Phonological learning in nature and the lab

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(1) Is the analytic bias seen in short-term phonological pattern learning experiments the same one that shapes natural-language typology? Are the lab experiments revealing biases in

a. L1 acquisition?

b. L2 acquisition?

c. Dialect, accent, or style accommodation?

d. An associative-learning process that is not used in any kind of natural-language learning?

e. A conscious strategy ("crossword-puzzle solving") that is not used in any kind of natural language learning?

All of these (except perhaps the last) could contribute to the biasing of historical change and hence of typology.

(2) ⇒ Need to compare the phenomena seen in short-term lab learning with those found in natural-language acquisition. Our confidence that the lab studies are relevant to acquisition, change, and typology will be affected by their congruity with

a. Observational data on natural-language acquisition

b. Other kinds of lab data on language learning

c. Naturally-acquired competence

d. Historical change (especially mismatches between channel bias and change)

e. Typology (especially where it mismatches channel bias)

N.B. It is OK if it turns out that lab learning involves domain-general associative processes, as long as those processes are also used to acquire natural language.

If it turns out that lab studies don't actually reveal analytic biases, that won't make them go away (Mitchell, 1990); it will only make it harder to find out what they are.

1 Easy come, easy go

(3) Exposure to a *more*-restrictive phonological pattern (than L1) leads to quick learning, but also quick forgetting.

(4) Learned quickly:

Study	Training trials
Kuo (2009)	24+72
LaRiviere et al. (1974)	88–90
Healy and Levitt (1980, Exp. 3)	60
Pycha et al. (2003)	18+36
Wilson (2006)	32
Peperkamp et al. (2006)	20
Wilson (2003)	20

(5) Forgotten quickly: In familiarize-and-test paradigms, performance degrades during the test phase, apparently because the learner is being exposed to contradictory information when choosing between legal and illegal test items.

a. Kuo (2009) had two test phases, the second of which was divided into two blocks:

Study 1	1:20	Listen to stimuli (24 disyllabic reduplicated nonsense words × 1 repetition).
Distraction 1	0:40	Arithmetic problems.
Test 1	4:00	2AFC, which sounds more like language? One legal, one not. 10 legals are old (heard in Study 1), 10 are new (legal onsets with new rimes).
Distraction 2	0:40	Arithmetic problems.
Study 2	4:00	Listen to stimuli again (24 × 3 repetitions).
Distraction 3	0:40	Arithmetic problems.
Test 2	8:00	Test 1 again **twice** in different order.

Performance on both of his phonetically-systematic patterns remained constant across those two blocks, but that on the phonetically-arbitrary pattern declined from the first to the second block of Test 2.

b. The unpublished Moreton experiments from last time worked the same way: The HH and VV patterns were robust from the first to second half of the test phase, but the arbitrary vowel-vowel pattern declined.

(6) Taylor and Houghton (2005): Directly addressed easy-come-easy-go using an induced-speech-error (tongue-twister) paradigm invented by Dell et al. (2000).

a. On each trial, the participant read a [CɛC CɛC CɛC CɛC] sequence, where the Cs were [h ŋ m n g k f s] (each occurred once per sequence). Total of 96 sequences.

b. "Experiment-wide constraint": E.g., [f] always onset, [s] always coda (or reverse, or used [k] and [g]).

c. Each sequence presented in writing. Read aloud to metronome, at about 2.5 beats per second.

d. Analyzed errors where one of the 8 Cs was substituted for another. Dell et al. (2000) found that "legal" errors (those that conformed to the experiment-wide constraint) greatly outnumbered "illegal" errors (well over 90%).

e. T&H's Exp. 4: 3 96-trial blocks of one exp.-wide constraint, then 1 block of the exact opposite. Result: Errors in 1st 3 blocks satisfied exp.-wide constraint 90% of the time (right from the start); those in the reversed block satisfied it 96% of the time.

f. Their Exp. 5: Maybe the inter-block break gave participants a chance to reset. So they tried reversing the experiment-wide constraint halfway through the 4th block. Result: Burst of errors for 9 trials, then they adapted to the new constraint just as well as they had to the old one.

g. For comparison, no one ever put [ŋ] in an onset or [h] in a coda (these were L1 English speakers). ⇒ L1 phonotactics were stronger. (But no attempt to was made to change them—as usual, the target pattern was more restrictive than L1.)

