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Finding Universal Grammar in Initial Syllables*

- Phonological alternations (e.g. *naɪf* ∼ *naɪvz*) are particularly costly in prominent positions (root, onset, stressed syllable, initial syllable).
- In well-behaved languages, like Turkish, stem-final alternations are rare in monosyllables. But English goes the other way, with more alternations in monosyllables.
- We show that the English situation is a historical accident: Speakers do not extend the generalization to novel items, and behave like Turkish speakers with novel alternations.
- Our experimental methods reveal a purely positional bias that is not coming from the ambient language. It's a Universal bias that is independent from the phonetic basis, and can work directly against it.

1 If Universal Grammar exists, where can we find it?

UG-skepticism is gaining traction, for partially good reasons:

(1) The old "poverty of the stimulus" arguments were oversold. The stimulus is noisy, but very rich, so it's getting harder to believe that crucial information is missing from it.

(2) Knowledge of articulation and acoustics could come from the environment, so the phonetic basis of phonology is not necessarily innate.

(3) The ability to find patterns and manipulate data is not unique to language, so it's conceivable that linguistic units are manipulated by general-purpose cognitive mechanisms.

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There are good answers for most of these objections, the best defense is offense:

(4) Incorporate quantitative methods into our work, making it account for more of the evidence than UG-less work.

(5) Improve the poverty-of-the-stimulus argument, especially experimentally.

(6) Show that the phonology-lexicon interface is organized by purely formal elements of the grammar, beyond the phonetic basis.

In other words, make the evidence weigh in favor of UG (though likely a smaller UG than Chomsky imagined).

2 What is initial syllable faithfulness?

From Beckman (1997, 1998):

(7) In Shona, [i] contrasts with [e] only in the initial syllable.

/sek+irir/	Ident(high)-σ1	Agree(high)	Ident(high)
a. se.ki.rir		*!	
b. si.ki.rir	*!		*
c. ☞ se.ke.rer			**

(8) In Tamil, codas keep their place of articulation only in the initial syllable.

/tunbã/	Ident(place)-σ1	Agree(place)	Ident(place)
a. ☞ tun.bã		*	
b. tum.bã	*!		*

/pasən+gə/	Ident(place)-σ1	Agree(place)	Ident(place)
a. pa.sən.gə		*!	
b. ☞ pa.səŋ.gə			*

Similarly in many other languages (see Casali 1998; Becker et al. 2011; Jesney 2009).

3 Good languages protect initial syllables

3.1 Turkish (Becker, Ketrez & Nevins 2011)

In Turkish, voicing alternations affect stops (p, t, ʧ, k) in some short words,

(9) tatʃ ∼ tadʒ-i 'crown NOM/POSS'
satʃ ∼ satʃ-i 'hair NOM/POSS'

and some long words:

(10) amatʃ ∼ amadʒ-i 'goal NOM/POSS'
anatʃ ∼ anatʃ-i 'cub NOM/POSS'

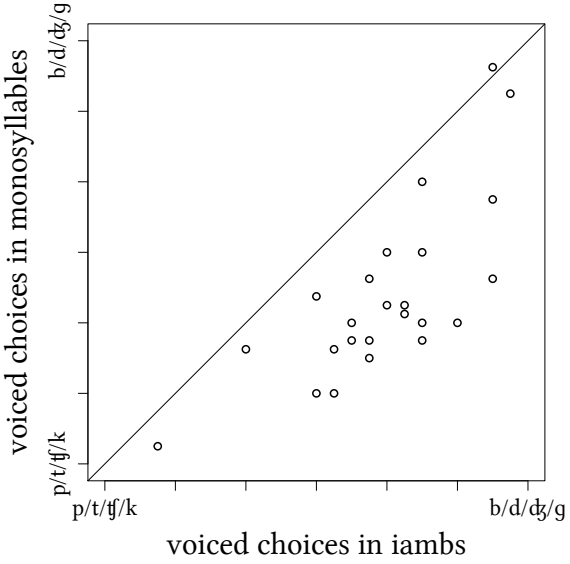
Long words are more likely to alternate (Lees 1961; Inkelas & Orgun 1995; Inkelas et al. 1997; Hayes 1995; Pycha et al. 2007). Data from Inkelas et al. (2000):

(11)

syllables	n	% voiced
σ	238	19%
σσ	454	64%
longer	806	49%

We asked 24 Turkish speakers to choose a possessive form for 72 nouns that we created, e.g. *tup*, *gujup* ("wug test", Berko 1958).

