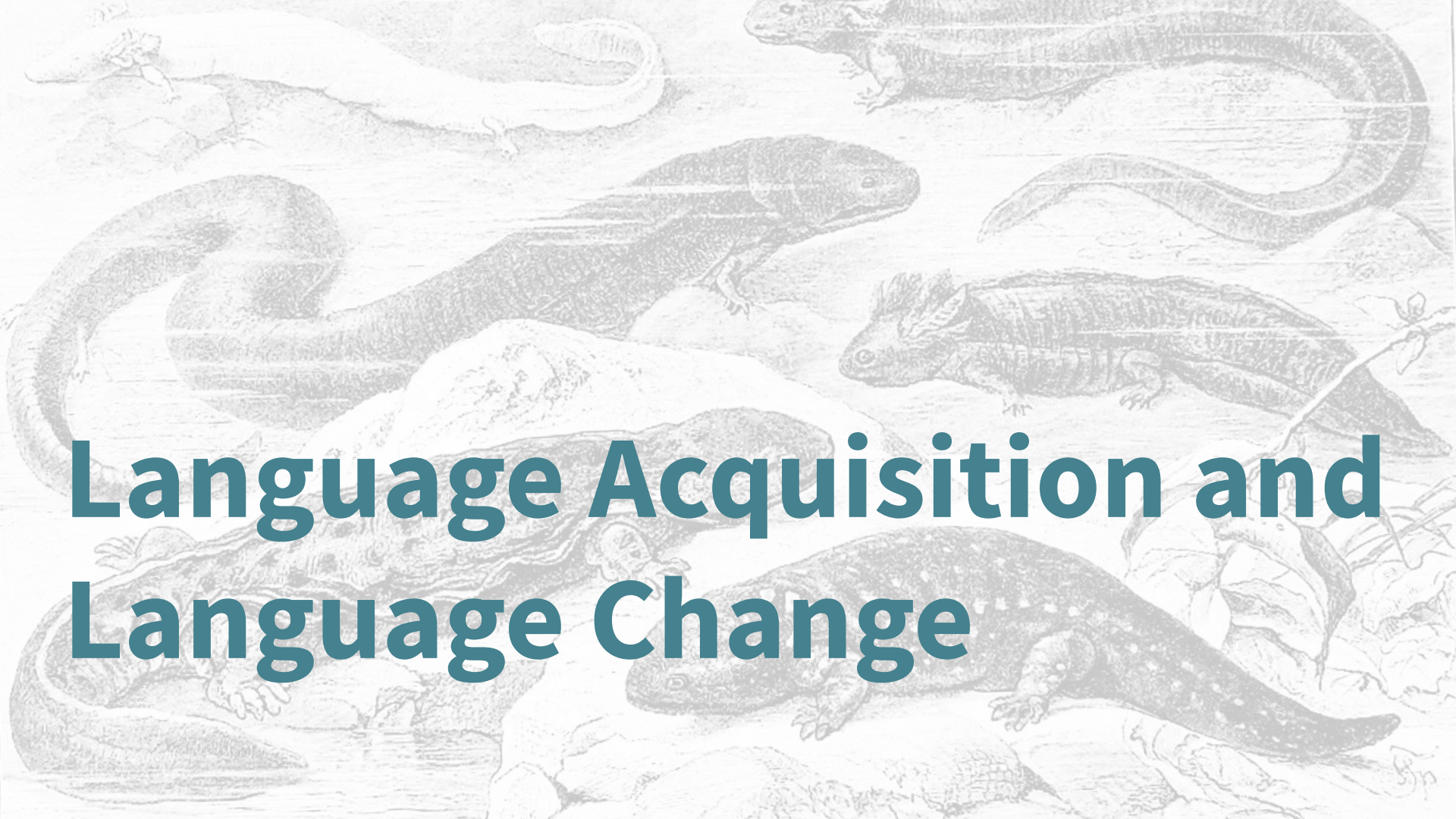
Outline

- Language Acquisition and Language Change
- Generalization Learning as a Specific Mechanism of Change
- A Process-Centered View of Language Change
- From Innovation to Propagation



Language Acquisition and Language Change

Language Change by Language Acquisition

- First language acquisition is one of the primary drivers of language change[1]
- Plays a role in both innovation and propagation

The general idea

- Minor "errors" in acquisition accrue over successive generations
- This eventually yields population-level change, which may be dramatic

→ Studying acquisition is a way to get at an understanding of the mechanisms of change (i.e., "Why and by what means does language change?")

[1] Paul 1880, Sweet 1899, Halle 1962, Kiparsky 1965, Andersen 1973, Baron 1977, Lightfoot 1979 *et seq*, Labov 1989, Niyogi 1996 *et seq*, Kroch 2005, Yang 2002 *et seq*, van Gelderen 2011, Cournane 2017, Kodner 2020, *inter multa alia*

Some Principles of Acquisition-Driven Change

“Language Change” and “Child Language Acquisition”

- Both are actually collections of distinct phenomena
- Certain aspects of acquisition drive certain types of change
- Many aspects of change are not driven by acquisition

→ Every claim, implicit or explicit, in the following format is wrong:
“Pretty much all language change accounted for by [my research focus]”

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Which changes are driven by some aspect of acquisition?

By what means does acquisition drive these change?

Some Principles of Acquisition-Driven Change

Individuals vs Populations

- **Learning and the grammar(s) we eventually acquire are crucially individual-level.** **Can be studied as cognitive science**
  i.e., a study of internal mental capacities, representations, and processes
- **Change is crucially population-level.** **Populations are subject to variation**
  i.e., structured heterogeneity,[1] studied under sociolinguistics

[1] Weinreich et al (1968) for classic reviews

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The tension between individuals and change is fundamental to the study of language change,[1] biological evolution, and many other fields.

How do we connect the individual and the population?

[1] Weinreich et al (1968) for classic reviews

To a Very Rough Approximation…

Processes of child language acquisition are more relevant for what I call "discrete" rather than "continuous" changes

Discrete Changes

Centered on actuation

- The kinds of changes generative theoreticians discuss
- Categorical properties of the grammar virtually fixed over individuals' lifetimes[1]
- New or lost structures or constructions

Continuous Changes

Often centered on incrementation

- The stereotypical subjects of variationist sociolinguistics[2]
- Positions in the vowel space, usage frequencies, optionality
- Spread through communities
- Often variable over lifetimes
- Often known to be driven by young adults

[1] Andersson 1995, Sankoff & Blondeau 2007, Nycz 2013
[2] Weinreich et al 1968 again…

Discrete and Continuous Changes

Actually two sides of one coin

- Once a discrete innovation enters the population, it becomes variation[1]
- Underlies the basic premise of variationist sociolinguistics:
  "The study of variation is the [continuous] distribution of discrete choices"[2]
- And the concept of competing grammars in historical syntax and morphology[3]

The interesting part of the discrete aspects of language change lies closer to actuation than incrementation[4]

[1] Kroch 2005, [2] Sankoff 1988, [3] Kroch 1994, [4] Weinrich et al 1968 for foundational discussion

Learner Innovation ≠ Learner Error

Innovations need not be due to “errors”

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Errors - “Blame the Child”

- The learner does not act correctly on its input “a buggy algorithm”
- Errors presuppose appropriate evidence and an available target

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Non-errors - “Blame the Environment”

- The learner acts correctly but is dealt a bad input sample
- Even for a good algorithm, “garbage in, garbage out”
- Change in the face of severely underspecified input or even trivial variation

→ We can study change by studying acquisition as a well-behaved system

Acquisition in the Past

- **Children in the past must have acquired language in the same way that modern children do - this is straightforward application of uniformitarianism[1]**
- **We can reason about acquisition in the past in the same way we do now**

[1] Labov 1972 as applied to linguistics, Walkden 2019, attributed originally to Lyell (1830), but the original definition comes with other assumptions too

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But where can we get data about acquisition in the past?

- We can't run experiments on subjects who are no longer alive
  With appropriate caution, we can project experimental results back to the past

  Not a unique problem – in all instances, lab experiments must be projected onto the outside population

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- We can't do corpus or modeling work on ancient child-directed speech (CDS)
  There is none! Overwhelmingly, modern languages don't have CDS either…

A similar issue faced in other historical sciences…

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Can non-child-directed speech corpora be substituted for child-directed speech to study the relevant problem?

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Yes! Sometimes it can! (Kodner, 2019, 2023)

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Taking Estimates from Other Corpora

- Maybe we can estimate child linguistic knowledge from adult and historical corpora when child-directed speech (CDS) is unavailable
- This is reasonable if CDS and non-CDS are sufficiently similar in respect to relevant linguistic properties

I demonstrate that historical and modern non-CDS are effectively indistinguishable from CDS in the relevant cases for the purpose of using them to estimate child linguistic experience

Four Features of First Language Acquisition

1. **All children receive unique input yet exhibit gross developmental uniformity**[1]
2. The type frequency of a pattern is crucial for acquisition of generalizations, as opposed to token frequency or attestation of specific items[2]
3. Token frequencies correlate with relative order of acquisition[3]
4. Early learner vocabularies are small[4]

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As a result,

- Applying a frequency cutoff to lemmas in CDS approximates a “typical” child
- Insight taken by type frequency-based models of acquisition[5]

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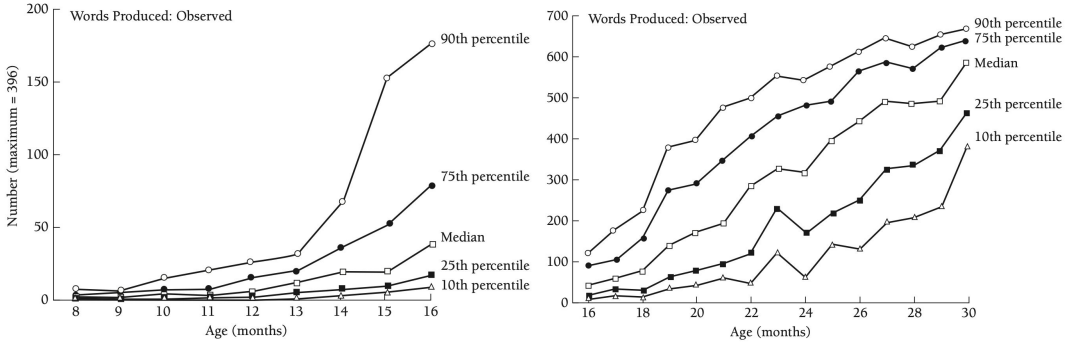
Child Lexical Knowledge

- Learners' vocabularies grow over the course of development
- There is significant individual variation, but consistent trends[1]
- **Only on the order of 10^2** for English and German learners by around age 3
- Children have the foundations for language-specific grammars by this point

Language	Estimated |Vocab|
English 2;10-3;0[1]	525-1,116
German 2;6[3]	$\mu = 429, \sigma > 100$



[1] Fenson et al 1994, Hart & Risley 2003, [2] Hart & Risley 2003, [3] Szagun et al 2006, Plots from Fenson et al 1994

Five Studies

1. **Trimming infrequent vocabulary from Mod. English CDS and non-CDS corpora**
2. Morphophonological and syn-sem type freqs across ModE CDS and non-CDS
3. Semantic overlap between ModE and Spanish, Latin, and PGmc lexicons
4. Morphological sparsity in Modern CDS, adult and historical corpora
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Ask during the Q&A 👍

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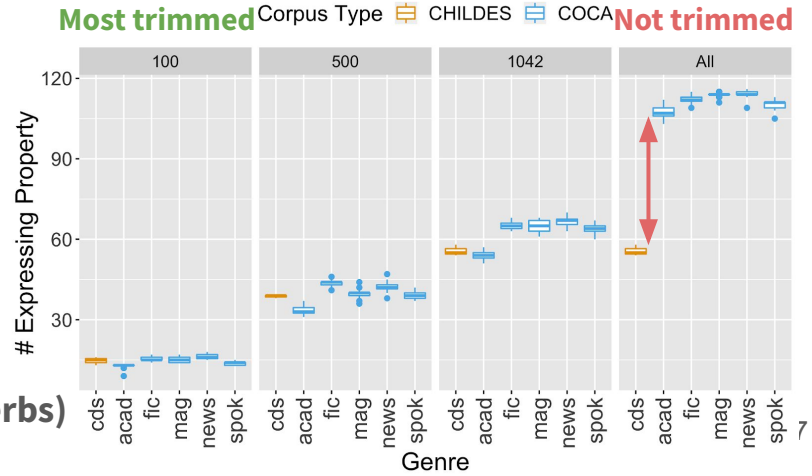
CDS becomes indistinguishable from adult corpora in terms of type attestation of various patterns when frequency trimming is applied