(7) L1 sound patterns are much more persistent than lab-learned ones.

Maybe persistence is proportional to quantity of training data ?

	Lab	L2	L1
Lots			*
More		*	
Little	*		

(8) Dialect acquisition in production:

a. Adults can learn a new dialect well enough to fool native speakers of both the original (Canadian English) and the target dialect (Alabama English), in judgments of 10-s excerpts from naturally-produced speech (Munro et al., 1999).

b. Carlson et al. (2009): American English listeners can overcome their L1 allophony pattern to acquire a Glaswegian Scottish distribution of /t/ and /ɹ/ allophones:

Dialect	[tʰ]	[ɾ]	[ɹ]
U.S. (D1)	/t/		/r/
Glasgow (D2)	/t/	/r/	—

Week 1	Week 2
Baseline (script only)	
Training × 2 (script + audio)	Training (script only)
	Refresher (script + audio, no /t/ or /r/)
Generalization A (script only)	Generalization A (script only)
	Generalization B (script only)

Glaswegian-like performance on /t/ was about 90% or better in all conditions (including generalization to new sentences). On /r/ it was more variable, $\sim 25-70\%$, depending mainly on prosodic environment, but still well above their American baseline.

Performance was stable from week to week.

(9) Perceptual adaptation to an unfamiliar foreign accent takes little exposure. Bradlow and Bent (2008): Two-day training, each session consisting of 5 times transcribing 32 Chinese-accented English sentences presented at +5 dB above white noise. Test: Transcribe another 16 sentences by a new Chinese-accented speaker, and 16 by a Slovakian-accented speaker. Results:

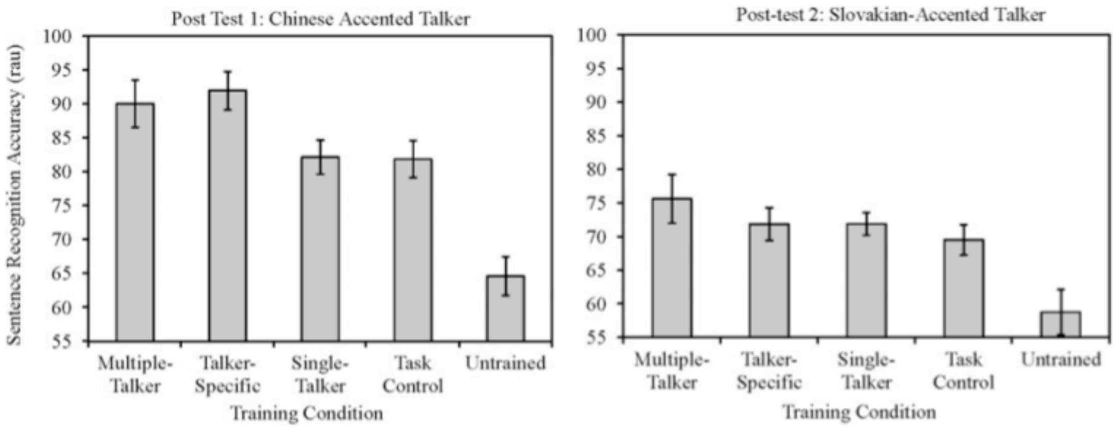

Fig. 3. Performance in RAU on the two post-tests in each of the training conditions in Experiment 2. Error bars represent the standard error of the mean. Training conditions are explained in Table 2 and in the accompanying text.