(12) Almost everybody (23/24) liked voiced possessives in polysyllables more than in monosyllables:



Conclusion: Turkish speakers prefer alternations in polysyllables, and extend this preference to novel words.

3.2 What's the best predictor of alternations?

We know that long words alternate more in Turkish, but what is the best way to characterize "long" and "short"?

(13) Various predictors of voicing alternations:

- Monosyllabicity (=protection by initial syllable faithfulness)
- Length in syllables, length in segments, raw phonetic length, etc.
- Neighborhood density, token frequency, other lexicon-based numbers (argued to matter in Ussishkin & Wedel to appear; Johnsen to appear)

(14) Monosyllabicity vs. length in segments

	χ^2	d.f.	*p*
monosyll	140.13	1	<.0001
r.segments	30.33	1	<.0001
Total	169.07	2	<.0001

	χ^2	d.f.	*p*
segments	5.63	1	0.0177
r.monosyll	169.00	1	<.0001
Total	169.07	2	<.0001

(15) Monosyllabicity vs. neighborhood density

	χ^2	d.f.	*p*
monosyll	147.74	1	<.0001
r.neighbors	32.20	1	<.0001
Total	163.16	2	<.0001

	χ^2	d.f.	*p*
neighbors	8.41	1	.0037
r.monosyll	157.82	1	<.0001
Total	163.16	2	<.0001

(16) Monosyllabicity vs. log token frequency

	χ^2	d.f.	*p*
monosyll	108.49	1	<.0001
r.frequency	10.16	1	0.0014
Total	115.38	2	<.0001

	χ^2	d.f.	*p*
frequency	1.79	1	0.1807
r. monosyll	113.84	1	<.0001
Total	115.38	2	<.0001

In Turkish, monosyllabicity is by far the best predictor of alternation.

3.3 Brazilian Portuguese

In Brazilian Portuguese, word-final [w] changes to [j] (Gomes & Manoel 2010) in some short words,

(17) sa**w** ∼ sa**js** ‘salt SG/PL’
pa**w** ∼ pa**ws** ‘stick SG/PL’

and in some long words:

(18) de'da**w** ∼ de'da**js** ‘thimble SG/PL’
ka'ka**w** ∼ ka'ka**ws** ‘cocoa SG/PL’

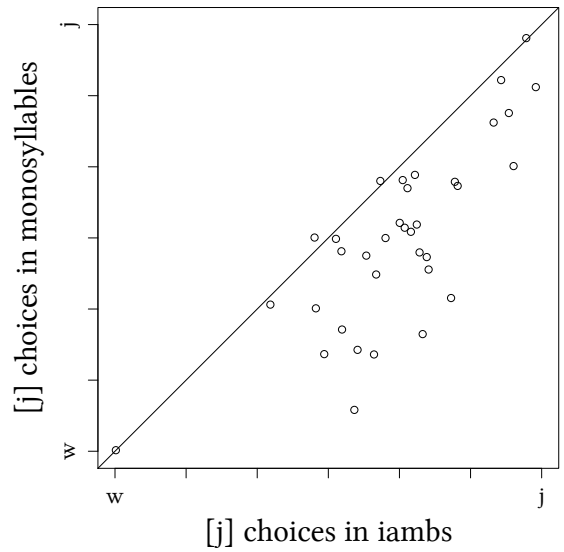
Real [w]-final words:

(19)

syllables	n	%[w]→[j]
σ	23	15%
σσ	87	83%
longer	107	94%

We gave 35 speakers of Brazilian Portuguese 63 [w]-final made-up words (e.g. *'daw*, *ma'haw*, *'ʃantaw*), and asked them to choose between a faithful [w] plural and an unfaithful [j] plural.