→ the adult corpora are reasonable substitutes



(# DO alternator verbs)

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- **Substantial semantic overlap between English CDS, Spanish CDS, and the most frequent items in Latin Perseus and among the most securely reconstructable Proto-Germanic verbs[1]**
- **Same NLP intuitions apply here**

Comparison	% Overlap
English CDS - EN CDS2	81.71%
English CDS - ES CDS	73.07%
English CDS - PGmc	66.67%
Spanish CDS - PGmc	71.32%
English CDS - Latin	75.77%
Spanish CDS - Latin	78.62%

[1] Seebold 1979 with the help of Don Ringe

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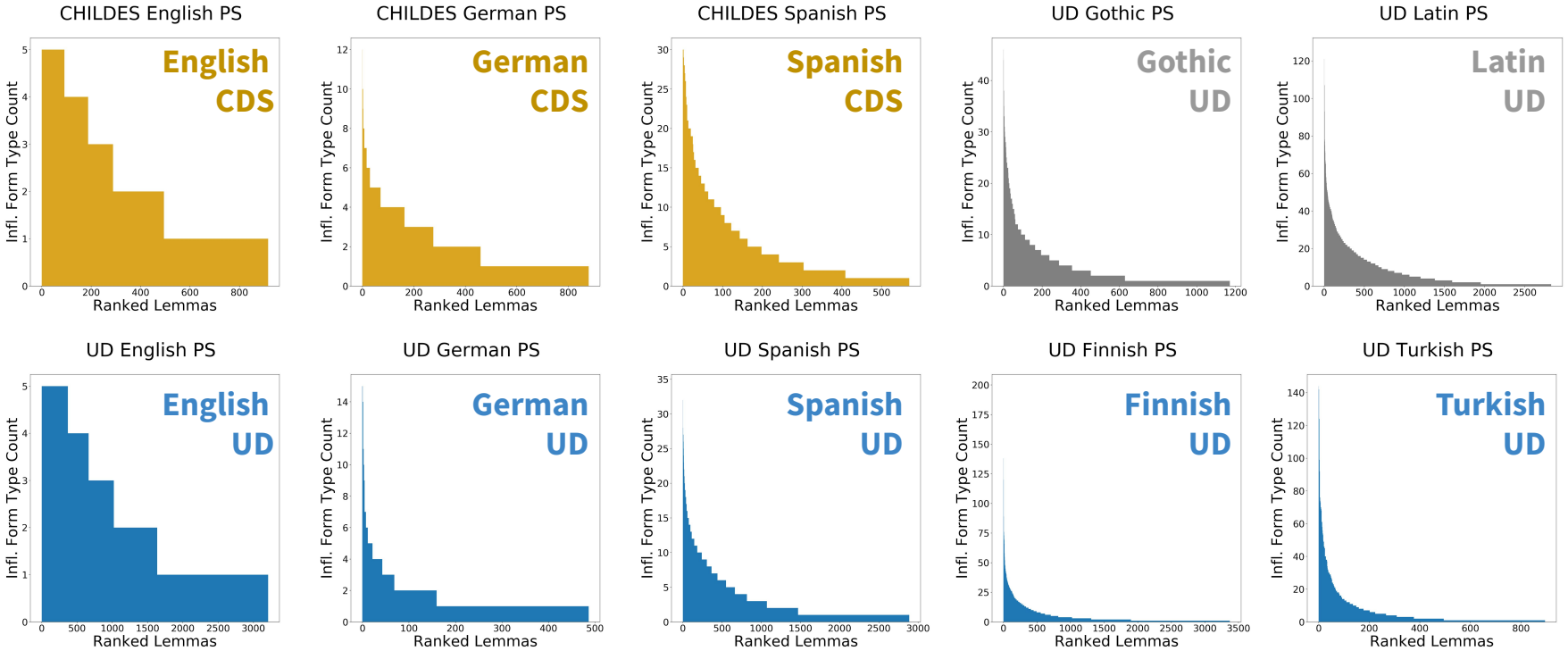
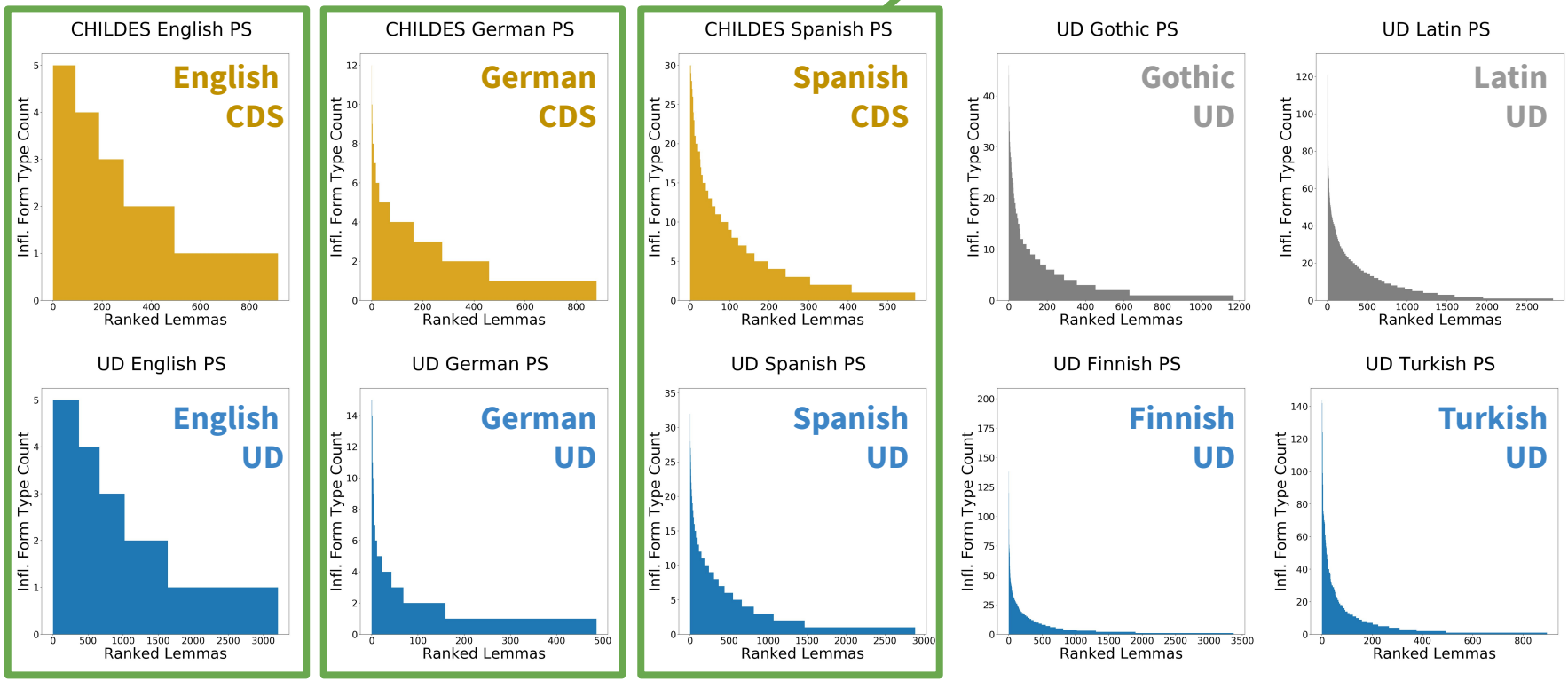
Zipfian Distributions



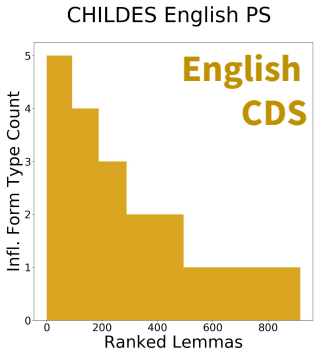
Zipfian Distributions

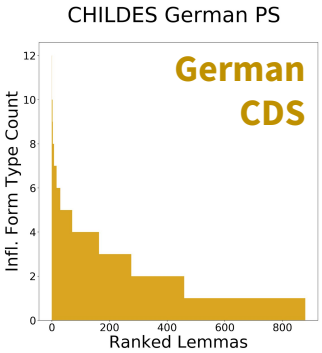
CDS and UD distributions correspond by language

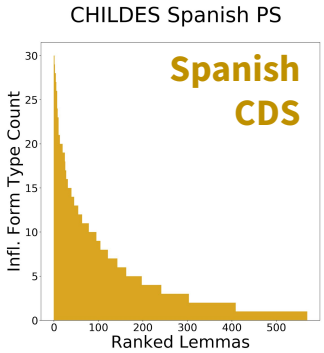


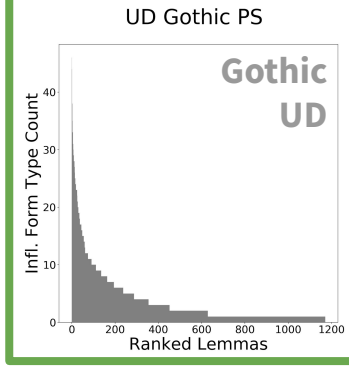
Zipfian Distributions

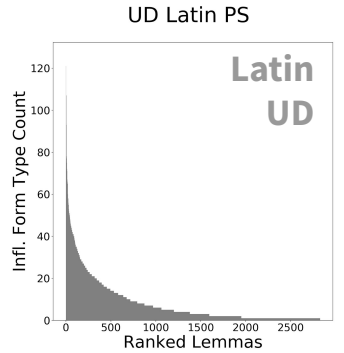
Historical corpora behave just like any other in this respect