No details as to what the accent consisted of, but it probably included phonotactic repairs—Broselow et al. (1998) cite a study to the effect that about 80% of coda stops in the L2 English of L1 Mandarin speakers (6–7 years of instruction, < 1 year in U.S.) were either deleted or epenthesized after (i.e., it wasn't just perturbation of phonetic realization of particular segments).

Other cases of rapid adaptation are reviewed in the same article.

(10) Adaptation to a new phonetic idiosyncrasy of an idiolect (s/ʃ boundary) is rapid, persistent (up to 12 hours), and resists deliberate attempts to make people unlearn it (Kraljic and Samuel, 2005).

(11) ⇒ "Easy come" may not be so rare. Not much is known about "easy go".

2 Perceptual effects

(12) Exposure to a *less*-restrictive phonotactic pattern can lead, not to learning, but to misperception, with L1-illegal stimuli being heard as L1-legal. E.g.:

a. Illusory vowels heard by L1 speakers in L1-illegal consonant clusters (Dupoux et al., 1999; Berent et al., 2007)

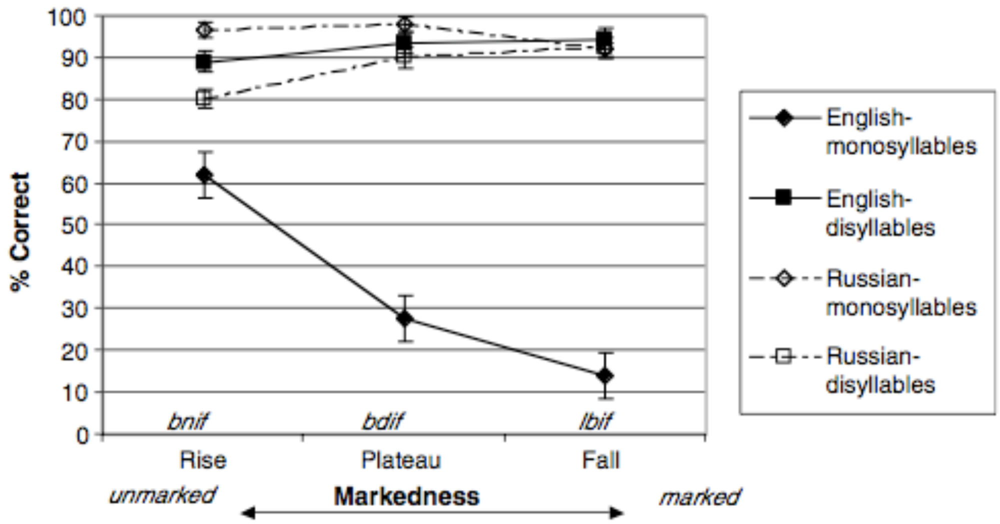

Fig. 1. Mean response accuracy of English and Russian speakers to monosyllabic nonwords and their disyllabic counterparts in Experiments 1–2 as a function of the number of syllables and the markedness of the monosyllabic counterpart. Error bars represent the confidence interval constructed for the difference among the means.

Berent et al. (2007)

b. [tl] and [dl] clusters perceived as [kl] , [dr] , [dər] , etc. when illegal in L1 (Massaro and Cohen, 1983; Pitt, 1998; Hallé et al., 1998; Moreton, 2002)

Table 2
Identification Test 1: Percentage of Dental-to-Velar and Dental-to-Labial Confusions According to Stimulus Type

	% of place confusions	
Item-initial cluster	Dental to velar	Dental to labial
Illegal		
/tl/	63.5	1.0
/dl/	47.9	1.0
Legal		
/tr/	8.3	1.0
/dr/	1.0	6.3

Hallé et al. (1998)

More evidence that L1 phonology doesn't "go easy".

(13) There is virtually no evidence that lab-learned phonotactics can affect perception. The closest study I know of is Ohala and Feder (1994): List-loading was used to induce phoneme restoration of /b/ or /d/ , which in turn affected perception of an [i-u] scale.

