

The case for UG

Evidence from phonology

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Last lectures

- Two mechanisms for productivity: rules and statistical learning
- Rules play a role in natural language
 - Demonstrably distinct from both
 - Statistical learning
 - Sensorimotor constraints

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Chomsky's big idea (1): Rules



What is it that a child learns about their language?

- ✓ Answer (so far): **Rules**
 - Plural: Noun+S
 - Sentence: NP+VP

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Today's question: How are linguistic rules acquired?

- Entirely learned from experience
- Partly innate?

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Course map

Introduction

- What is language?
- The innateness debate
- What's the evidence (take 1)

What is a rule?

- Do infants use them?
- How to tell?

Rules of morphology:
the battle over
inflection

The UG hypothesis
(in phonology)

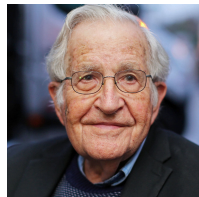
We are
here!

Language and beyond (a choice):
Reading and phonology
Numeric cognition

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Chomsky's big idea (2): UG

- Children have language (knowledge) for the same reason they have two hands
 - Language: a mental organ
- Both are biological capacities that are *innately* constrained
 - The innate aspect of language is called universal grammar (UG)



Is language a specialized, modular, domain-specific system?

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Case study: Phonology

- Onset clusters

– *blog*

– *lbog*

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Phonology--an unusual place to look for UG

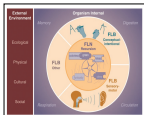
- Chomsky's own work on UG mostly concerns syntax

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Phonology ≠ specialized

REVIEW: NEUROSCIENCE
The Faculty of Language: What Is It, Who Has It, and How Did It Evolve?
Mark A. Huelskamp, Mark A. Huelskamp, Dr. Huelskamp



Available online at www.sciencedirect.com
ScienceDirect
Cognition 171 (2018) 179–218

COGNITION
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Discussion
The evolution of the language faculty:
Clarifications and implications

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2.4. Phonology

In HCF we considered phonology as a mapping from narrow syntax to the SM interface. To this being repetitive, phonology does not represent “a major counterexample to the recursion-only hypothesis” but is irrelevant to the recursion-only hypothesis advanced in HCF. We suggested that the computational resources of recursion and its mapping to SM and CI are the only FLN-specific properties, and that other principles external to language might be responsible for the residual complexity and details of the SM/CI interface. Given our recent knowledge, much of phonology is likely part of FLN, not FLN, either because phonological mechanisms are shared with other cognitive domains (reading, music, and dance) or because the relevant phenomena appear in other species, particularly bird and whale “song”. Some regularities in phonology may result from other principles, perhaps organism-independent, that determine computationally efficient mappings from narrow-syntactic objects to the SM interface, a possibility that can be formulated today, but so far resists serious inquiry. Specific aspects of phonology other than those that follow from recursion plus mapping to the interfaces may well be part of FLN—but this possibility should be stated as a hypothesis and tested, not assumed.

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Phonology--an unusual place to look for UG

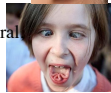
- Chomsky's own work on UG mostly concerns syntax
- Laypeople think phonological knowledge doesn't concern rules to start with
 - *So do many phonologists...*
- No innate rules either...

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Naïve theory of phonology: why there is no UG

- Object 1: Diversity
 - UG in phonology makes no sense—languages are so different from each other...
 - English : *blog*
 - Russian: *lbog*
- Objection 2: sensorimotor correlates
 - To the extent some phonological preferences are general they are nonlinguistic:
 - Audition
 - Articulation
 - *Note:* Per naïve phonology, there are no rules and no UG:
 - Phonological preferences are universal, but they are only due to domain general pressures (e.g., audition)— *not* due to UG!



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Our goal

- Face your biases: naïve phonology is not necessarily right
- Does UG constrain phonology: that's an empirical question
 - Let's find out!

Disclaimer: as usual, our goal is to show how to "fight the fight"

The victor is yet unknown...

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Phonology *is* the right place to look

- Last time: phonology is governed by algebraic operations
 - Contrary to the received wisdom
- Finding evidence for UG in phonology would offer particularly strong case for UG, generally!

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The OT approach to UG

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What's wrong with *lbog*? Two questions....