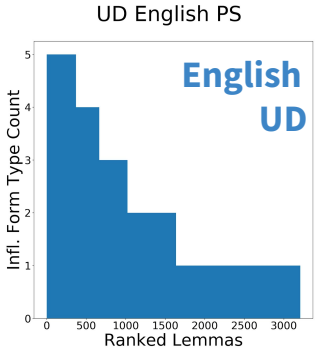


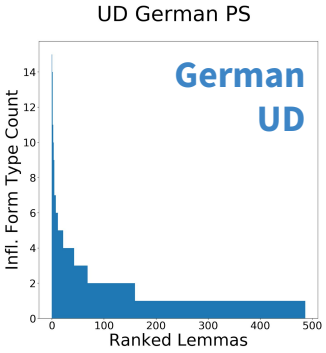


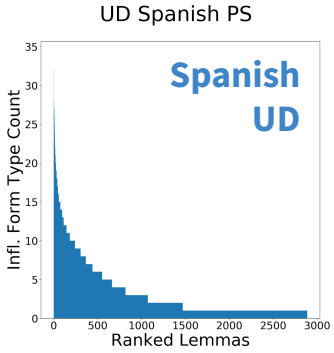


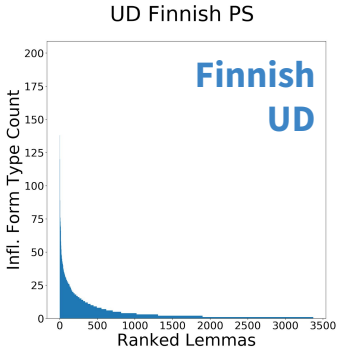


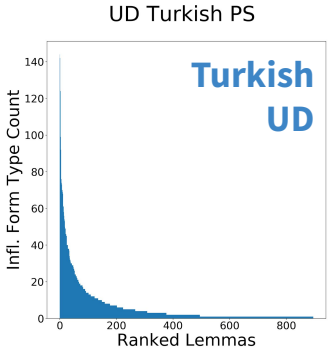




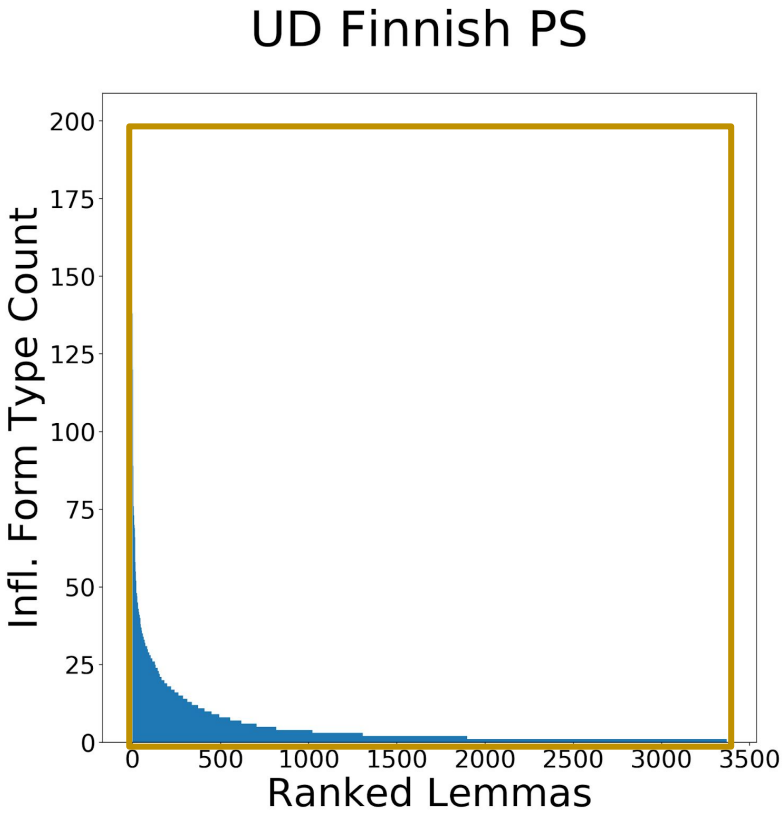








A different way to read these plots



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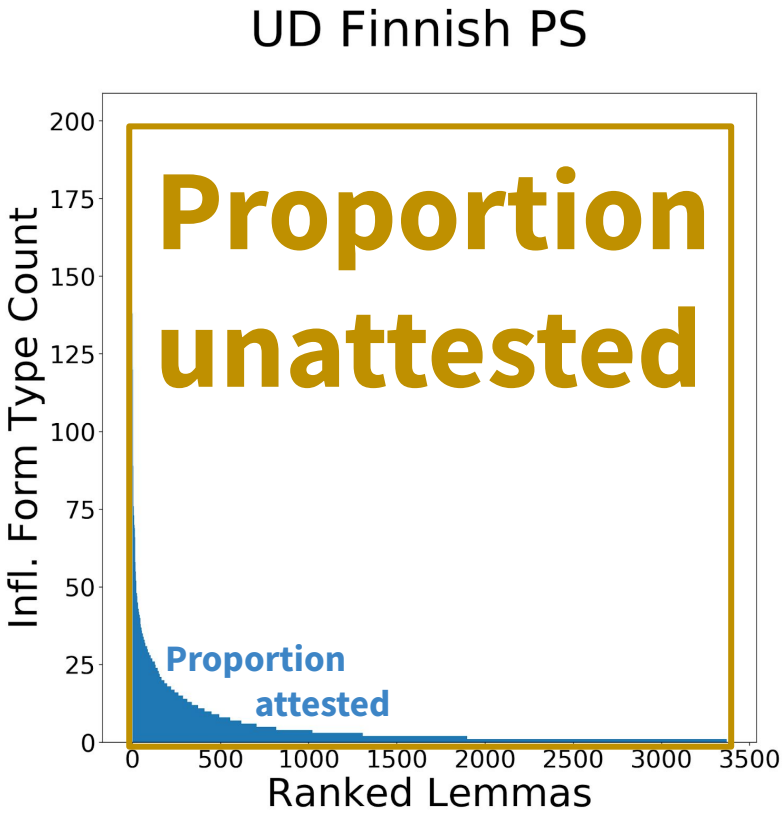

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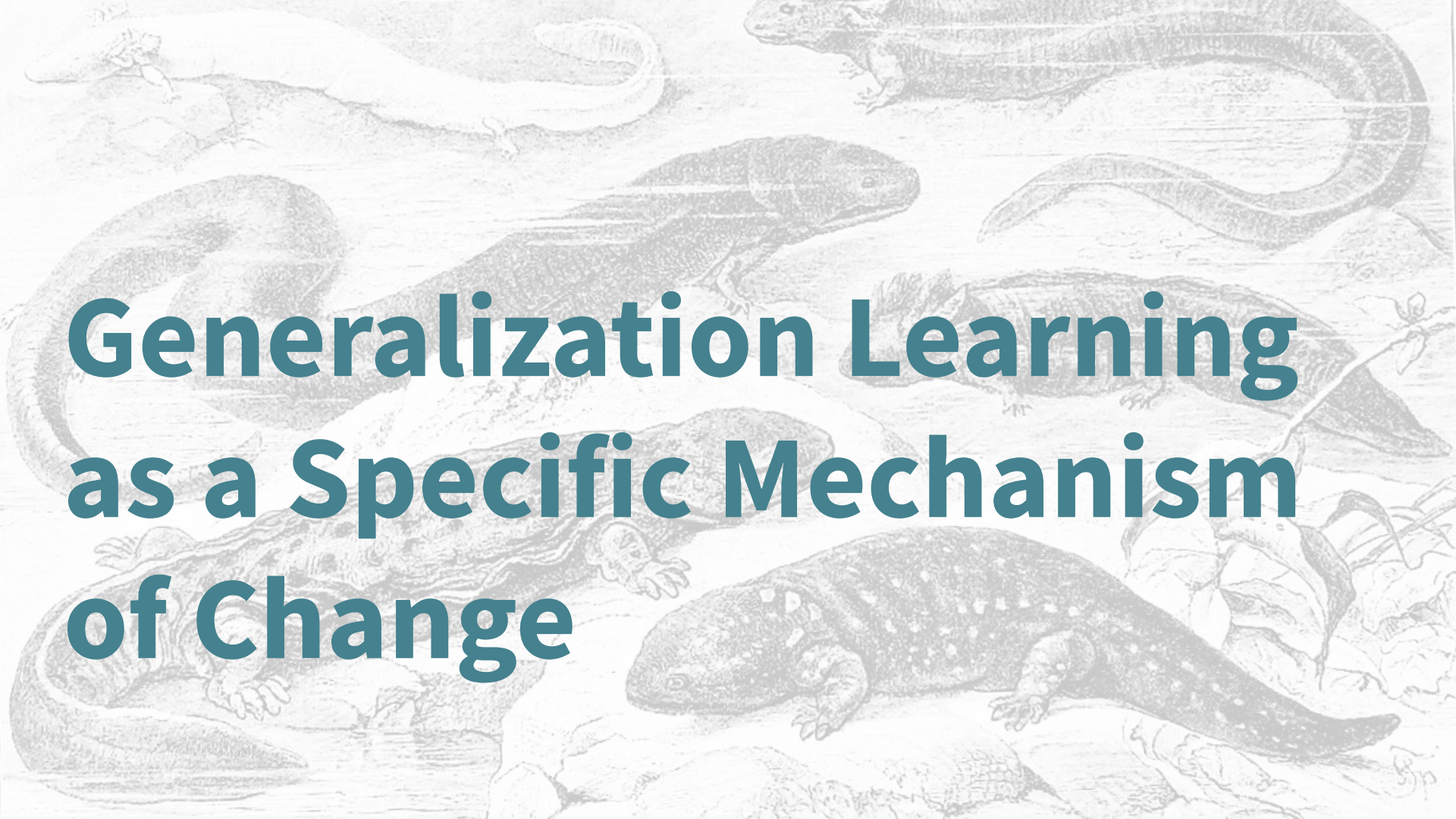
Conclusions

- **Though CDS-derived and non-CDS derived lexicons differ in terms of exact lexical makeup and other superficial corpus stats (eg token/type ratio),**
- **They are quantitatively similar or indistinguishable over linguistic dimensions**
- **When frequency-trimmed to approximate learner vocabulary sizes**

With appropriate pre-processing, historical and modern adult-derived corpora may be reasonably used to approximate child linguistic experience



Generalization Learning as a Specific Mechanism of Change

Actuation and the Paradox of Language Change[1]

If children are so good at acquiring language,
how are they so bad at it?

Helps to have a precise definition of actuation[2]…

Actuation = Innovation + uptake into the speech community

(The hand-off from an individual-level process to a population-level one)

[1] term coined by Niyogi & Berwick 1997, [2] definition paraphrased from Labov, Yager & Steiner 1972, [3] Yang 2005, 2016

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…and precise models of the relevant aspects of acquisition

Today we focus on the Tolerance Principle[3], a model of generalization learning

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The Tolerance Principle (Yang 2005, 2016)

- A concrete model for the acquisition of linguistic generalization
- A cognitively-motivated **evaluation metric** over linguistic hypotheses
- Separates the algorithmic aspects of acquisition from the representations over which generalizations are formed

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Has been applied to a wide range of generalization-learning tasks

- Inflection in Arabic, Cree, English, Frisian, German, Icelandic, Polish, Spanish…
  (Yang 2005, 2016, Belth et al 2021, Björnsdóttir 2021, Munshi 2021, Merkuur 2021, Henke 2022,…)
- Dutch, English, and Latin derivational morphology (Yang 2016, van Tuijl and Coopmans 2021, Kodner 2022)
- Argument structure constraints in English, Icelandic, and Korean
  (Yang 2016, Irani 2019, Lee & Kodner 2019, Nowenstein et al 2020, Pearl & Sprouse 2021)
- 'Root infinitive' phenomenon (or lack thereof) in English, French, Hebrew and Spanish (Payne 2022)
- Phonological 'rules' in English (Sneller et al 2018, Richter 2021, Dresher and Lahiri 2022)
- Variation in Scottish *amn't* (Thoms, Adger, Heycock, Jamieson & Smith)

and many more…

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And has gained backing from a range of psycholinguistic experiments

(Schuler, Newport & Yang 2017, Koulaguina & Shi 2019, Emond & Shi 2021, 2023, Li & Schuler 2023)

And end-to-end computational learning implementations

(Belth, Payne, Beser, Kodner & Yang 2021, Payne 2022, Belth 2023, ***and we have more in prep!***)

The Tolerance Principle (Yang 2005, 2016)

How many exceptions is “too many” exceptions?

Given a hypothesized generalization operating over some class, quantitatively define the number of exceptions below which the generalization is tenable

N = number of types that should obey the generalization

e = number of types that do not obey the generalization

θ = max # of exceptions that can be tolerated

Exceptions are tolerable if

$$e < \theta$$

$$\theta = N / \ln N$$

N and *e* Vary over Individual Development

- *N* and *e* are properties of each individual
- *N* is the number of class members a child has learned so far

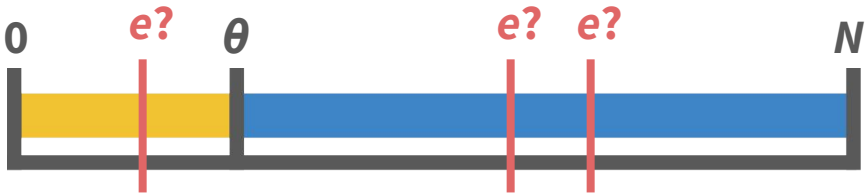
→ *N* and *e* grow as the learner's vocabulary grows

Can learn generalizations over small *N* not possible over large *N*

→ This predicts observed learning trajectories

Visualization of the Tolerance Principle

N = types it should apply to
e = types that are exceptions
θ = tolerance threshold