(14) Give the learner more training data: Can phonotactic restrictions observed by L2 but not L1 affect phonetic perception?

What we want:

a. L1 allows comparable configurations Y and N.

b. L2 allows Y, but not N.

c. Positive results would look like this:

Group	Perception	
	Y	*N*
L1 mono	good	good
L1 learners of L2	good	enh
L2 mono	good	bad

(15) No one seems to have done exactly the experiment we want.

a. Trapman and Kager (2009): Russian $\#C_1C_2$ onsets are a superset of Dutch:

TABLE 3
Russian Two-Consonantal Word Onsets Compared to Dutch

		plosives						fricatives							nasals		liquids		glides	
		p	t	k	b	d	g	f	s	ʃ	x	v	z	ʒ	m	n	r	l	w	j
plosives	p		pt						**ps**	pʃ	*px*					***pn***	**pr**	**pl**		**pj**
	t			tk					**ts**	**tʃ**		**tv**			***tm***		**tr**	*tl*		**tj**
	k		*kt*						***ks***		*kx*	**kv**			*km*	**kn**	**kr**	**kl**		***kj***
	b					bd											**br**	**bl**		**bj**
	d				*db*		*dg*					**dv**	*dz*	dʒ	*dm*	dn	**dr**	dl		**dj**
	g					*gd*						*gv*			*gm*	gn	**gr**	**gl**		*gj*
fricatives	f	fp	ft	fk							fx						**fr**	**fl**		***fj***
	s	**sp**	**st**	**sk**				**sf**	ss	*sʃ*	**sx**	sv			**sm**	**sn**	sr	**sl**		sj
	ʃ	**ʃp**	**ʃt**	ʃk				*ʃf*	*ʃs*		*ʃx*	ʃv			**ʃm**	**ʃn**	*ʃr*	ʃl		*ʃj*
	x											xv			xm	***xn***	**xr**	**xl**		*xj*
	v				vb	vd	*vg*					vv	vz	*vʒ*	vm	vn	**vr**	**vl**		**vj**
	z				zb	zd	zg					**zv**	*zz*	zʒ	zm	zn	zr	zl		zj
	ʒ				*ʒb*	*ʒd*	*ʒg*					*ʒv*	ʒz		*ʒm*	ʒn	ʒr	*ʒl*		*ʒj*
nasals	m				*mb*		*mg*			*mʃ*	*mx*					mn	mr	ml		mj
	n	*np*	*nt*			*nd*											nr			**nj**
liquids	r		*rt*	*rk*		*rd*						rv		rʒ						rj
	l				*lb*	*ld*	lg					*lv*		*lʒ*		*ln*				lj
glides	w																			
	j																			

Note: Palatal and nonpalatal consonants have been collapsed. Clusters printed in boldface have Dutch counterparts. Shaded areas exclude manner and voicing combinations which are generally unattested, as well as any combinations with /w/, which is not a phoneme of Russian. Clusters printed in italics have type frequencies N < 5 in a lexicon based on the Uppsala Corpus.

Advanced L1 Russian learners of L2 Dutch were compared with L1 Dutch speakers (and advanced L1 Spanish learners of L2 Dutch, of which no more here).

(i) Stimuli had word-initial clusters that were all legal in Russian but some illegal in Dutch. All of the *C*s were phonemes in both languages. Audio only.

(ii) Wordlikeness judgments: 7-point rating scale; how "typically Dutch" does it sound? Both L1 groups gave higher ratings to Dutch-legal than Dutch-illegal clusters. More-advanced Russian speakers were more Dutch-like in their responses.

(iii) Lexical decision: Was that a real word of Dutch? Measure how long it takes to make a correct rejection. Are words with un-Dutch phonotactics rejected faster? Again, the L1 Russian speakers performed like the L1 Dutch speakers, rejecting words with un-Dutch onsets faster.

(iv) ⇒ It *is* possible to acquire more-restrictive L2 phonotactics.

What's missing?

