Productivity & Paradigmatic Gaps

Charles Yang, Kyle Gorman, Jennifer Preys & Margaret Borowczyk
University of Pennsylvania

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stride-strode-*strode/???stridden

	BNC	COCA		BNC	COCA
ride	1607	10904	stride	102	402
rides	230	2495	strides	54	682
riding	1696	10994	striding	253	715
rode	1079	5997	strode	641	1752
*rided	1	0	*strided	0	2
ridden	456	1303	*stridden	1	2

p= 1.6e-37 ***p***=1.5e-295

From COCA (1990-2005) (1)... while Angela has stridden into the country
(2) ... And he'd shattered the screen of his monitor with one kick of his oaken legs, hauled open the steel door normally used only by Ted, and stridden into the Grim Reaper personally

you say “stridden”? more later!

When language fails

- Halle (1973): Some 75+ Russian verbs, all in the 2nd conjugation, do not have a first person singular non-past form
  - *lažu ‘I climb’
  - *pobežu/*pobeždu ‘I conquer’
  - *deržu ‘I talk rudely’
  - *mužu ‘I stir up’
  - *erunžu ‘I behave foolishly’

+: Sims (2006, OSU Dissertation)

How language succeeds

- Sapir (1928: 37-38) “the fact of grammar, a universal trait of language, ... a generalized expressions of the feelings that analogous concepts and relations are most conveniently symbolized in analogous form ... All grammars leak”
- Chomsky & Halle (1968: 172) “Clearly, we must design our linguistic theory in such a way that the existence of exceptions does not prevent the systematic formulation of those regularities that remain.”
- Language is **productive** but not in an obvious way
  - English words are overwhelmingly stress initial (86-90% token, 80% type in CHILDES input; Legate & Yang 2012) but English does **not** have a QI metrical system

Outline

- A model of learning productive processes (Yang 2002, 2005, 2010)
- Failure to reach productivity leads to gaps (Halle 1973, esp. fn 1)
    - Five case studies: English past tense, **amn't**, Spanish, Polish and Russian

Productivity is Categorical

- Only **one** out of 86 children produced *bing-bang*, *gling-glang* (Berko 1958)
- Over-regularization (holded): **8-10%**
- Over-irregularization (brang): **<0.2%**
  - Xu & Pinker (1995): many are t/d deletion.
- Strongly confirmed cross-linguistically (Guasti 2002)
- Rating studies (e.g., Albright & Hayes 2002) can be misleading (Gleitman et al. 1983)
  - But -ed forms of pseudo-irregulars are consistently rated better (Pinker & Prasada 1991)
  - Schütze (2005), Yang (2008)

Tolerating Exceptions

- The child has learned only two words: sing-sang, & ring-rang
  - /i→a/
  - Exceptions accumulate as vocabulary grows
    - bring, sting, swing, wing, etc., and the rule /i→a/ stops working so well (cf., “add -d” fails on only about 150 words)
- How many exceptions are “too many”?
  - not statistical summary of the data (Albright & Hayes 2002, Baayen 1993, etc.)

Theory ⟹ Processing ⟹ Learning

- Exception 1
- Exception 2
- Exception 3
- ...
- Rule

- Exceptions exhibit frequency effects: this can be formalized as a ranked-list (Forster 1976, Murray & Forster 2004)
- Crucially, rule-following items would have to wait to be processed after the exceptions are checked
- You **should** be skeptical!

Measuring Rules

- Exceptions are faster than Rules (when suitably matched in frequencies)
- Grammaticality judgment on the fly: “kicked the bucket” faster than “lifted the bucket” by **51ms** (Swinney & Cutler 1979)
- Production latency: German irregular past participle (-n) faster than regular (-t) by **38ms** (Clahsen & Fleischhauer 2011): stem and surface frequencies matched
- This leads to an evaluation metric in the sense of SPE

Price of Exceptions

- Exception *1*
- Exception *2*
- Exception *3*
- ...
- Exception *e*
- Rule (***N-e***)