- Why is *lbog* banned?
 - Linguistic constraint
 - Nonlinguistic (i.e., domain-general) constraints
- How generally?
 - Universally
 - Not-universally

	Universality	Diversity
Linguistic constraints		
Domain-general (audition, articulation)		

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What needs to be explained

- Why languages differ from each other
 - English: **ptil*
 - Hebrew: OK (*ptil* ‘wick’)
- Why they are similar
 - Across languages, *ptil* is still less frequent than *play*

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question

- Does language diversity mean there are no universals (and no UG)?
- Not necessarily
 - It depends on your theory of UG!
 - Optimality theory (Prince & Smolensky, 1993): a theory of violable UG constraints

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How can a single theory capture both universality and diversity?

It's all in the ranking!

John	Cheap	Tastes good
☞Dunkin	✓	*
Tatte	*	✓

Bill	Tastes good	Cheap
Dunkin	*	✓
☞Tatte	✓	*



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- All constraints are universal
- Differences in ranking
- A UG theory of coffee explains both things!

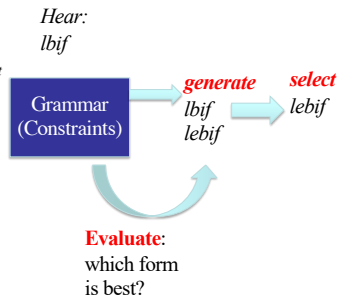
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How the grammar works?

- **Generates** all possible representation for the input
- **Evaluates** these representations:
 - Which input incurs the *least severe* constraint violation?
- **Selects** the optimal representation

– Notice:

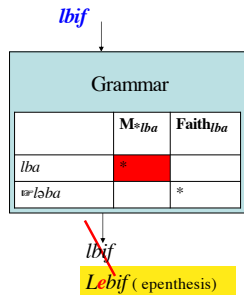
- All constraints are violable
- All forms violate *some* constraint
- Winners are the “least offender”



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What's in the grammar: Hebrew/English

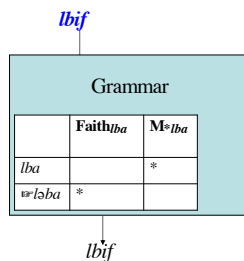
- Two sets of universal constraints:
 - **Markedness:** avoid certain structures
 - *Informally:* Avoid *lba*
 - **Faithfulness:** output is faithful to input
 - *Fill:* do not add new segments to input
 - *Parse:* don't delete segments from input
- These constraints are ranked
 - **English/Hebrew:** Markedness outranks faithfulness
 - **consequence:** The grammar of English “repairs” *lba* (as *leba*)



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What's in the grammar: Russian/Ukraine

- Two sets of universal constraints:
 - **Markedness:** avoid certain structures
 - *Informally:* Avoid *lba*
 - **Faithfulness:** output is faithful to input
 - *Fill:* do not add new segments to input
 - *Parse:* don't delete segments from input
- These constraints are ranked
 - **Russian/Ukraine:** Faithfulness outranks Markedness
 - **consequence:** Russian speakers tolerate *lba*



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Hebrew vs. Russian same constraints, different ranking

Russian/Ukraine: *lba* OK

Grammar		
	Faith _{lba}	M _{lba}
<i>lba</i>		*
<i>ʁ-ləba</i>	*	

lba has a cost...

Hebrew/English: no *lba*

Grammar		
	M _{lba}	Faith _{lba}
<i>lba</i>	*	
<i>ʁ-ləba</i>		*

Universal knowledge about
lba (even if unattested)

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Optimality theory: the big ideas



Alan Prince
Rutgers



Paul Smolensky
John Hopkins

- **Universal grammar:** all grammars share the same universal constraints
- These constraints are *active* universally
 - *Regardless of linguistic experience*

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Our question: Universals in phonology?

- Do languages share aspects of phonological organization: are certain syllables systematically preferred to others?
 - E.g., *blog* > *lbog*
- Do speakers exhibit these preferences *even when they are not attested in their language?*
- What is the source of these universals?
 - UG (domain-specific)
 - Other factors (domain general)

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Outline: Does UG prefer *blog*>*lbog*?

- Test 1: Cross-linguistic tendencies...
- Test 2: Can we explain them in OT?
- Test 3: What about individual speakers
 - Do speakers prefer *blog*>*lbog*
 - Even when their language allows neither
 - Is the preference due to UG?

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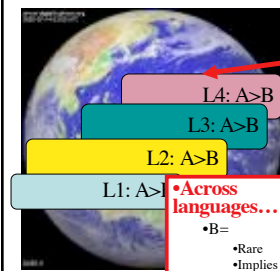
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Test 1: cross-linguistic tendencies

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Language universals and UG markedness



- Across languages, certain structures are dispreferred
- Why?
 - Historical accident
 - Domain-general mechanisms
 - Sensation
 - Articulation
 - UG (language instinct): universal markedness constraints

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Language universals and UG markedness

Facility of language (UG) $A > B$

Grammatical Markedness (Prince & Smolensky, 1993):

- B Violates grammatical constraints in *all* grammars
- regardless of whether B/A attested

• Across languages...