- Tasks aren't about phoneme perception.
- No comparison to monolingual Russian speakers (and can't be, since the task is about perceived Dutchness).

b. Cebrian (2007): English bans lax V in open sylls, which affects syllabification of intervocalic C and pronunciation of final V. Catalan doesn't observe this constraint. Catalan L1/English L2 vs. English L1 speakers. Two tests:

(i) Wug test with made-up words presented as plurals (...Cs/z or ...Vz, where V could be tense or lax); they had to give singular. Would they treat it like "deer" and "sheep", or would they lop off the z? Lax-V conformity: 85% for L1 Eng., 62% for L2 Eng.

(ii) Template-matching task: They are given two made-up ...Vz words, one with tense V and one with lax (e.g., [spiz, gIz]) and have to decide how to use those two words in the frame sentence "Here are two ___, the one on the left is called ___". Conformity: 95% for L1 Eng., 60% for L2.

What's missing?

- Not a perception task
- No comparison to L1 Catalan monolinguals (and can't be, since they have to do an English morphological task)

c. Dong (2008, Exp. 1): Dutch C_1C_2 onset restrictions:

pl bl	*tl *dl	kl	fl vl
pr br	tr dr	kr	fr vr

Mandarin Chinese distinguishes /l/ vs. /r/ , but lacks all of these clusters (its only clusters have C_2 = glide).[1]

(i) C_1C_2VC monosyllables produced by a Dutch speaker, where C_2 was either /l/ or /r/ . Task was to identify C_2.

(ii) Compared advanced L1 Mandarin/L2 Dutch speakers with L1 Dutch speakers.

(iii) Results:

[1]There is a strong tendency in loanword adaptation to map rhotics to /l/ (Miao, 2005, 71–75), and to perceive IPA [r] as [l] in onset position (Smith and Kochetov, 2008).

	Mandarin		Dutch	
C_1	l	r	l	r
p	92	73	100	100
b	85	73	100	98
t	*78	81	*100	98
d	*87	96	*100	99
k	88	85	100	99
f	98	76	98	100
v	97	70	100	100

What's missing?

- Mandarin is *more* restrictive than Dutch.
- Dutch listeners were at ceiling — no evidence that L1 Dutch has a perceptual bias favoring [r] over [l] after [t, d] .

(16) ⇒ Virtually no evidence that non-L1 sound patterns can affect phonetic perception, but that's because so little research has been done in this area.

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3 Content of biases

(17) Are the learning biases in lab-learned phonology more like those found in natural language, or more like those found in similar kinds of lab learning using non-linguistic stimuli?

(18) Substantive analytic bias in the lab would be very strong evidence that the lab task was engaging the learning mechanisms used for natural language. However, as we saw last time, the evidence for analytic bias is still rather thin.

(19) The paradigmatic-simplicity-bias results (featurally-systematic, especially single-feature, distinction easier than featurally-arbitrary) are consistent with a long, long history of work on supervised and unsupervised category learning, reviewed in Ashby et al. (1999); Feldman (2004); Pothos and Close (2008).

(20) Current general psychological models of category learning don't address syntagmatic simplicity bias (single-feature dependency easier than two-feature dependency), because their representational systems don't accommodate multiple instances of a single feature (Ashby et al., 1999; Love et al., 2004).

⇒ Not clear whether this is something unlike what is found in other domains.

(21) However, there may be other kinds of formal simplicity which are relevant to phonological learning, and which may differ from what is found in some other domains.

(22) Typical phonotactic-learning experiment:

a. Expose to positive (pattern-conforming) stimuli only (analogous to natural L1 acquisition).

b. No feedback during training ("unsupervised learning").

c. Test performance in distinguishing conforming from nonconforming stimuli.

(23) A non-linguistic study, deliberately intended by the authors as an analogue to artificial-grammar experiments: Billman and Knutson (1996).

a. Stimuli are fictitious animals, with 7 ternary attributes (head, body, texture, legs, tail, habitat, time of day).

b. Exp. 1: Train by viewing positive stimuli where attributes are correlated with each other (e.g., the head predicts the tail and vice versa). Participants are told it's an exp. on "visual memory".