<

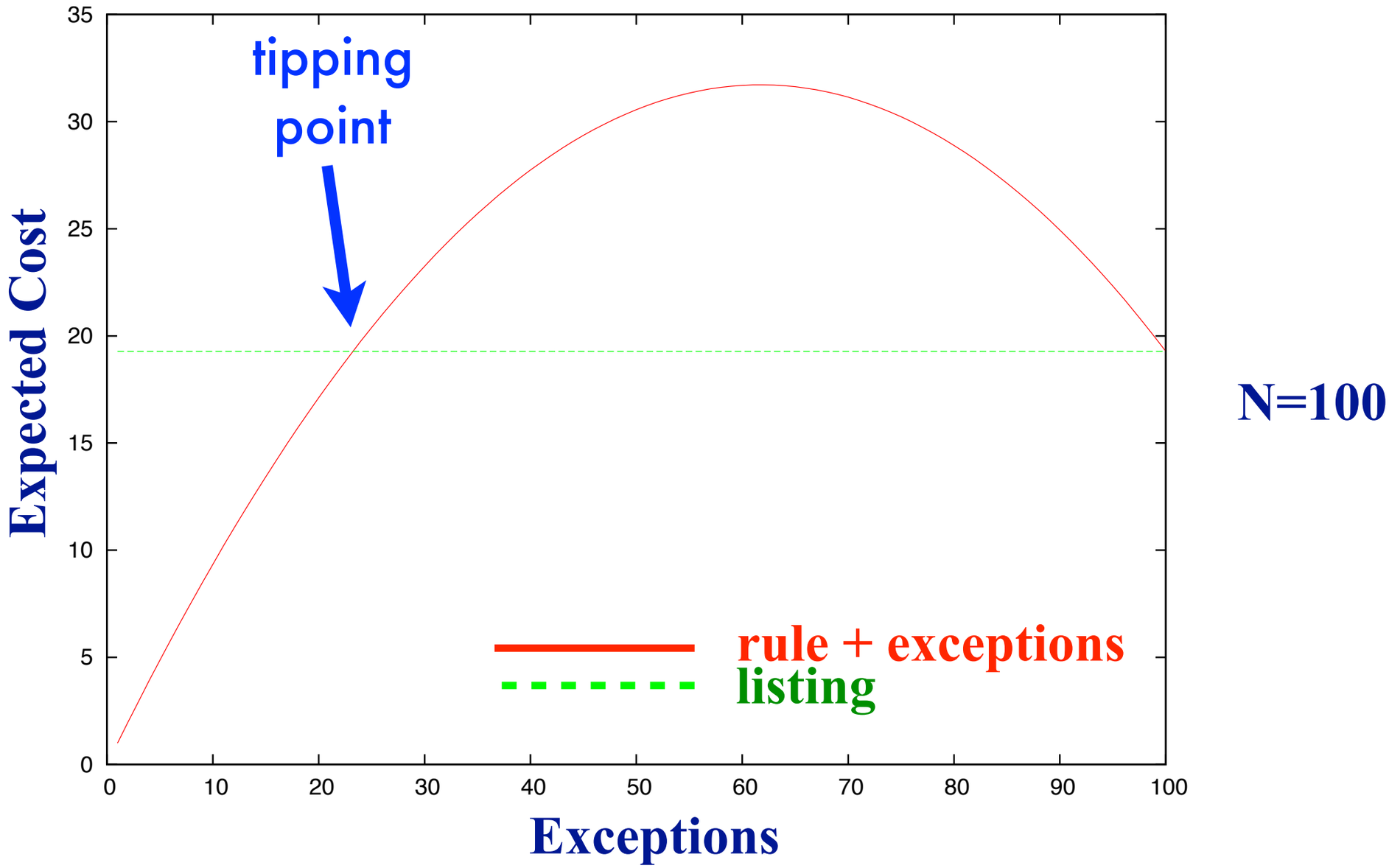
- Exception *1*
- Exception *2*
- Exception *3*
- ...
- ...
- Exception ***N***