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acquire pattern as rule
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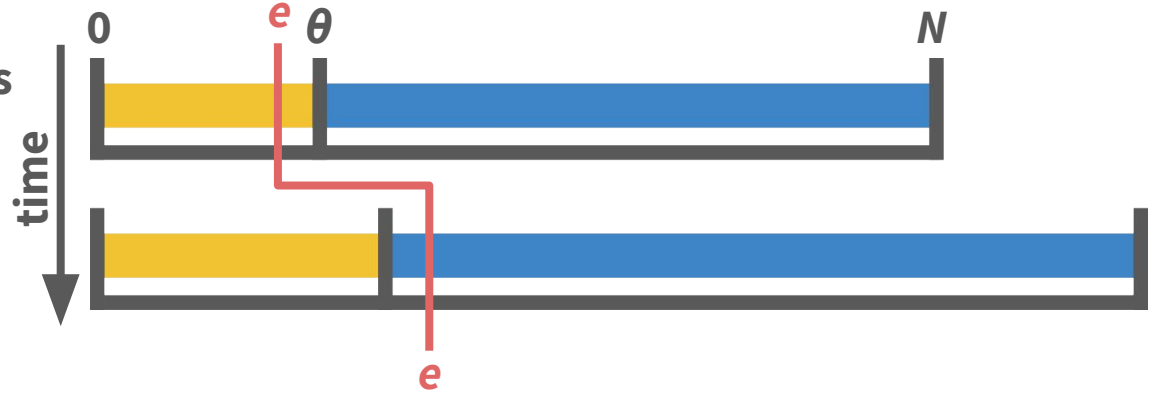
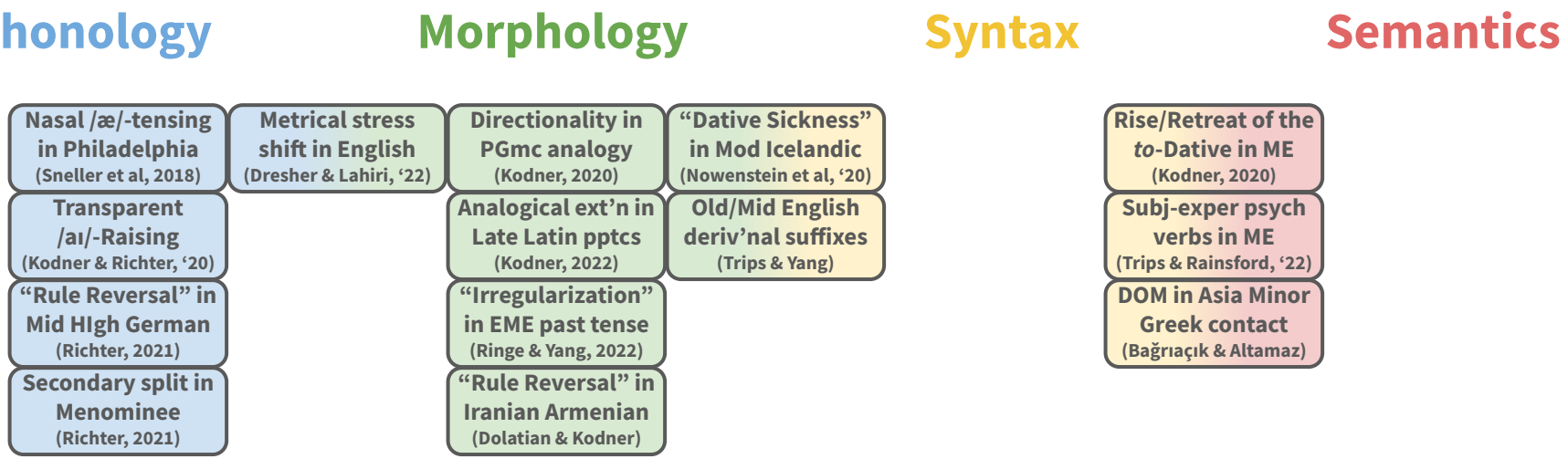


- *N* grows over an individual's development, *θ* grows more slowly
- If *θ* grows faster than *e*, a pattern may fall into productivity
- If *e* grows faster than *θ*, a pattern may fall out of productivity

The Tolerance Principle and Language Change



A shared mechanism:

Innovations through generalization learning during language acquisition

The Tolerance Principle and Language Change

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Semantics

Many types of change:

Cross-cutting traditional levels of the grammar

A shared mechanism:

Innovations through generalization learning during language acquisition

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Innovations through generalization learning during language acquisition

Many types of change:

Cases of secondary split

Cases of analogical extension

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Semantics

A shared mechanism:

Innovations through generalization learning during language acquisition

Many types of change:

Cases of secondary split

Cases of analogical extension

Cases of grammaticalization, reanalysis, and bleaching…

The Tolerance Principle and Language Change

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Semantics

A shared mechanism:

Innovations through generalization learning during language acquisition

Many types of change:

Cases of secondary split
Cases of analogical extension
Cases of grammaticalization, reanalysis, and bleaching**…and more!**

The Tolerance Principle and Language Change

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Semantics

Many types of change:

Cases of change in a contact setting

A shared mechanism:

Innovations through generalization learning during language acquisition

The Tolerance Principle and Language Change

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Semantics

A shared mechanism:

Innovations through generalization learning during language acquisition

Many types of change:

Cases of change in a contact setting

and specifically attrition-related

The Tolerance Principle and Language Change

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Semantics

Many types of change:

Applications that I've worked on

A shared mechanism:

Innovations through generalization learning during language acquisition

The Tolerance Principle and Language Change

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Semantics

Many types of change:

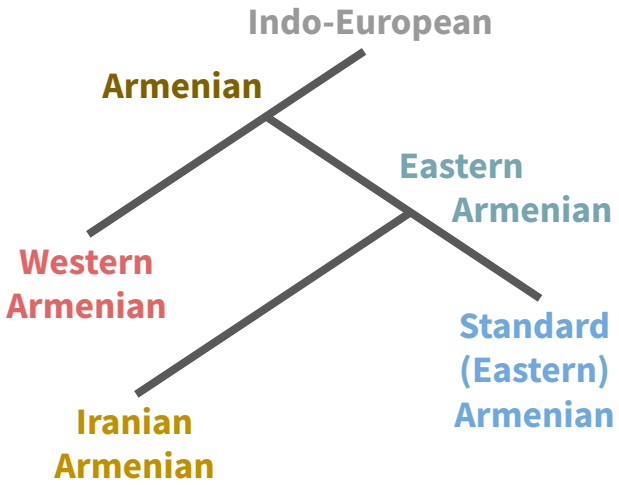
A example for today

A shared mechanism:

Innovations through generalization learning during language acquisition

Հայերեն: The Armenian Language(s)

- A branch of Indo-European spoken indigenously in the southern Caucasus and eastern Anatolia
- A large diaspora in former Ottoman, Soviet, and Persian territories as well as the USA
- Two primary branches: Western and Eastern
- Our focus is Tehrani Iranian Armenian spoken in Tehran and Los Angeles
- Eastern, similar to Standard Armenian



Standard Eastern Armenian is conservative in the relevant paradigm, so we use it as a proxy for pre-modern Iranian Armenian

Standard Eastern vs Tehrani Armenian Paradigms

- Eastern Armenian distinguishes perfectivity in the past tense
- Two inflectional classes by theme vowel: A-Class, E-Class.
- E-Class is by far the largest

	Form	A-Class *read*	E-Class *sing*	Irreg. *eat*
Standard	INF	*kardal*	*ergel*	*utel*
	PST.PFV.3PL	*kardac'in*	*ergec'in*	*keran*
	PST.IPFV.3PL	*kardain*	*ergein*	*utein*
Iranian	INF	*kardal*	*ergel*	*utel*
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In (Conservative) Std Eastern:

- -Vc'i- is the default way to form perfects
- Many irregular E-Class perfects show -a- instead of -ec'i-

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In (Conservative) Std Eastern:

- -Vc'i- is the default way to form perfects
- Many irregular E-Class perfects show -a- instead of -ec'i-

In (Innovative) Tehrani Eastern:

- Regular E-Class perfects have an ending -a- like conservative irregulars rather than -ec'i-
- Analogical extension from the small irregular class to the dominant one

An ‘Elsewhere Reversal’

The conditioned and default realizations seem to have flip-flopped!

- *-c’-i-* was the default, now it’s limited to A-Class
- *-Ø-a-* was limited to irregulars, now it’s the default

	Form	A-Class *read*	E-Class *sing*	Irreg. *eat*
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	Vocab Items for Perfect
ASP[PFV] T[PST] ↔	*-Ø-a-* / LIST___
	-c’-i- / ELSEWHERE
ASP[PFV] T[PST] ↔	*-c’-i-* / TH[=*a*]____
	-Ø-a- / ELSEWHERE

Two Additional Observations

Some regular E-Class verbs already had -*a*- perfects

- Observed in Western as well as Eastern Armenian
- They coexist with -*ec'i*- perfects (sometimes only in the 3rd person singular)
- Tend to be high-frequency verbs ('*do*,' '*bring*,' '*give*,' '*say*,'...)

Outside of Iranian Armenian, -*a*- perfects are more common in

- Intransitive verbs[1]
- Verbs with monosyllabic roots

[1] Martirosyan 2009

There are actually two changes here…

1. **A Phonological Change**
   Hiatus glide insertion > Deletion
   Conservative > Iranian
   /ei/ > [eji] /ei/ >[i]

2. **A Morphological Change**
   The analogical extension
   Conservative → Iranian
   -ec'i- ***-a-***

	Form	A-Class *read*	E-Class *sing*	Irreg. *eat*
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Proposal: Indirect Causation

1. **The phono change made a novel alternative morpho generalization available to learners**
2. **A speaker adopting this novel generalization could spread *-a-* to regular E-Class verbs via over-regularization, a normal process during acquisition**

A learner has two options after the phono change

Conservative Generalization

- *-c'-* is the default perfect
- *-a-* vowel is listed

-a- remains restricted to irregulars

Predicts *ergec'in* in this case

Innovative Generalization

- *-a-* vs *-i-* marks aspect
- *-c'-* is a property of A-class

When there is no (overt) TH, perfect = *-a-*, imperfect = *-i-*

Predicts *ergan* in this example

Pre-Iranian

Form	A-Class *read*	E-Class *sing*	Irreg. *eat*
INF	*kardal*	*ergel*	*utel*
PST.PFV.3PL	*kardac'in*	*erg-?-n*	*keran*
PST.IPFV.3PL	*kardain*	*ergin*	*utin*

Predictions

If the phonological change set up the analogy, then

- **A-Class should retain -*ac'i*- perfects because its imperfect retains [aji]**
- **If an Armenian variety has the Elsewhere Reversal, it must also have /ei/>[i]**
- **If an Armenian variety has /ei/>[i], it may or may not have have the reversal**

Predictions

If the phonological change set up the analogy, then

- **A-Class should retain *-ac'i-* perfects because its imperfect retains [aji] ✔**
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Iranian

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Imperfect	Perfect	# of Varieties Surveyed
-ein	*-ec'in*	(Standard Eastern)
-in	*-ec'in*	10
-in	*-(ec')in*	3
-in	*-an*	1 (Tehrani Iranian)
-ein	*-an or -in*	unattested

Innovation

✔ /ei/ > [eji], no reversal

✔ /ei/ > [i], no reversal

✔ /ei/ > [i], optional reversal

✔ /ei/ > [i], complete reversal

✘ /ei/ > [eji], reversal

May have reversal

Cannot have reversal

Methodology

Estimate learner vocabularies in increasing increments

- Verbs extracted/annotated from an Eastern Armenian frequency dictionary[1]
- Vocabularies estimated by taking the top *V* for *V*=50, 60,...,100, 200,..., 600
- Represent verbal lexicon size and growth over the course of development[2]

Explore feasible incrementation pathways

- What novel generalizations (if any) can be tolerated at each *V* size?
- These are **feasible incrementation pathways** for the Elsewhere Reversal as new cohorts successively extend over-generalizations

[1] Ղազարյան 1982, [2] Bornstein et al 2004 reports that verbs make up a third to a half of the lexicon during childhood for several languages

Data Summary (Std East)

- E-Class accounts for most verbs
- Irregular, monosyllabic, and intrans. constitute large subsets of E-Class

We take irregular E-Class verbs with *-a-* perfects in Standard as the initial state (purple column) and ignore optional *-a-* verbs (conservative assumption)

V	E-Class All	Std E *-a-*	E-Class Irreg	E-Class 1σ	E-Class Intrans
50	33	8	15	26	10
60	41	10	17	32	11
70	47	10	18	36	16
80	56	12	23	42	20
90	63	12	24	46	23
100	72	12	28	49	28
200	161	13	54	106	64
300	243	16	79	144	97
400	332	17	112	176	144
500	416	17	143	217	189
600	508	19	175	250	229

1. Initial Over-Generalization

Extend -*a*- immediately to all E-Class?