   (i) "Structured": Two other attributes were perfectly correlated with head and tail; any one of them perfectly predicts the other three. The other 3 attributes vary randomly.

   (ii) "Isolating": Only (e.g.) head and tail are correlated; the other 5 attributes vary randomly.

   Test with 2AFC, with some attributes covered up so that (e.g.) only the head, tail, and irrelevant attributes are visible (the point is to see whether people learned the head-tail pairing, so we have to prevent those in the "Structured" condition from using any of the correlated pairings to do the task). Results: 76% correct in "Structured" > 66% in "Isolating", averaged across different versions of the exp.

c. Exp. 2: Same, with many more different versions to average out effects of concrete stimulus properties (e.g., if head-tail were inherently more learnable than head-habitat). Results: Structured was 73% correct > Isolating 62%,

d. Exp. 3: This time, the "Structured" condition had three attributes correlated together, while "Orthogonal" had three different correlated attribute pairs that did not correlate with each other. Results: 77% correct in structured > 66% in orthogonal.

⇒ Correlations between features are easier to learn if they are correlated with other features.

(24) Compare Skoruppa et al. (2009):

a. Typological observation: Phonetically-dissimilar sounds that are in complementary distribution "by accident" are not allophones of each other (e.g., hangma).

b. L1 French speakers were exposed to one of 6 patterns made from a subset of their native inventory. Each pattern had a predictable alternation (intended to simulate allophony—but could it have been treated as morphophonemic? does that make a difference?) involving one, two, or three features:

Features involved	Code	Alternations	Pr(correct) Old	Pr(correct) New
Place	S1	p/t, z/ʒ	0.78	0.66
	S2	ʃ/s, d/b		
Place Manner	M1	p/s, d/ʒ	0.23	0.15
	M2	ʃ/t, z/b		
Place Manner Voicing	L1	p/z, t/ʒ	0.33	0.18
	L2	ʃ/d, s/b		

c. Stimuli were 12 pairs of "Adj+N" phrases, where the "Adj" was /ʁe/ 'small' vs. /nø/ 'big'. Initial *C* of "N" alternated depending on "Adj". (Participants were instructed that some nouns could change depending on the adjectives.)

d. Training: "I say /ʁe nibu/ ; you say:". Participant gives same noun with other adjective, then gets feedback in the form of the correct answer. 6 nouns in all (2 with each alternation, plus 2 non-alternating fillers).

e. Test like training, but no feedback. Test includes the trained nouns, plus 12 new ones (8 experimental, 4 non-alternating filler).

f. Transcribed by native French speaker who didn't know what the stimulus was. Results: No difference between Old and New, but the Place-only group learned much better than the other two (which did not differ from each other).

(25) Differences between Billman and Knutson (1996) and Skoruppa et al. (2009):

a. Adding correlated features improved performance with the animal pictures, but impaired performance with the alternations. That *could be* evidence that two different learners are at work here, but...

b. The tasks aren't parallel (unsupervised passive exposure and 2AFC test, vs. supervised production training and cued production test). What if Skoruppa et al. had used a procedure like Pycha et al. (2003)?

c. The Skoruppa et al. experiment was stuck with a confound: Is it adding features that is the problem, or do, e.g., manner features in particular make an alternation hard to learn? (Unavoidable; French won't let you change manner without changing place.)

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4 Discussion

(26) How convincing is the evidence that short-term phonological learning experiments engage learning processes that are relevant to phonological typology in nature (via change)?

(27) For comparison, to what extent do phonetic (production and perception) experiments in the lab reveal channel biases in natural speech?

(28) Returning to the Berent et al. (2007) study in (12), notice that all of the clusters are English-illegal, yet English speakers misperceive them at different rates (unlike Russian speakers). What has this got to do with the question of analytic bias?

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