(20) Almost everybody (31/35) liked [j]-plurals in iambs more than monos:



Conclusion: Brazilian Portuguese speakers prefer alternations in polysyllables, and extend this preference to novel words.

4 Generalizing using initial syllable faithfulness

The goal: Get trends that are created by existing lexical items into the grammar, so they can be projected onto novel items.

4.1 Making lexical trends available to the grammar

The secret is "inside-out derivations" (Hayes 1995, 1999; Becker 2009; Becker et al. 2011), or outside OT, the "single surface base hypothesis" (Albright 2002, 2008).

Turkish:

(21) The UR of *satʃ* ∼ *satʃ-ɨ* 'hair' is /satʃ/
The UR of *tatʃ* ∼ *tadʒ-ɨ* 'crown' is /tatʃ/

(22) Some items require Ident(voice) ≫ *VTV, and some *VTV ≫ Ident(voice)

Brazilian Portuguese:

(23) The UR of *paw* ∼ *paw-s* 'stick' is /paw/
The UR of *saw* ∼ *saj-s* 'salt' is /saw/

(24) Some items require Ident(back) ≫ Max(float), others Max(float) ≫ Ident(back)

4.2 Projecting from the grammar to novel items

(25) Inconsistent behavior in known items forces the learner to adopt lexically-specific rankings

/amatʃ + ɨ/	Ident(voice)-σ1	*VTV	Ident(voice)
a. amatʃɨ		*!	
b. ☞ amadʒɨ			*

/anatʃ + ɨ/	Ident(voice)-σ1	Ident(voice)	*VTV
a. ☞ anatʃɨ			*
b. anadʒɨ		*!	

(26) Cloning (Pater 2006, 2009; Coetzee 2008; Becker 2009) allows the learner to maintain a single grammar:

IDENT(voice)-σ1≫ IDENT(voice)$_{anatʃ}$ ≫ *VTV ≫ IDENT(voice)$_{amatʃ}$

(27) Monosyllables respond to IDENT(voice)-σ1

/tatʃ + ɨ/	*VTV	IDENT(voice)-σ1	IDENT(voice)
a. tatʃɨ	*!		
b. ☞ tadʒɨ		*	*

/satʃ + ɨ/	IDENT(voice)-σ1	*VTV	IDENT(voice)
a. ☞ satʃɨ		*	
b. sadʒɨ	*!		*

The grammar:

(28) IDENT(voice)-σ1$_{satʃ}$ ≫ IDENT(voice)$_{anatʃ}$ ≫ *VTV ≫ IDENT(voice)$_{amatʃ}$, IDENT(voice)-σ1$_{tatʃ}$

As more lexical items are learned, the grammar gets updated:

(29) IDENT(voice)-σ1$_{160\ items}$ ≫ IDENT(voice)$_{120\ items}$ ≫ *VTV ≫ IDENT(voice)$_{280\ items}$, IDENT(voice)-σ1$_{40\ items}$

Popular clones have more influence on novel words:

(30) IDENT(voice)-σ1$_{80\%}$ ≫ IDENT(voice)$_{30\%}$ ≫ *VTV ≫ IDENT(voice)$_{70\%}$, IDENT(voice)-σ1$_{20\%}$

The view of the grammar from a polysyllable's point of view:

(31) ~~IDENT(voice)-σ1$_{80\%}$~~ ≫ IDENT(voice)$_{30\%}$ ≫ *VTV ≫ IDENT(voice)$_{70\%}$, ~~IDENT(voice)-σ1$_{20\%}$~~

Novel monosyllables get protection from two faithfulness constraints: IDENT(voice) and IDENT(voice)-σ1. Novel polysyllables get protection only from IDENT(voice), so their probability of coming out faithful is lower.