N **= |E-Class ⊂** ***V*****|** **e = |⊂ E-class with -*ec'i*- perfect in Standard|**

1. Initial Over-Generalization

Extend -*a*- immediately to all E-Class? Impossible.

N = |E-Class ⊂ ***V***| ***e*** = |⊂ E-class with -*ec'i*- perfect in Standard|

V	50	60	70	80	90	100	200	300 …
N (***e***)	33 (25)	41 (31)	47 (37)	56 (44)	63 (51)	72 (60)	161 (146)	…
Tolerable?	✘	✘	✘	✘	✘	✘	✘	✘

1. Initial Over-Generalization

Extend -*a*- immediately to all E-Class Intransitives? Only *V* < 70

N = |E-Class intrans ⊂ *V*| *e* = |⊂ E-class intrans with -*ec'i*- perf in Std|

V	50	60	70	80	90	100	200	300 …
N (*e*)	33 (25)	41 (31)	47 (37)	56 (44)	63 (51)	72 (60)	161 (146)	…
Tolerable?	*?*	✔	✘	✘	✘	✘	✘	✘

? = within 1 of θ

Extend -*a*- to all Irregular E-Class Intransitives? *V* < 200

N = |Irreg E-Class intrans ⊂ *V*| *e* = |⊂ Irreg E-class intrans with -*ec'i*- " " "|

V	50	60	70	80	90	100	200	300 …
N (*e*)	15 (7)	17 (7)	18 (8)	23 (11)	24 (12)	28 (16)	54 (39)	…
Tolerable?	✔	✔	✔	✔	✔	✔	✘	✘

2. If -*a*- Spread to all Irregular E-Class, then…

Further extend -*a*- to all E-Class Monosyllables (1σ)? *V* < 70

V	50	60	70	80	90	100	200	300	400
N (*e*)	26 (12) ✔	32 (16) *?*	36 (20) ✘	42 (23) ✘	46 (26) ✘	49 (27) ✘	106 (64) ✘	144 (91) ✘	… ✘

? = within 1 of θ

Further extend -*a*- to all E-Class Intransitives? *V* < 200

V	50	60	70	80	90	100	200	300	400
N (*e*)	10 (5) ✔	11 (5) ✔	16 (9) *?*	20 (9) ✔	23 (11) ✔	28 (14) *?*	64 (30) ✘	97 (41) ✘	… ✘

Further extend -*a*- to all E-Class 1σ Intransitives? *V* < 400

V	50	60	70	80	90	100	200	300	400
N (*e*)	10 (5) ✔	11 (5) ✔	16 (9) *?*	20 (9) ✔	23 (11) ✔	23 (11) ✔	28 (14) *?*	28 (14) *?*	… ✘

3. If -*a*- Spread to all Irreg and 1σ E-Class, then…

Further extend -*a*- to all E-Class? *V* < 400

V	50	60	70	80	90	100	200	300	400
N (*e*)	33 (6) ✔	41 (8) ✔	47 (9) ✔	56 (10) ✔	63 (13) ✔	72 (17) ✔	161(42) ✔	243(72) ✔	… ✘

Further extend -*a*- to all E-Class Intransitives? All *V*

V	50	60	70	80	90	100	200	300	400
N (*e*)	10 (1) ✔	11 (1) ✔	16 (1) ✔	20 (1) ✔	23 (2) ✔	28 (2) ✔	64 (9) ✔	97 (15) ✔	… ✔

This process was repeated iteratively to uncover feasible incrementation pathways

Feasible Pathways for Analogical Extension

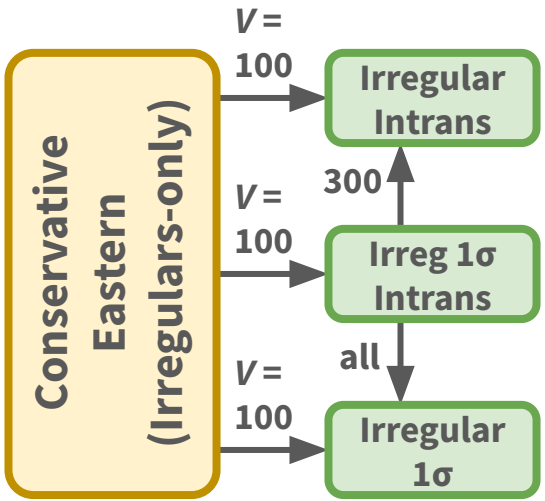
If *V*=100 is used as the min |*V*| needed for incrementation:

- Several pathways for incrementation to the analogical extension

Feasible Pathways for Analogical Extension

If V=100 is used as the min $|V|$ needed for incrementation:

- **Several pathways for incrementation to the analogical extension**



Attested Iranian (all E-Class)

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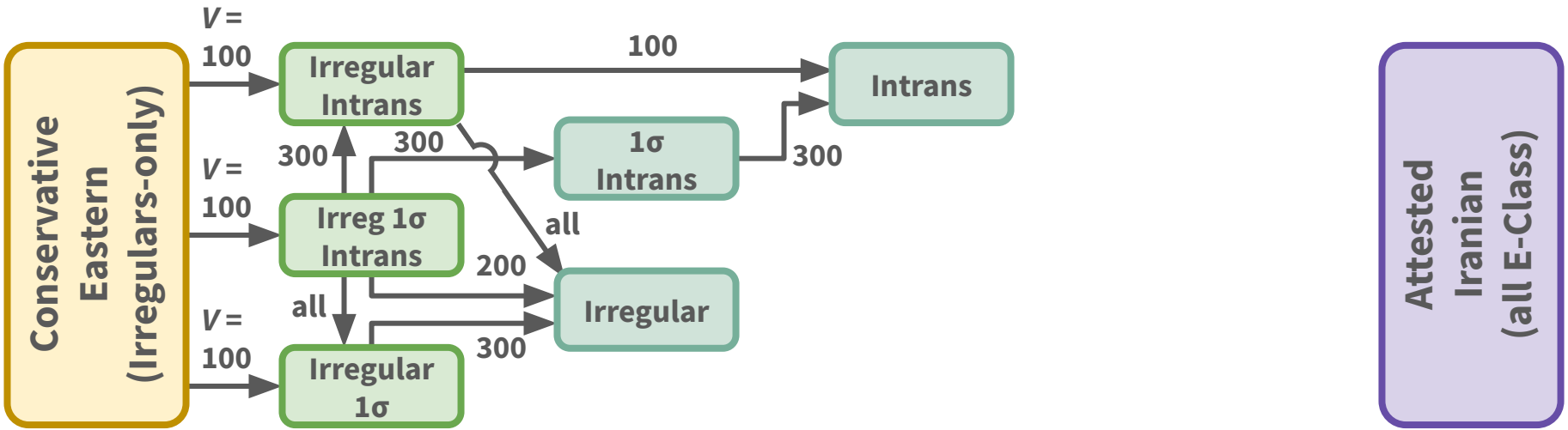

Feasible Pathways for Analogical Extension

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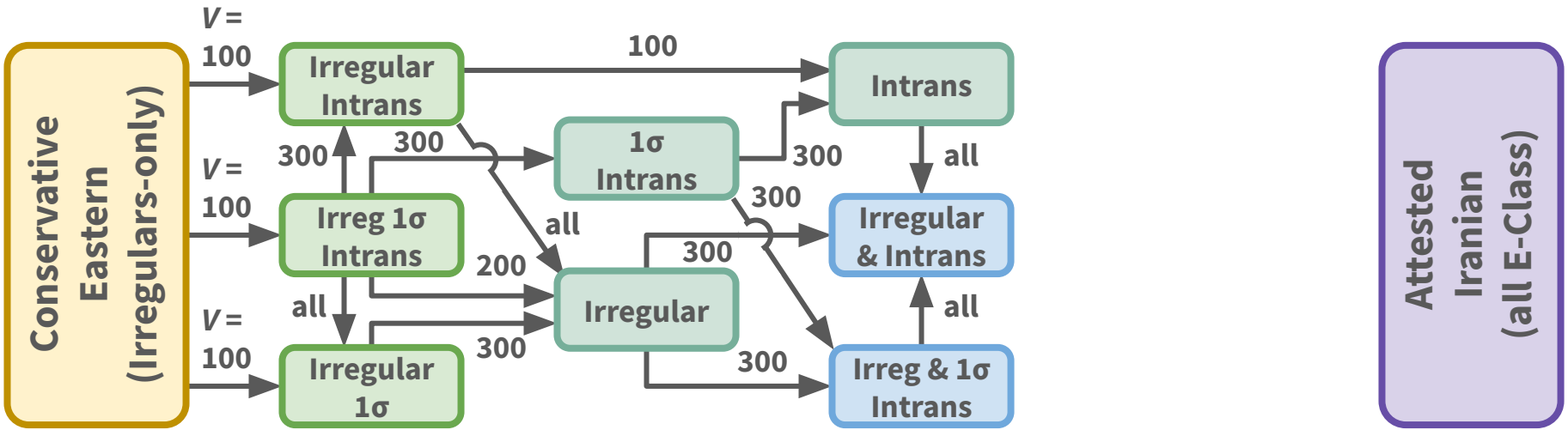

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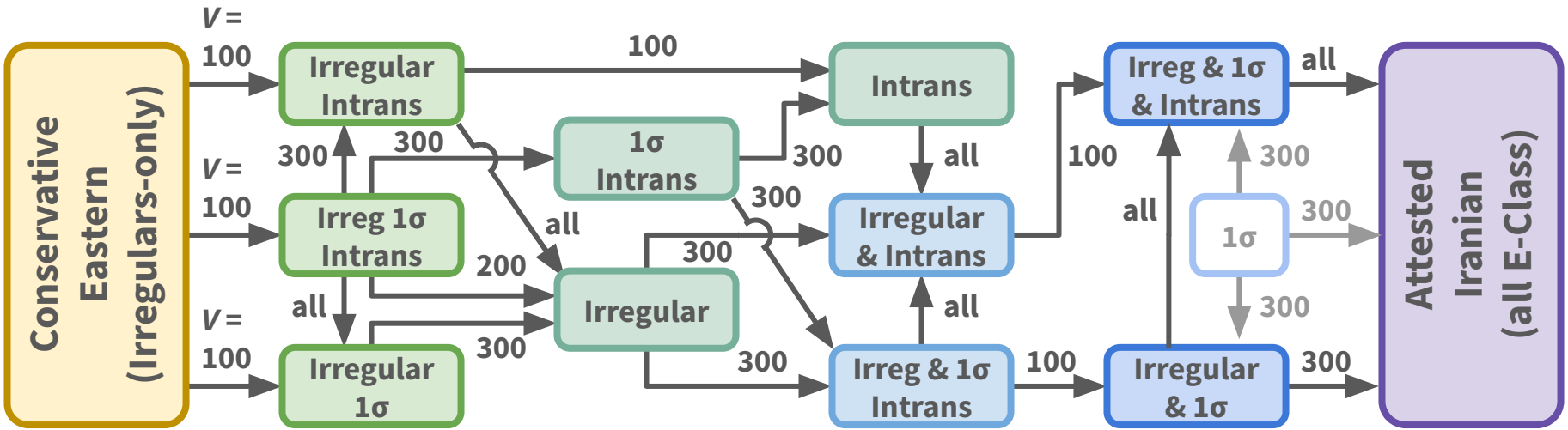

Conclusions

Analogical Extension: Just Fortuitous Analogical Leveling

- Analogical change is the population-level diachronic extension of individual learner over-generalization
- Leveling and extension share an identical mechanism
  Extension is just quantitatively less likely to be actuated

The only reason we could draw this conclusion is because we committed to a mechanism!

Conclusions

Phonological Change: A Necessary but not Sufficient Condition

- **A phonological change is implicated in permitting this morphological change**
  But only indirectly, through learner innovation
- **Change is a contingent process. Acquisition and social factors come into play**
  This change did not *have to* happen just because it could happen
- **Necessary but insufficient condition is backed up by a typological survey**

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Precise Predictions: A Directed Search for Armenian Varieties

- The quantitative learning approach here makes precise predictions
- We now have a lead for what to look for in related Eastern Armenian varieties

A Process-Centered View of Change

The Tolerance Principle and Language Change

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Many types of change:

Cross-cutting traditional levels of the grammar

A shared mechanism:

Innovations through generalization learning during language acquisition

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Cases of grammaticalization, reanalysis, and bleaching…

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Cases of secondary split
Cases of analogical extension
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Semantics

A shared mechanism:

Innovations through generalization learning during language acquisition

Many types of change:

Cases of change in a contact setting

and specifically attrition-related

Why do these case studies cross-cut classifications?