$$p_e T[\text{listing } e] + (1 - p_e)e \quad < \quad T[\text{listing } N]$$

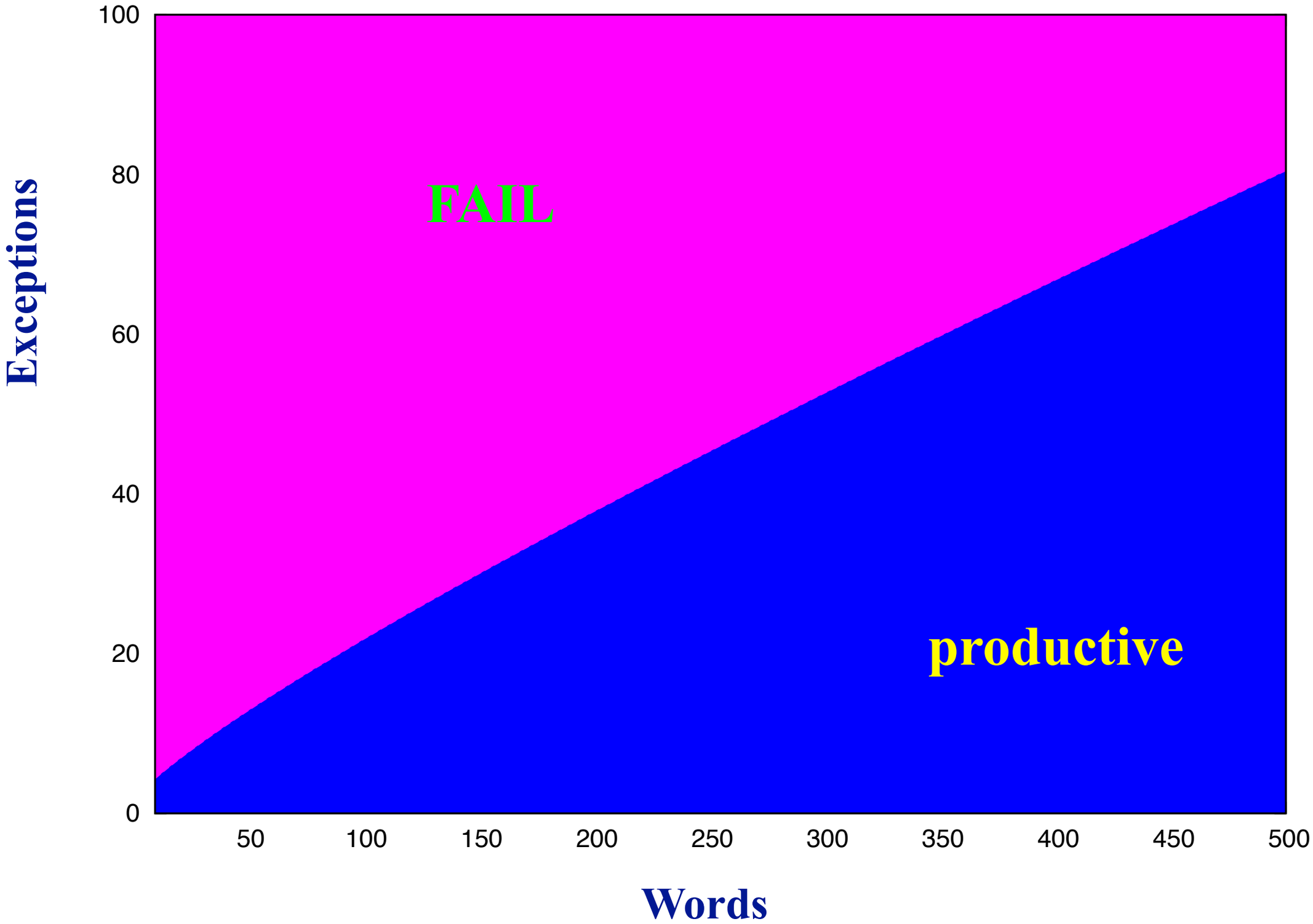
Tipping Point

- Assume word frequencies follow Zipf's law (they **really** do)
- Maximum # of exceptions

$$e \approx \frac{N}{\ln N}$$



Filibuster Proof



Tipping Points

N	e
10	4
20	7
50	13
100	22
200	38
500	80
1000	144
2000	263
5000	587
10000	1086

- Productive rules can tolerate few exceptions (sub-linear)
  - "-ed" rule is safe (M=120, N=800, 800/ln800≈120)
- Makes predictions about morphological and syntactic productivity (**room for individual variation**)
- Makes predictions about productivity of rules on purely numerical basis
- See our other papers for details for predictions among morphological productivity, phonological and syntactic acquisition and language change

Five Case Studies of Gaps

- Most accounts of paradigmatic gaps
  - multiple forms so the speaker is at a loss, or some forms are generated but “dispreferred”
  - Halle (1973) and Baronian (2005): the gapped forms are not generated (e.g., [-lexical insertion]), but no concrete proposal on why and where gaps occur