- B =
- Rare
- Implies A

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Typological markedness:
cross-linguistic statistical tendencies

- Across languages, certain onset clusters are preferred (e.g., more frequent)

$bla > bna > bda > lba$

- Within any language
 - If “bad” clusters are allowed, so are “better” clusters
 - But: “better” clusters do not imply “bad” clusters

	<i>bla</i>	<i>bna</i>	<i>bda</i>	<i>lba</i>
English	+			
Ancient Greek	+	+		
Hebrew	+	+	+	
Russian	+	+	+	+

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If $bnif \rightarrow blif$

		large rise <i>Blif</i> (UM)		
		+	-	
Small rise <i>Bnif</i> (M)	+	57	1	58
	-	18	14	32
		75	5	90

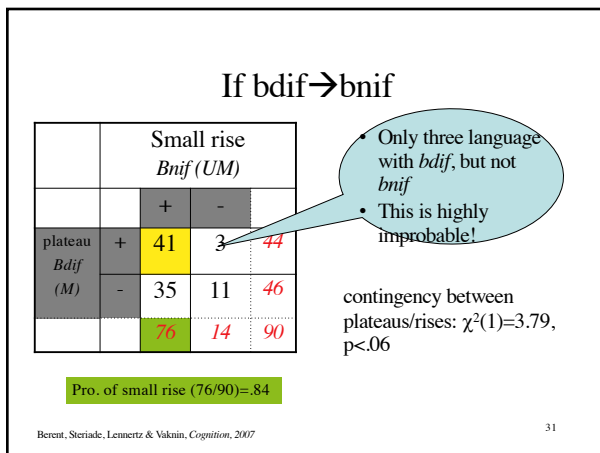
Pro. of large rise (75/90) = .83

contingency between small/large rise:
 $\chi^2(1) = 23.28, p < .0001$

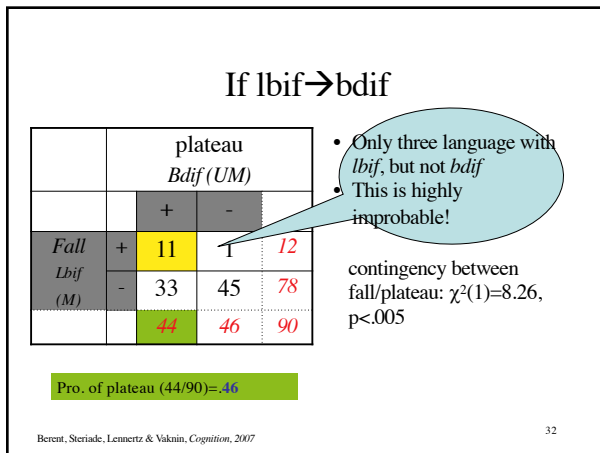
Only one language has *bnif*, but not *blif*
This is highly improbable

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summary

- We can confirm that if a language has the “worse” onset, it tends to have the better one as well. Counter-examples exist, but they are rare.
 - *Lbif* → *bdif*
 - *Bdif* → *bnif*
 - *Bnif* → *blif*

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Outline:
Does UG prefer *blog* > *lbog*?

- ✓ Test 1: Cross-linguistic tendencies...
- Test 2: Can we explain them in OT?
 - The role of sonority
 - Sonority leads to repair
- Test 3: What about individual speakers
 - Do speakers prefer *blog* > *lbog*
 - Even when their language allows neither
 - Is the preference due to UG?

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Test 2: can we capture these
typological tendencies by UG?

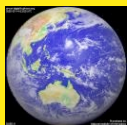
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Is this *really* due to UG?

• Across languages

- $bl > bn > bd > lb$
- Large rise > small rise > plateau > fall



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Linguistic account: *sonority*

Sonority **levels**

Obstruents	p,b,k, g,t,d	1
Nasals	n,m	2
Liquids	l,r	3
Glides	y,w	3

- Sonority: an abstract **formal phonological** property of segments
 - Defined primarily by the *manner of articulation feature* (phonology)
- Remember:
 - Features are related to articulation (high sonority ~ loud)
 - But features are **abstract**:
 - Reflect how your brain categorizes the sound
 - Not the physical sound itself

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Sonority captures the syllable hierarchy!