An Old Idea: Taxonomies of Outcomes

- **These case studies share a mechanism (i.e., generalization learning)**
- **But the traditional classifications are based on outcomes**
- **The relationship between outcomes and mechanisms is complex**

  → they don't line up very well

  → if our goal is to figure out why and by what means language changes, classifying and reclassifying of outcomes is unlikely to get us there

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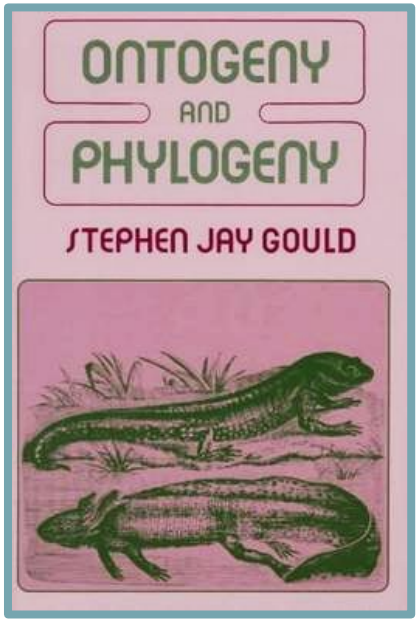
A Better Idea: A Taxonomy of Mechanisms

- It would give us a very different view of the "landscape" of language change
- Would help explicate the "why and by what means" questions of change

A Similar Problem in Biological Evolution

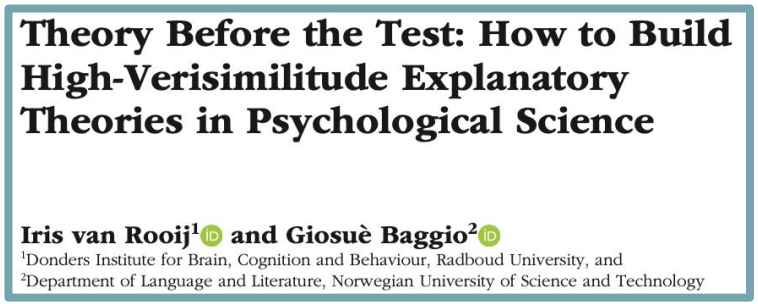


"The confusion between von Baer and Haeckel arises from **an unfortunate tradition in natural history, the emphasis of results rather than processes and their explanations**" (Gould, 1977, pg. 3)

"De Beer subdivides deviation according to where in ontogeny a new character appears and whether we shall consider its effect or the feature it replaces; **this confusion and proliferation [of classification schemes] illustrates the unnecessary complexities that we engender in *producing taxonomies of results* rather than *explications of processes.***"
(pg. 225, *italicization his*)

A Similar Problem in Cognitive Psychology

"Drawing on the philosophy of psychological explanation, we suggest that **psychological science, by focusing on effects, may lose sight of its primary explananda: psychological capacities.**"
(van Rooij & Baggio, 2021)


Theory Before the Test: How to Build High-Verisimilitude Explanatory Theories in Psychological Science

Iris van Rooij[1] and Giosuè Baggio[2]
[1]Donders Institute for Brain, Cognition and Behaviour, Radboud University, and
[2]Department of Language and Literature, Norwegian University of Science and Technology

"**However, effects are explananda (things to be explained), not explanations. …The effect itself is in need of explanation.** Moreover, effects such as we experimentally test in the laboratory are secondary explananda for psychology. **Ideally, we do not construct theories just to explain effects. Rather, [they] serve to arbitrate between competing explanations of the capacities** for cognitive control, speech perception, memory, and vision, respectively."

A Partial Taxonomy of Actuation Mechanisms

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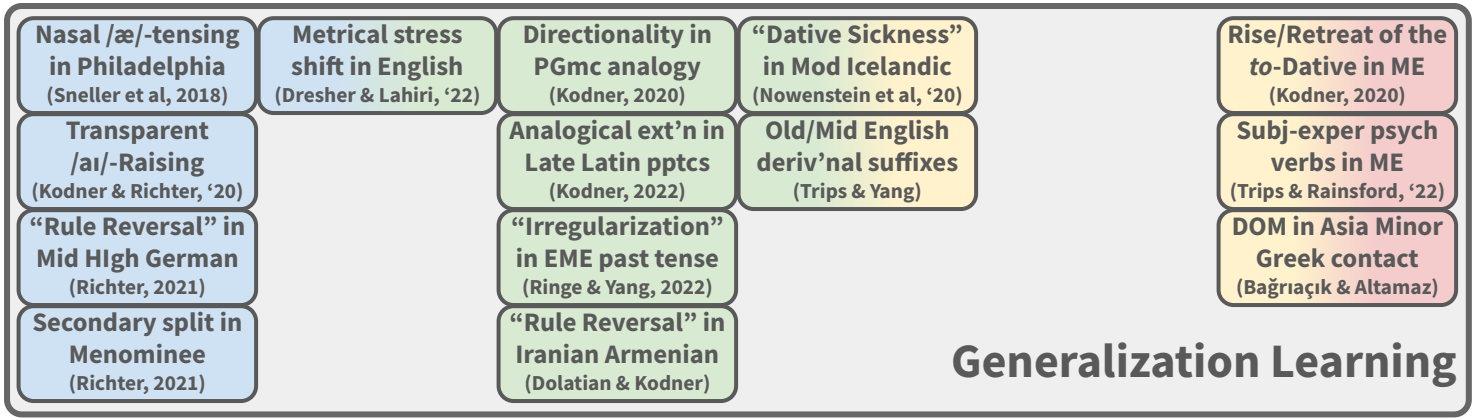

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Generalization Learning

Innovation During Language Acquisition

Misinterpretation of ambiguous input
Reanalysis side of hypo/ercorrection
Interpretation of modals (cf Cournane 2017)

Biased Hypothesis Generation
Phonological reanalysis (Kiparsky 1968)
Economy biases (cf van Gelderen 2004, Biberauer & Roberts 2016)

Maximizing Parsing Success
Vowel mergers (cf Yang 2009)
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Phonetic side of hyp.correction

Sociolinguistic accommodation

"Deliberate" creativity

Mechanical priming effects

L2 Learning and Transmission

• • •

Adult-Driven Change

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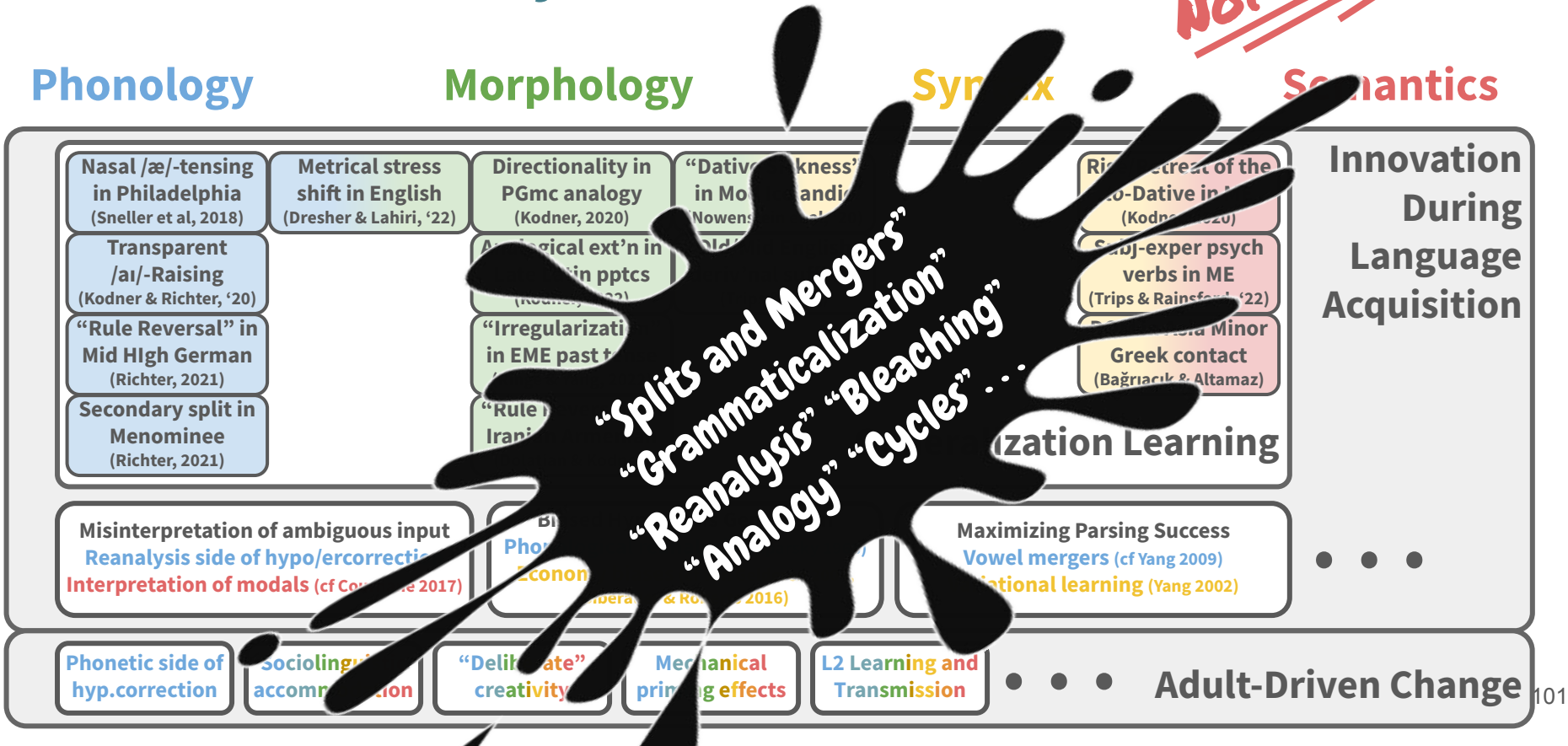
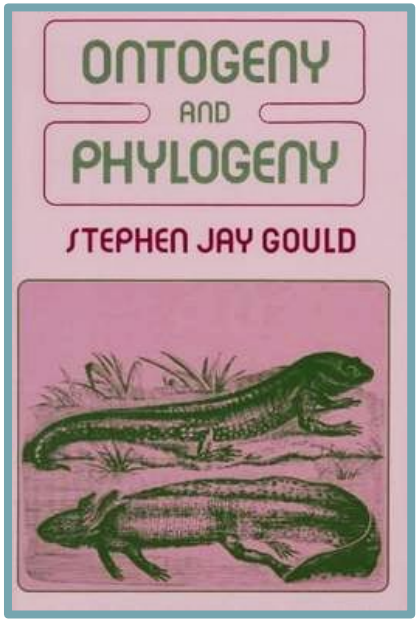


How can we develop an explication of mechanisms?

Old theories do not collapse under disconfirmatory evidence alone

"Natural history does not refute its theories by cataloguing empirical exceptions to them (while working within a paradigm that engendered the theory in the first place)." (pg. 167)

"The data of natural history are so multifarious, complex, and indecisive that simple accumulation [of data points] can almost never resolve an issue. Theory must play a role in guiding observation, and theory will not fall on the basis of data accumulated in its own light." (pg. 6)



How can we develop an explication of mechanisms?

Theory and empirical evidence should grow together

"A first thought may be to derive [a capacity] f from observations of the input-output behavior of a system having the capacity under study. However, for anything but trivial capacities, where we can exhaustively observe (or sample) the full input domain, this is unlikely to work…**it is worth building a set of good candidate theories before selecting from the set.**"

"We argue that **even before (and interlaced with) putting computational-level theories to empirical tests, they can be put to theoretical tests, in what we call the theoretical cycle**, in which one assesses whether one's formalization of intuitive, verbal theories satisfies certain theoretical constraints on a priori plausibility."