Gaps = Below Tipping Point

- Alternations constitute exceptions for each other
  - U-shape curve in past tense acquisition
    - Irregulars are initially accurate: the “dip” is caused by the emergence of “-ed” as a productive rule
    - Initial verbs are mostly irregulars: the child needs to accumulate enough regulars to know “-ed” is productive
- If there are too many exceptions, everyone is a loser

Case I: stride

- **150** irregular verbs in English
- A great majority shows preterite~past participle syncretism (“brought”, “kept”, “lost”): **102**
- But that’s not enough to be extendable: **48** exceptions vs. **30** (150/ ln 150)
- You must hear it in the input, and if no one says anything, you’ll be at a loss too!
- Ditto for *forwent, *sightsaw, ...

stride-stridden sub-regularity?

- irregular verbs containing /aI/ and coda does not contain a nasal (e.g., **find**, **shine**) tend to have /ɪ ... ən/ in past participle
- **abide, arise, bite, ?chide, dive, drive, fight, hide, light, ride, override, rise, slide, strike, strive, ?thrive, write**
- **17** words can tolerate **6** exceptions
- /aI/→/ɪ ... ən/ for past participle may be on the cusp of productivity but it's clearly not for everyone

Case II: amn't (23/ln23 = 7)

a.	do	[du]	don't	[dont]
b.	does	[dʌz]	doesn't	[dʌzn̩t]
c.	did	[dɪd]	didn't	[dɪdn̩t]
d.	have	[hæv]	haven't	[hævn̩t]
e.	has	[hæz]	hasn't	[hæzn̩t]
f.	had	[hæd]	hadn't	[hædn̩t]
g.	can	[kæn]	cannot can't	[kænat] [kænt]
h.	could	[kʊd]	couldn't	[kʊdn̩t]
i.	may	[me]	——	——
j.	might	[mait]	mightn't	[maitn̩t]
k.	shall	[šæl]	shan't	[šænt]
l.	should	[šʊd]	shouldn't	[šʊdn̩t]
m.	will	[wɪl]	won't	[wont]
n.	would	[wʊd]	wouldn't	[wʊdn̩t]
o.	dare	[der]	daren't	[dernt]
p.	must	[mʌst]	mustn't	[mʌsn̩t]
q.	need	[nid]	needn't	[nidn̩t]
r.	ought	[ɔt]	oughtn't	[ɔtn̩t]
s.	am	[æm]	——	——
t.	are	[ar]	aren't	[arnt]
u.	is	[ɪz]	isn't	[ɪzn̩t]
v.	was	[wʌz]	wasn't	[wʌzn̩t]
w.	were	[wr̩]	weren't	[wr̩nt]

Zwicky & Pullum (1983)

Case III: Spanish

- In some Spanish verbs, an unstressed *e* or *o* in the final root syllable becomes *ie* [je] and *ue* [we] under primary stress: diphthongization (Harris 1969)