5 English: A bad language?

5.1 The lexicon: more alternations in monosyllables

Final [f/θ] alternate with the voiced [v/ð] in some nouns, but not others (Jespersen 1909; Berko 1958; Hayes 2009):

(32) [naɪ**f**] ∼ [naɪ**v**z] ‘knife’
[pæθ] ∼ [pæ**ð**z] ‘path’

(33) [ʃɛɹɪ**f**] ∼ [ʃɛɹɪ**f**s], *[ʃɛɹɪvz] ‘sheriff’
[mæmɪθ] ∼ [mæmɪθs], *[mæmɪðz] ‘mammoth’

What determines whether a noun alternates or not?

(34) Not (just) spelling:

- Spelling doesn’t help at all with [θ].
- <roofs> is about 100 times more common than <rooves> in Google, but [rʊvz / ruvz] is very common.
- [ʤəˈɹævz] is spelled with <ff>, which is not expected to alternate.

(35) Not (just) history, since the patterns changed quite a bit in recent history:

- Post-[r] voicing is new: [dwoɹf] ‘dwarf’, [woɹf] ‘wharf’, [skɑɹf] ‘scarf’.
- Loss of most vowel alternations: [stæf] ∼ *[steɪvz] ‘staff’
- Alternations lost for many speakers (completely or in some contexts).

So what does determine whether a noun alternates or not?

(36) Morpho-syntactic context:

- No alternation in the genitive: knife’s, path’s, roof’s, dwarf’s, etc.
- Compounds: [buðz] ‘booths’ vs. [tol-buθs] ‘toll-booths’
- Plurals vs. denominal verbs: Plurals voicier in some items (knives/to knife), verbs in others (beliefs/to believe), or same (halves/to halve).

(37) Segmental context:

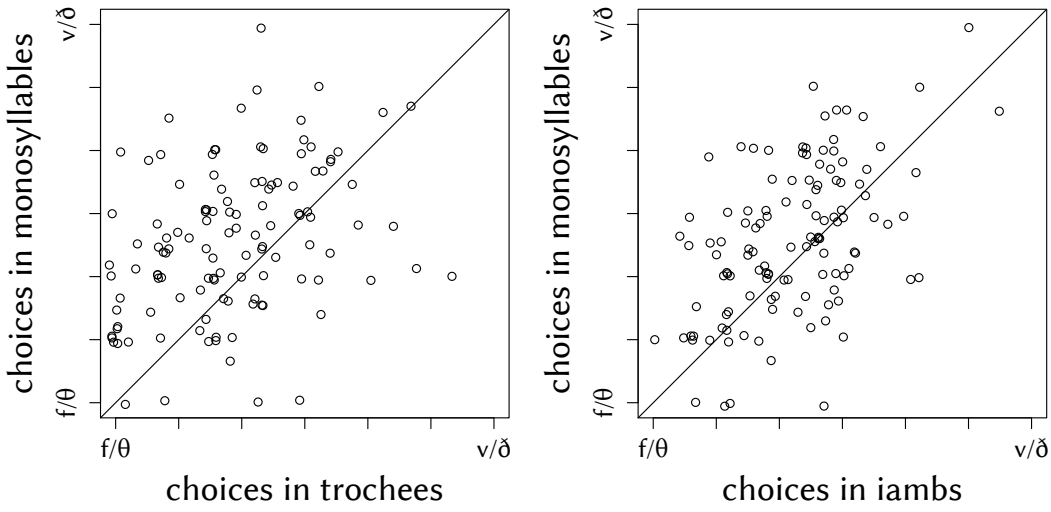
- Long vowels are voicier than short vowels (leaves vs. cliffs).
- Complex codas are voicier than simple codas (shelves vs. chefs).