Theory Before the Test: How to Build High-Verisimilitude Explanatory Theories in Psychological Science

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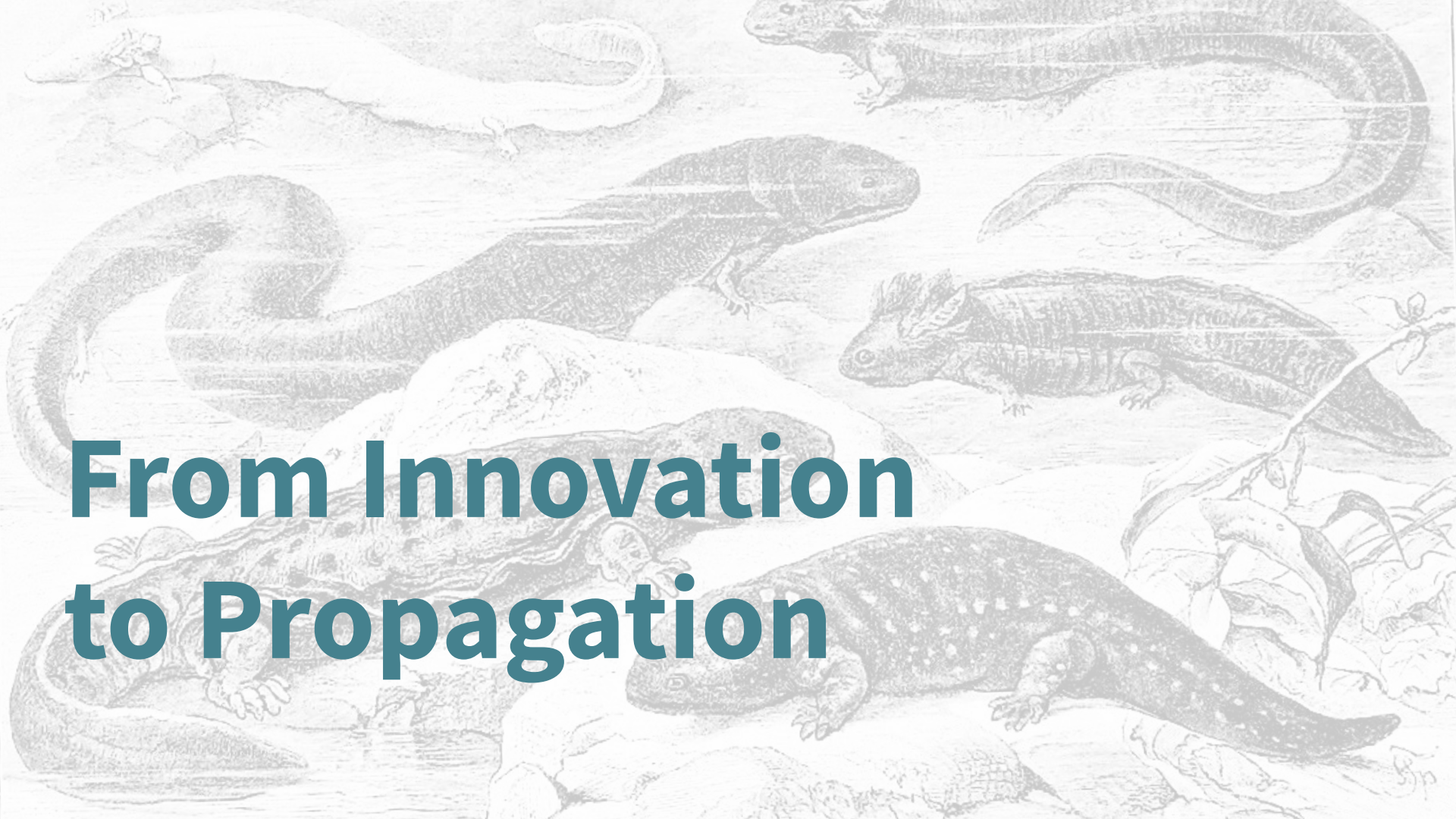
How can we develop an explication of mechanisms?

- **Cognitive science**, **language acquisition**, and **theoretical linguistics** provide a wealth of models for learning, processing, and representation
- **Traditional historical linguistics**, **sociolinguistics**, and **corpus linguistics** provide a wealth of data and knowledge of human interaction
- **Cognitive**, **quantitative**, **algorithmic** models like the Tolerance Principle reveal connections between disparate surface phenomena



From Innovation to Propagation

Actuation and the Paradox of Language Change[1]

If children are so good at acquiring language,
how are they so bad at it?

Helps to have a precise definition of actuation[2]…

Actuation = Innovation + uptake into the speech community

(The hand-off from an individual-level process to a population-level one)

[1] term coined by Niyogi & Berwick 1997, [2] definition paraphrased from Labov, Yager & Steiner 1972, [3] Yang 2005, 2016

Tractable not Trivial Learning

- One cannot acquire language from input alone
- The language faculty renders learning possible in the face of input sparsity[1]
- But many language specific patterns must still be acquired from the input[2]

Input is both richer and poorer than typically acknowledged

- Zipfian and other long-tailed distributions for all manner of linguistic features
  Most lexical items appear only once even in massive corpora
  Sparsity is consistently worse than our intuitions about sparsity
- Language is acquired from surprisingly small amounts of input without actionable negative evidence
  ~1/100,000x the input than the current state of the art NLP systems!

[1] Chomsky 1959, 1980, [2] eg Baker's Paradox (Baker 1979)

Learning takes a while

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- The language faculty renders learning possible in the face of input sparsity[1]
  Sparsity is consistently worse than our intuitions about sparsity
- But many language specific patterns must still be acquired from the input[2]

A language is not acquired all at once

- Some aspects are acquired quite early, some quite late
- Phonology and morphology are "mostly" done by age 3-4 cross-linguistically
- But some aspects of semantics are not complete before middle school![3]

[1] Chomsky 1959, 1980, [2] eg Baker's Paradox (Baker 1979), [3] see Cournane 2017 for discussion

Transmission is not strictly linear and generational

- Children mature in communities and receive input from multiple speakers
- Community input is formally necessary for attested dynamics of change[1]
- Young children learn sociolinguistic variables[2]
- Children attend to input from older children[3] who are not linguistically mature
- Multiple competing targets may be present in the input

Everybody receives input from multiple grammars

"Monolingual" "Multilingual"

Multi-idiolect multi-dialectal traditional multilingual

[1] Niyogi & Berwick 2009, [2] Labov 1989, Anderson 1990, [3] Manly 1930, Weinreich, Labov & Herzog 1968 p 145, Roberts and Labov 1995, Labov 2001 pg. 449, Nardy, Chevrot & Barbu 2014, Loukatou & Demuth 2021

Conceptualizing the Hand-Off

Solution to the Paradox of Language Change

- **Children are good at acquisition, but it's still hard!**
- **Learning targets are obscured by**
  Ambiguous surface constructions
  Variation of all kinds in the input
  Severe skew and sparsity in the input

→ **So even a "perfect" learner can initiate change**
"blame the environment"

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"blame the environment"

A thought experiment: "Sibling-Induced Change"

“Sibling-Induced Change”

Imagine two young children, Alice is slightly older than Bob

- Alice is currently producing innovative forms
- Bob is receiving both conservative adult input and Alice’s

How does this affect Bob?

“Sibling-Induced Change”

Can Bob identify Alice’s innovation?

- **Alice is mostly consistent with adults**
- **Bob may rarely if ever hear a conservative token corresponding Alice’s**
- **If Bob never hears a conservative token, he cannot know if Alice is innovating**

“Sibling-Induced Change”

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Will Bob adopt Alice’s innovation?

- In cases of severe sparsity, yes. What choice does he have?
- In other cases, even young children orient toward peers[1]

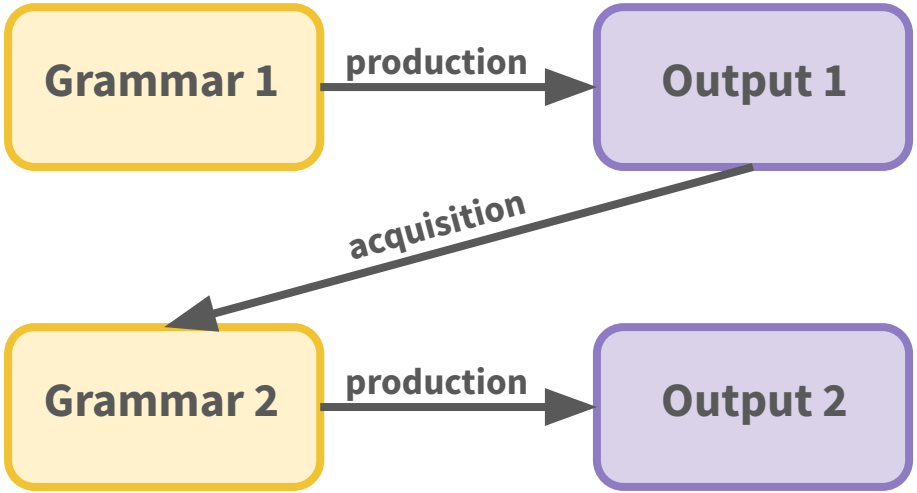
  → Bob may prefer Alice’s forms over his parents

  → He could learn both! (Competing grammars and sociolinguistic variation)

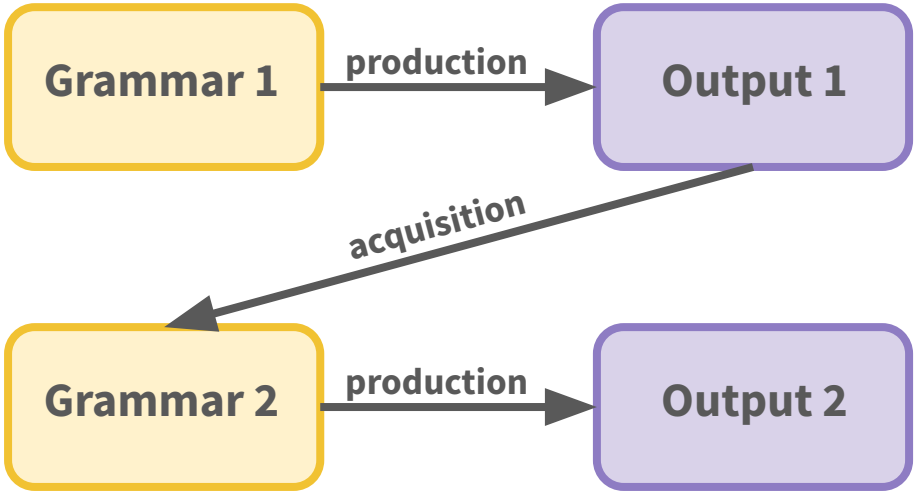
[1] t

Z-Model of Language Acquisition and Change

- Andersen 1973 originally conceived of this as a cycle of error-prone abductive and inductive learning
- Can be interpreted as alternating I-language and E-language
- Presents a role for competence and performance, or representation, learning, and social/diachronic factors

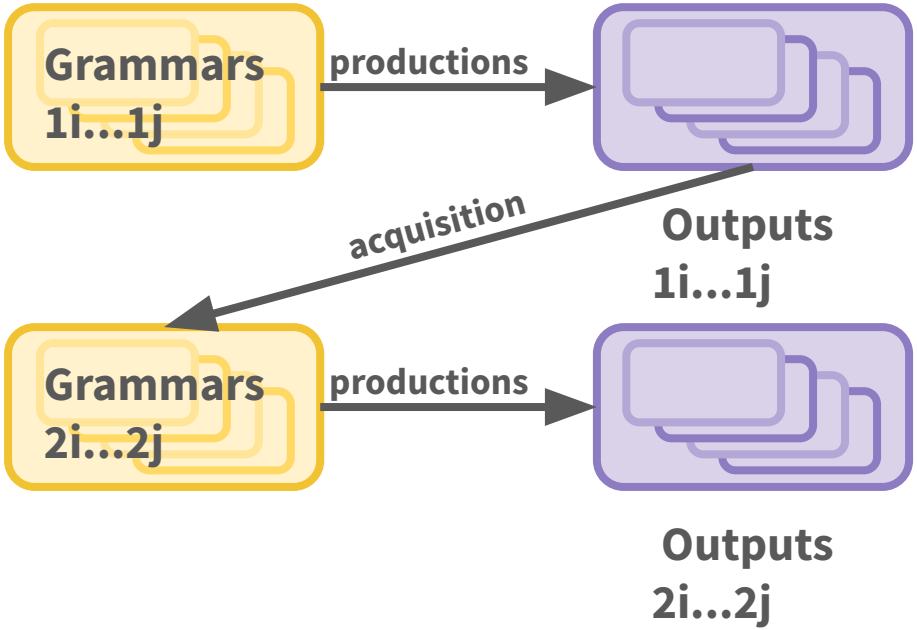


Insufficiency of the Z-Model



Insufficiency of the Z-Model

- **Individual production**
  - Variation across social settings
  - Variation over lifetimes