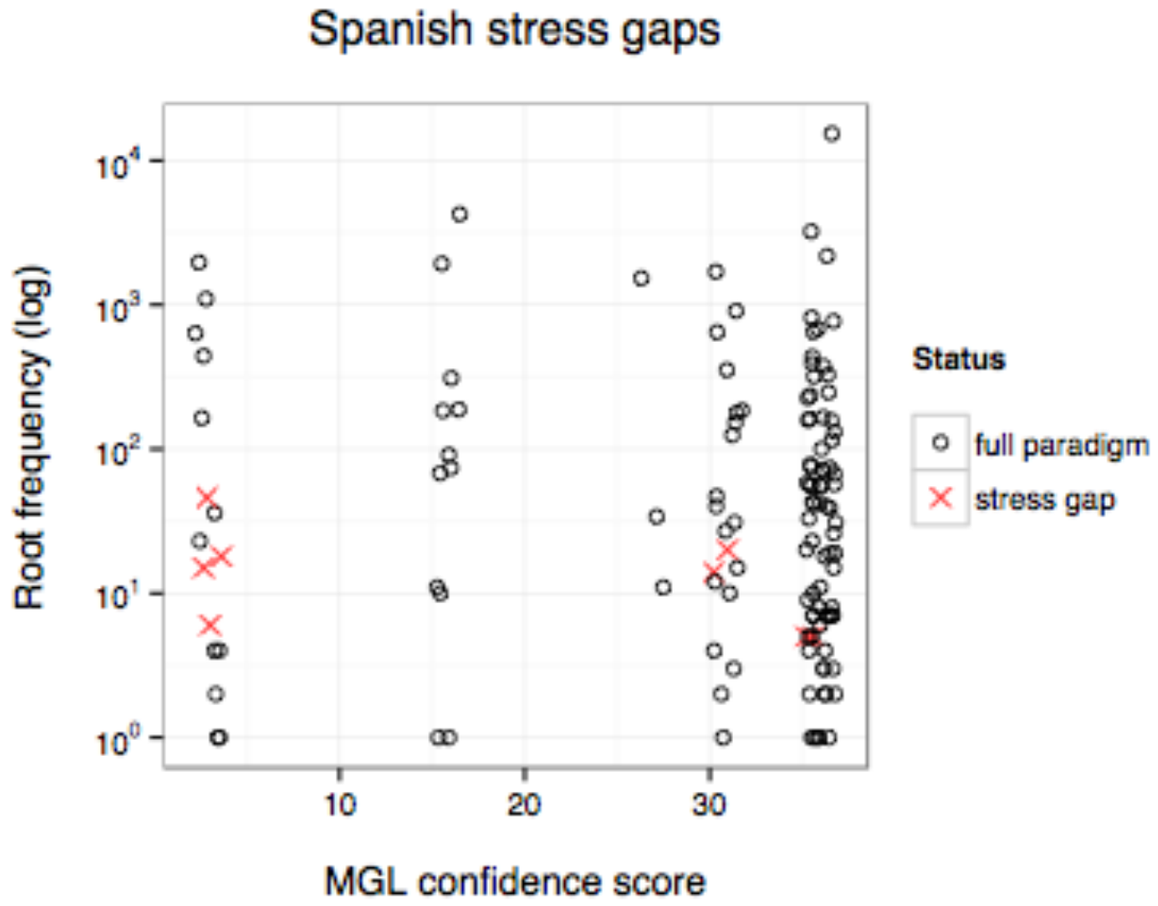
conjugatio	no change	e-ie, o-ue	**N**	threshold
first (-ar)	**1050**	125	1175	166 (***yes***)
second (-	**189**	29	218	42 (***yes***)
third (-ir)	**19**	**33**	52	13 (***no***)

- No change is the default in 1st and 2nd, and that's how children over-regularize (Clahsen et al. 2002, Mayol 2007)

- Third conjugation has no default and that's where gaps are found (e.g., abolir-*abolo/*abuelo 'abolish', colorir-*coloro/*coluero 'colorize'; Real Academia Española 1992)

A Comparison

- Albright (2003): an inductive generalization model (Albright & Hayes 2002, see also Chomsky 1955, Mitchell 1982)
- Claims correlation both model confidence and speaker judgment
- Tested on 3rd conjugation roots
- Confidence does not correlate with gaps or attested forms



Case IV: Polish

- Polish **singular** masculine genitives take either -*a* or -*u* as suffix but neither seems to be the default based on a suite of tests.
  - **Plurals** take -*ow* as the default, with exceptional -*i/y* suffix
- Posed as a challenge to the dual route model of morphology in favor of all storage/usage via token frequency (Dabrowska 2001)
- Analysis of child-directed Polish in CHILDES

suffix	type freq.	productive?	ave. token freq.	error %
-a (sg.)	**837**	**no**	7.17	1.28%
-u (sg.)	**516**	**no**	8.8	0.24%
-ow (pl.)	**551**	**yes**	6.5	0.41%
-i/y (pl.)	**61**	**no**	11.4	**15.53%**

predict gaps and default, and rejects the pure frequency account

Case V: Russian

- Root final *t* of many verbs in Russian 2nd conjugation is realized as č in the 1sg. non-past
  - but many instead mutate to šj (smutit'-smušju/'confuse') or have a gap (očutit'sja- *očučus'/*očušjus' 'find oneself')
- Counting Russian National Corpus words (> 1 per million)
- 59 verbs of this type, 19 following the minority pattern
  - 19 > 59/ln 59 = 14

Summary

- Gaps arise when productivity fails (Halle 1973), and productivity fails when **e**>**N**/ln **N**
- More general, a predictive model of productivity can keep exceptions at bay: the core grammar is not threatened, and evaluation metrics still have shelf life.