(38) **Prosodic shape (length and stress)**

- Monosyllables are voiciest: [ˈnaɪvz], [ˈpæðz]
- Iambs less voicy: [ʤəˈɹævz] ‘giraffe’, [vɚˈmuðz] ‘vermouth’
- Trochees least voicy: *[ˈʃɛɹɪvz], *[ˈmæmɪðz]

We asked 120 English-speaking Mechanical Turkers to rate plural forms for 126 real nouns.

(39) Almost everybody liked voiced plurals in monosyllables better than in trochees (89/120) and in iambs (81/120).



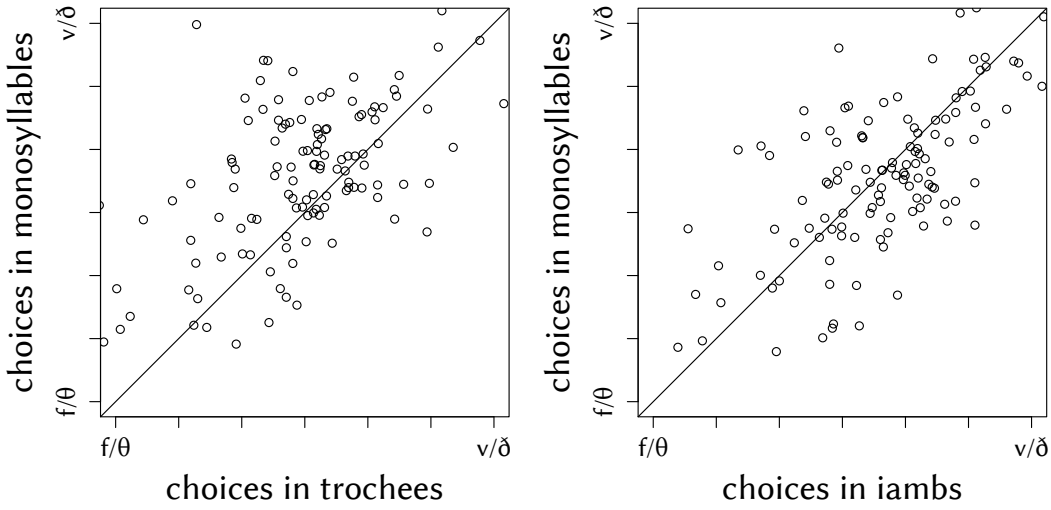
(40) Stress effect: less alternations in unstressed vowels.

(41) Anti-initial syllable effect: less alternations in non-initial syllables.

5.2 Novel words: No preference for monosyllables over iambs

We gave 120 English-speaking Mechanical Turkers 132 f/θ-final made-up nouns: Monosyllables (*ˈsmaf*, *ˈwaθ*), iambs (*gliˈnaf*, *ʤɪˈzaθ*), and trochees (*ˈtakɪf*, *ˈhakɪθ*).

(42) Almost everybody liked voiced plurals in monosyllables better than in trochees (91/120), but the vote is split on iambs vs. monos (59/100).



(43) Stress effect is projected from the lexicon; anti-initial syllable effect isn't.

(44) "Surfeit of the stimulus" (Becker et al. 2011): The speakers are given ample evidence in the lexicon, yet fail to form a generalization.

(45) No anti-initial syllable effect even with twice the items and 3–4 times the participants as Turkish and Brazilian Portuguese.

(46) Similar preliminary results with Russian voicing alternations.

5.3 UG doesn't allow accurate projection from the lexicon

(47) Monosyllables rely on the ranking of IDENT(voi)-σ1

/naɪf + z/	IDENT(voice)$_{aff}$	IDENT(voice)-σ1	IDENT(voice)
a. ☞ naɪvz		*	*
b. naɪfs	*!		

/stæf + z/	IDENT(voice)-σ1	IDENT(voice)$_{aff}$	IDENT(voice)
a. stævz	*!		*
b. ☞ stæfs		*	

(48) Polysyllables aren't affected by IDENT(voice)-σ1:

/ʤəɹæf + z/	IDENT(voice)-σ1	IDENT(voice)$_{aff}$	IDENT(voice)
a. ☞ ʤəɹævz			*
b. ʤəɹæfs		*!	