Insufficiency of the Z-Model

- **Individual production**
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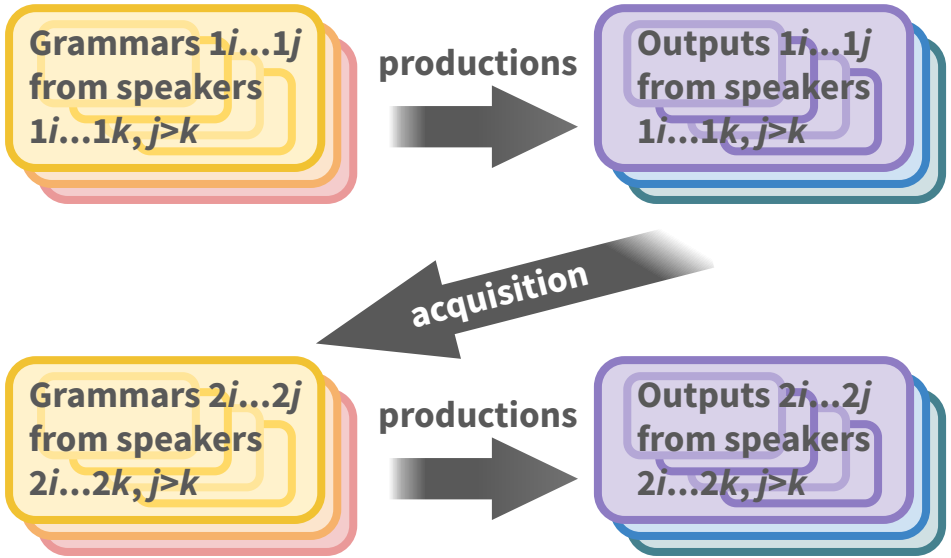
  - Variation over lifetimes
- **Community Embedding**
  - Variation across people
  - Everyone receives many inputs



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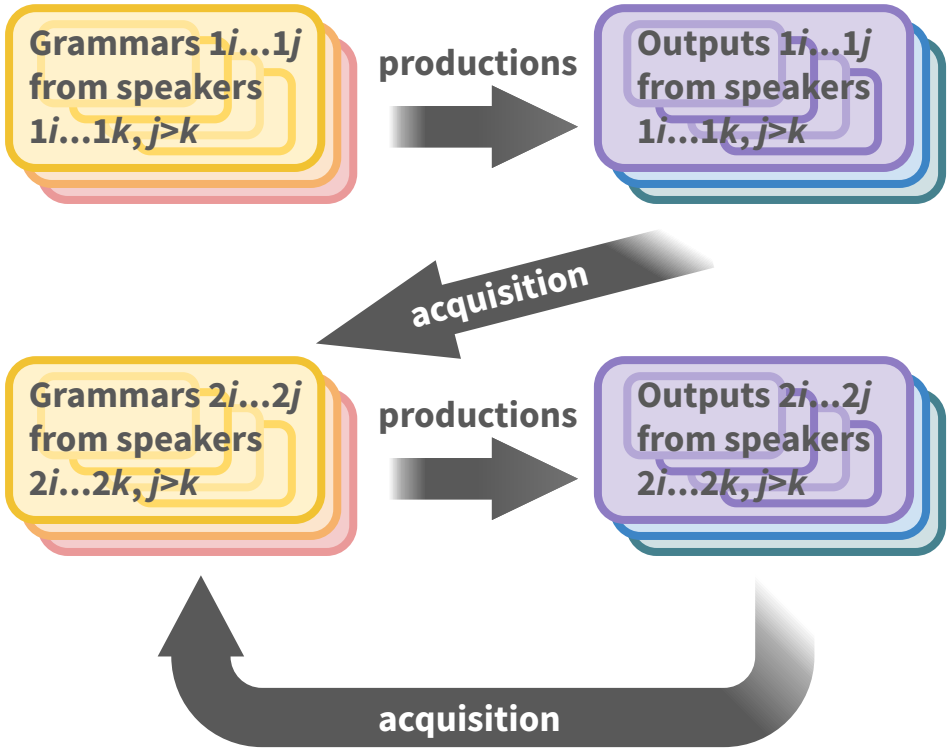

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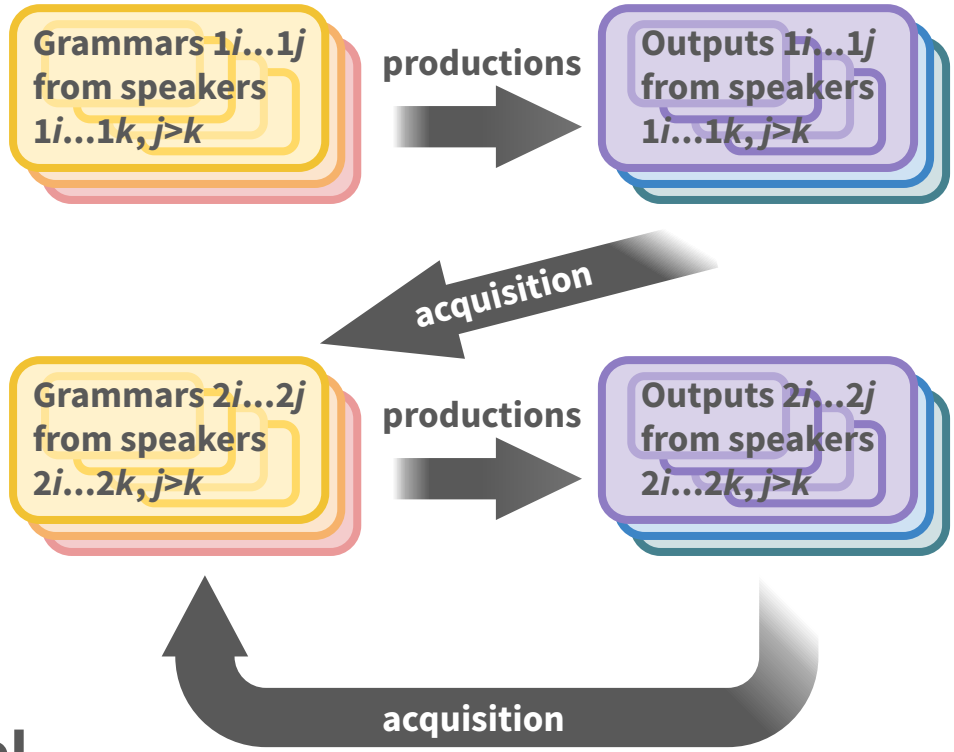

More of a

"Cyclic multi-multi-Z" model

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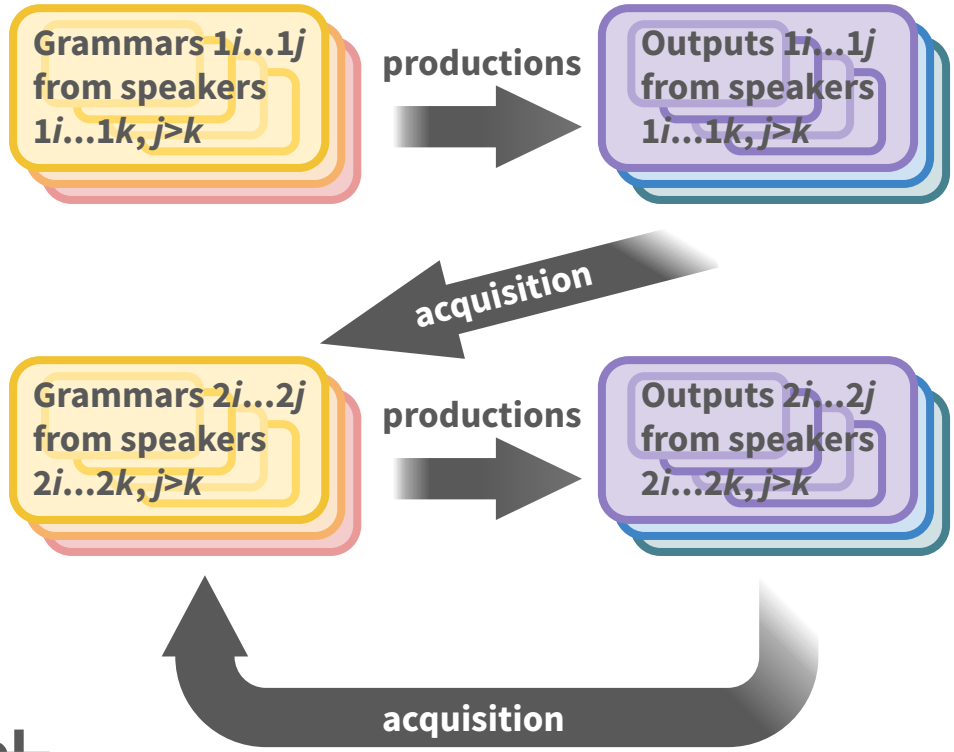


Sibling-Induced Change

~~"Cyclic multi-multi-Z" model~~

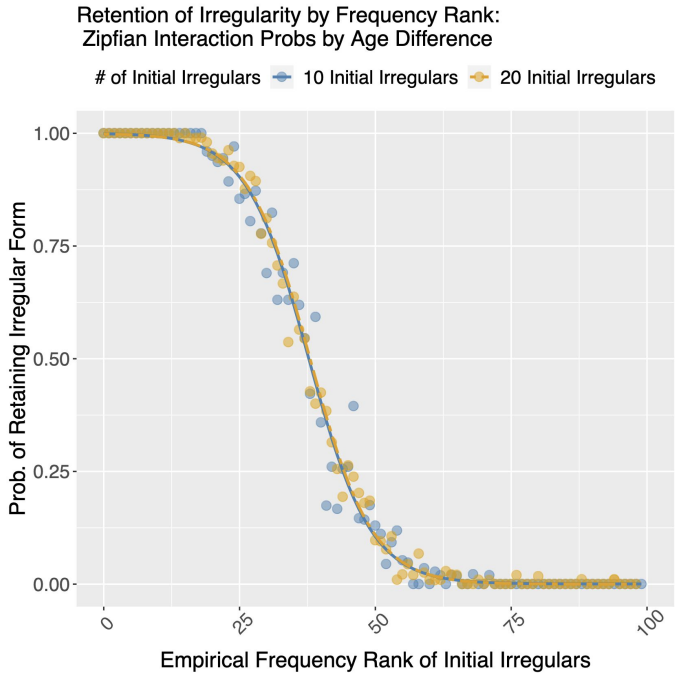
Additional Predictions

Relationship between learning trajectories and change

- **Innovations need to occur/be sustained late enough to be transmitted to peers**
  → Errors that occur early should not be transmitted, even if frequent
- **Late childhood innovations correspond to common trajectories of change**
  morphological overregularization, changes in modal semantics,
  certain innovations in argument structure, certain phonological rules…
- **Early childhood innovations do not correspond to common changes**
  Consonant harmony, dramatic phonotactic simplification + reduplication,
  instant total loss of inflection…

Proofs-of-Concept

1. **As a baseline for trade-offs in morphological paradigms[1]**
   - **It is sufficient on its own to reproduce**
     - Correlations between token frequency and irregularity
     - Correlations between paradigm size and irregularity
   - **A much richer model than iterated learning**
     - Includes a population ← change is population-level!
     - Does not privilege generational transmission
2. **Modeling semantic change in Chinese classifier systems[2]**



[1] Kodner, 2023, [2] Kali & Kodner, 2022

Language Acquisition and a Process-Centered View of Language Change

The End

Thank you!