Sonority **levels**

Obstruents	p,b,k, g,t,d	1
Nasals	n,m	2
Liquids	l,r	3
Glides	y,w	3

Sonority **profile (Cline)**

Sonority cline	C1	C2	$\Delta C2-C1$
Large rise	$b=1$	$l=3$	2
Small rise	$b=1$	$n=2$	1
plateau	$b=1$	$d=1$	0
fall	$l=3$	$b=1$	-2

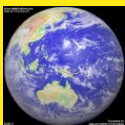
III-formed

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Source of sonority hierarchy

• Across languages

- $bl > bn > bd > lb$
- Large rise > small rise > plateau > fall



• Optimality Theory (Prince & Smolensky, 1993/2004):

UG
$bl > bn > bd > lb$



Grammatical constraints are universal

- present in *all* grammar
- regardless of whether clusters are attested

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Sonority in Optimality theory

What is universal?

- Syllable hierarchy forms part of UG:

- a scalar markedness constraint

– Informally: **lba*

**lb > *bd > *bn > *bl*

- For a formal account, see Smolensky (2006)

How languages differ?

- "Tolerance" for "bad" (marked) syllables:

- the ranking of faithfulness relative to markedness constraints

**lb > *bd > *bn > *bl*
(markedness)
Russian English (faithfulness)

- Tolerance of "bad" syllables implies "good" ones

*Smolensky, P. (2006). Optimality in Phonology II: Harmonic completeness, local constraint conjunction, and feature domain markedness. In 30 Smolensky & G. Legendre (Eds.), *The harmonic mind: From neural computation to Optimality-theoretic grammar* (Vol. 2: Linguistic and philosophical implications, pp. 27-160). Cambridge, MA: MIT Press.

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Example: Tolerance of sonority falls depends on constraint ranking

Russian allows *lba*

/lba/	Fill (No addition)	*no sonority falls* *lba
☺ <i>lba</i>		*
<i>leba</i>	*	

English bans *lba*

/lba/	*no sonority falls* *lba	*Fill (No addition)
<i>lba</i>	*!	
☺ <i>leba</i>		*

- "No sonority falls": syllables may not fall in sonority (informally; for actual constraint, see references)

Ill-formed clusters are repaired by the grammar

*Berent, J., Lennertz, T., Smolensky, P., & Vainin-Nusbaum, V. (2009). Listeners' knowledge of phonological universals: Evidence from nasal clusters. *Phonology* 26, 75-108.
*Smolensky, P. (2006). Optimality in Phonology II: Harmonic completeness, local constraint conjunction, and feature domain markedness. In 31 Smolensky & G. Legendre (Eds.), *The harmonic mind: From neural computation to Optimality-theoretic grammar* (Vol. 2: Linguistic and philosophical implications, pp. 27-160). Cambridge, MA: MIT Press.

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Our questions :

- Are English speakers sensitive to the structure of syllable they have never heard before? (*poverty of a stimulus argument*)

bl > bn > bd > lb

- Is this due to a UG constraint?

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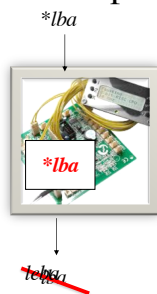
Test 3: individual speakers

What we know about what we have
never heard before...

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Rationale: repair

- Prediction: ill-formed syllables are repaired
- E.g., *lba* → *leba*



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Rationale: repair

- The likelihood of repair depends on well-formedness
 - The worst form the onset, the more likely its repair
- Repair → misidentification
 - Repair is a "litmus test" of well-formedness



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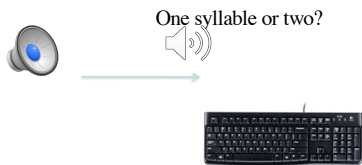
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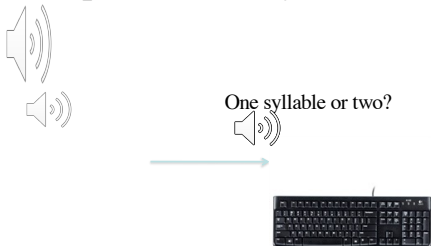
Experiment 1: Syllable count



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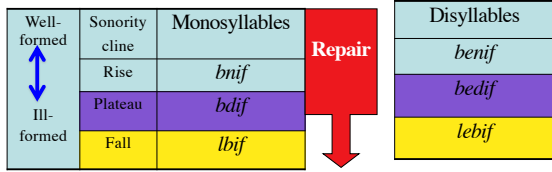
Experiment 1: Syllable count



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Experiment 1: syllable count

Berent, Steriade, Lennertz & Vaknin, *Cognition*, 2007

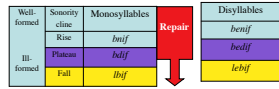
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Experiment 1: syllable count

Logic

- Manipulate well-formedness of monosyllables
- Prediction: ill-formed monosyllables will be repaired (as disyllables) → misidentified as “disyllables”
 - Incorrect disyllabic responses could indicate repair
- Question: does repair depend on well-formedness?