/bəlif + z/	IDENT(voice)-σ1	IDENT(voice)	IDENT(voice)$_{aff}$
a. bəlivz		*!	
b. ☞ bəlifs			*

The grammar:

(49) IDENT(voice)-σ1$_{stæf}$ ≫ IDENT(voice)$_{bəlif}$ ≫ IDENT(voice)$_{aff}$ ≫ IDENT(voice)$_{ʤəɹæf}$, IDENT(voice)-σ1$_{naɪf}$

A fuller lexicon:

(50) IDENT(voice)-σ1$_{30\ items}$ ≫ IDENT(voice)$_{90\ items}$ ≫ IDENT(voice)$_{aff}$ ≫ IDENT(voice)$_{10\ items}$, IDENT(voice)-σ1$_{70\ items}$

But now the odds are stacked against the monosyllables:

(51) IDENT(voice)-σ1$_{30\%}$ ≫ IDENT(voice)$_{90\%}$ ≫ IDENT(voice)$_{aff}$ ≫ IDENT(voice)$_{10\%}$, IDENT(voice)-σ1$_{70\%}$

Individual items can be learned, but the generalization cannot be projected.

Possible grammars: Monosyllables are protected more than polysyllables; Monosyllables and polysyllables are equally protected.
Impossible grammar: *Polysyllable are protected more than monosyllables.

5.4 Artificial voicing: More alternations in polysyllables

English speakers regulate voicing alternations in the plural on [f] and [θ].
We asked 80 Mechanical Turkers to voice [p, t, k] with the plural suffix [ni] and see what happens.

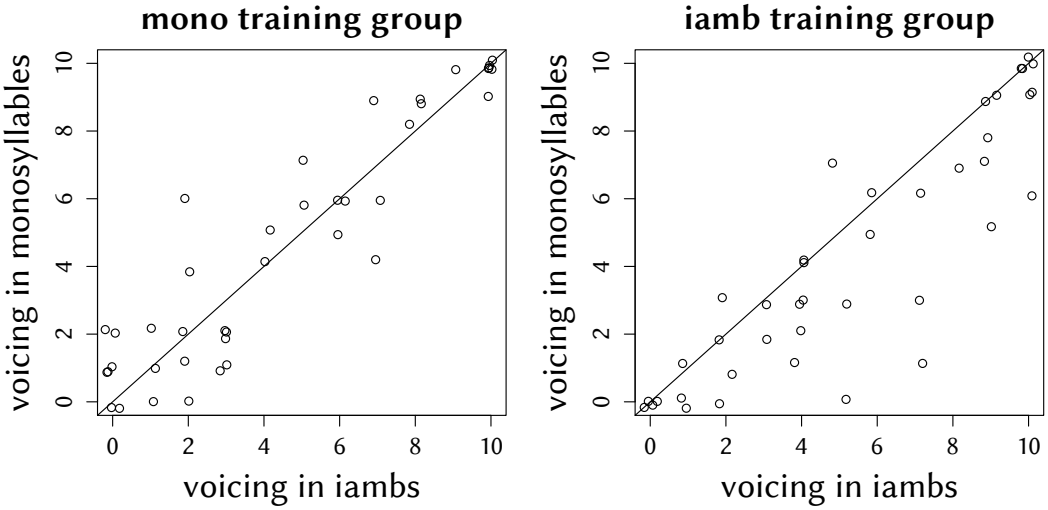
(52) Artificial grammar setup (à la Wilson 2006)

	the "mono training" group		the "iamb training" group	
Training	*10 stop-final monos*		*10 stop-final iambs*	
	mip	mibni	təgep	təgebni
	stut	studni	gəʃut	gəʃudni
	prok	progni	ləʃok	ləʃogni
	5 sonorant-finals		*5 sonorant-finals*	
	muŋ	muŋni	muŋ	muŋni
	nədʒol	nədʒolni	nədʒol	nədʒolni
Testing	*10 stop-final monos*		*10 stop-final iambs*	
	gaɪp	_____	fətʃop	_____
	klet	_____	bəgit	_____
	dok	_____	ʧəpak	_____
	10 stop-final iambs		*10 stop-final monos*	
	fətʃop	_____	gaɪp	_____
	bəgit	_____	klet	_____
	ʧəpak	_____	dok	_____
	10 sonorant-finals		*10 sonorant-finals*	
	pler	_____	pler	_____
	ʒətaɪm	_____	ʒətaɪm	_____

(53) The predictions

- If speakers generalize the anti-initial syllable effect from the fricatives: The "mono training" group should voice monos only, the "iamb training" group should voice both monos and iambs.
- If speakers use initial syllable faithfulness: The "iamb training" group should voice iambs only, the "mono training" group should voice both monos and iambs.

(54) The “mono training” group voiced monos and iambs equally (no anti-initial syllable effect), but the “iamb training” group voiced monos significantly less often than iambs.



Conclusion: Given a chance, English speakers ignore the anti-initial syllable effect of their language, and prefer a Turkish/Portuguese initial syllable effect.

6 Beyond protection of monosyllables

So far, we used initial syllable faithfulness to separate monosyllables from polysyllables.
The next step: Show that initial syllable faithfulness distinguishes among polysyllables as well.

6.1 German: Another bad language

In German, the back vowels (a/o/u) front in the presence of various affixes.
The plural can only impact the initial syllable (at least in real words):

(55)

d**o**rf ∼ d**ø**rf-ə	‘village’
fl**u**s ∼ fl**y**:s-ə	‘river’
br**u**:dər ∼ br**y**:dər	‘brother’
b**o**:dn̩ ∼ b**ø**:dn̩	‘floor’

Other affixes, such as the diminutive, are a little more permissive:

(56)

d**o**rf ∼ d**ø**rf-çən	‘village’
br**u**:dər ∼ br**y**:dər-çən	‘brother’
hal**o**: ∼ hal**ø**:-çən	‘hello’
admir**a**:l ∼ admirɛ:l-çən	‘Admiral’

So German umlaut has an anti-initial syllable effect: The unfaithful mapping impacts initial syllables *more* than non-initial syllables.

No wug-test results yet, but see Wiese (1996); Fanselow & Féry (2002); van de Vijver & Baer-Henney (2010)

6.2 Artificial umlaut

We asked 66 English-speaking Mechanical Turkers to learn an artificial language that has “umlaut” in either the initial or non-initial syllable:

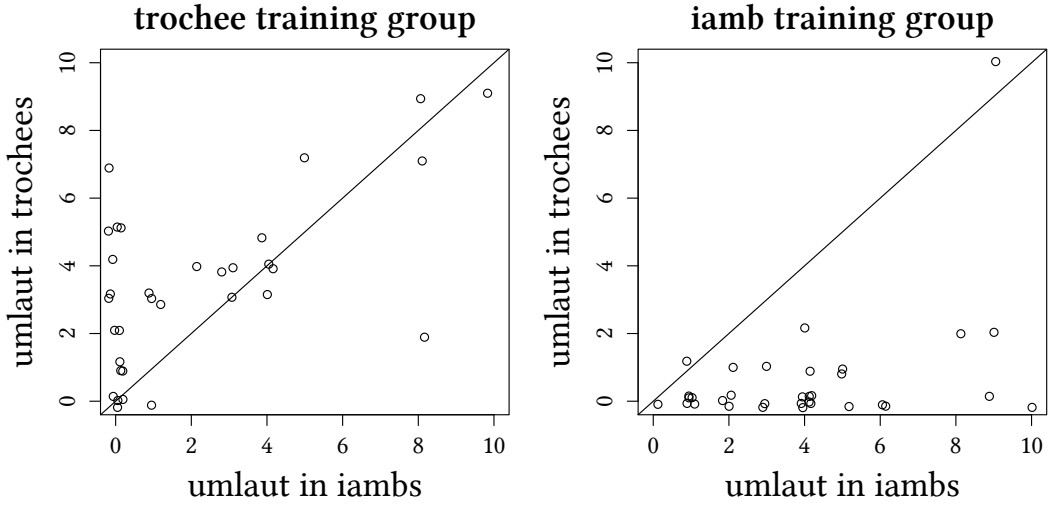
(57) Artificial grammar setup

	the “trochee training” group	the “iamb training” group
Training	*5 [e] + 5 [u] trochees*	*5 [e] + 5 [u] iambs*
	brezəl brozəl	trəmel trəmol
	zuməp ziməp	səfup səfip
	5 [a] (both shapes)	*5 [a] (both shapes)*
	baləd balədni	baləd balədni
	təkaʃ təkaʃni	təkaʃ təkaʃni
Testing	*5 [e] + 5 [u] trochees*	*5 [e] + 5 [u] iambs*
	ʃebəf _____	kəzem _____
	funəl _____	pədul _____
	5 [e] + 5 [u] iambs	*5 [e] + 5 [u] trochees*
	kəzem _____	ʃebəf _____
	pədul _____	funəl _____
	10 [a] (both shapes)	*10 [a] (both shapes)*
	gəmat _____	gəmat _____
	skakəl _____	skakəl _____

(58) The predictions

- Projection from real English: Not much to project — no predicted difference between the groups. If anything, an anti-initial syllable effect (*fʊt, tuθ, gus, wʊmɪn, maʊs, laʊs*).
- Initial syllable faithfulness: The "iamb training" group is not told that they can impact initial syllables, so they should only umlaut in iambs. The "trochee training" group should umlaut both trochees and iambs.

(59) The "trochee training" group voices iambs significantly more often than the "iamb training" group voiced trochees.



Conclusion: We see that initial syllables are protected from alternations in both monosyllables and in polysyllables. No need for faithfulness to monosyllables.

Is initial syllable faithfulness due to phonetic lengthening of initial syllables?

(60) Barnes (2006): Longer vowels are protected by faithfulness more than short vowels. Turkish initial syllables are long → protected from alternations.

(61) Phonetically in English, vowels are shortened in trochees, so it's really [zŭməp] vs. [səfuːp].

(62) If longer vowels are protected by faithfulness more than short vowels, then the "iamb training" group should extend the alternation more than the "trochee training" group — the exact opposite of what actually happened.

(63) The initial syllable is protected even though it's phonetically short.

7 Conclusions

The good languages:

- Turkish and Portuguese protect monosyllabic lexical items from alternations more than polysyllabic items.
- The trend is projected from the lexicon onto novel items ("wug test").

The bad language(s):

- English (and maybe also German and Russian) protect monosyllabic lexical items less than polysyllables.
- Step I: No projection of the trend from the lexicon onto novel items.
- Step II: Emergence of initial syllable faithfulness with novel alternations.

Properties of initial syllable faithfulness:

- Not a pure monosyllabicity effect — protects initial syllables in polysyllables.
- Not a phonetically grounded effect — protects short vowels more than long vowels.
- Shows up without any evidence from the ambient language = doesn't need to be learned.

And more generally:

- The Universal elements of phonological theory are not limited to the phonetic basis. Phonology includes purely positional formal properties.
- Wug testing reveals how speakers organize their lexical items, and what generalizations they make over them.
- Artificial grammar experiments reveal implicational relationships in phonology = they reveal the elements and positions that the phonology can refer to, and the "elsewhere" elements and positions.
- Experimental techniques confirm that phonology cannot be reduced to bookkeeping. There is a lot of bookkeeping, but it is mediated by the inherent structure of the grammar.

Finally, we need to thank UG-skeptics for making us work harder and making our empirical basis stronger.

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