E.g., *bena* > *beda* > *leba*

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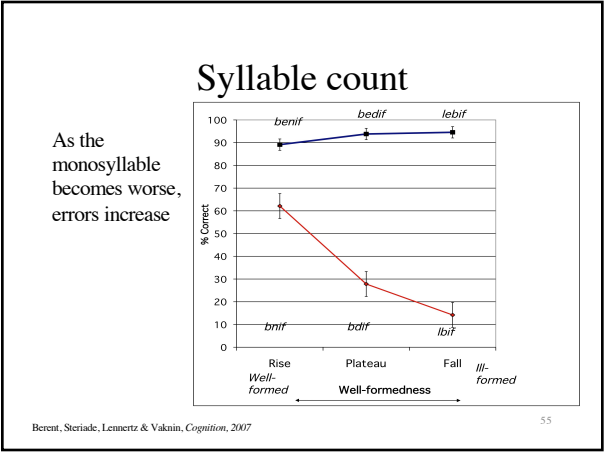
Method

- **Materials:**
 - 30 monosyllabic triplets
(*bnif,bdif, lbif*)
 - 30 disyllabic triplets
(*benif,bedif, lebif*)
- Materials are recorded by a native Russian speaker
- Participants (N=16 English speakers)

[illegible]

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Experiment 2: Identity judgment

- Same or different?

Berent, Steriade, Lennertz & Vaknin, Cognition, 2007

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Experiment 2: Identity judgment

Identical trials	
<i>Bnif</i>	<i>bnif</i>
<i>bdif</i>	<i>bdif</i>
<i>lbif</i>	<i>lbif</i>
<i>benif</i>	<i>benif</i>
<i>bedif</i>	<i>bedif</i>
<i>bedif</i>	<i>bedif</i>

Non-identical-trials		
<i>Small rise</i>	<i>bnif</i>	<i>benif</i>
<i>Plateau</i>	<i>bdif</i>	<i>bedif</i>
<i>Fall</i>	<i>lbif</i>	<i>lebif</i>

Repair

Berent, Steriade, Lennertz & Vaknin, Cognition, 2007

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Experiment 2: Identity judgment

prediction

- As monosyllable becomes worse formed, repair increase
- People will incorrectly mis-identify non-identical trials as identical
- The worse formed the onset, the more likely the error

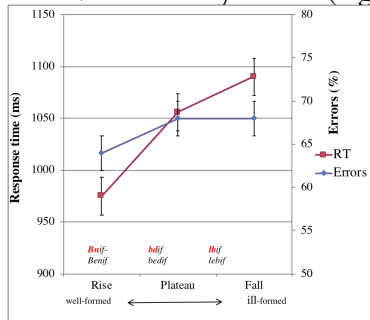
Non-identical-trials		
Small rise	<i>bnif</i>	<i>benif</i>
Plateau	<i>bdif</i>	<i>bedif</i>
Fall	<i>lbif</i>	<i>lebif</i>

Berent, Steriade, Lennertz & Vaknin, *Cognition*, 2007

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Nonidentity trials (e.g., *lbif-lebif*)



- As the syllable becomes worse, people confuse it with its disyllabic counterpart
- More errors
- Slower RT

Berent, Steriade, Lennertz & Vaknin, *Cognition*, 2007

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Conclusions so far

- People are sensitive to the structure of syllables that *they have never heard before*
- Evidence: repair
 - Syllables that are rare across languages (onsets with small sonority distances) are harder to identify
 - Misidentified as disyllables
 - Confused with their disyllabic count
 - erparts
- Conclusion: sensitivity to syllable structure

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Small sonority distances are misidentified

- **hb>bu>hd>lb**
 - Bregert, I., Steilade, D., Lennertz, T., & Vakis, V. (2007). What we know about what we have never heard: Evidence from perceptual illusions. *Cognition*, 104, 591-630.
 - Bregert, I. (2008). Are phonological representations of printed and spoken language isomorphic? Evidence from the restrictions on unattended onsets. *Journal of Experimental Psychology: Human Perception & Performance*, 34, 1288-1304.
 - Bregert, I., Lennertz, T., Jan, J., Moreno, M. A., & Smolensky, P. (2008). Language universals in human brains. *Proceedings of the National Academy of Sciences*, 105, 5327-5332.
 - Bregert, I., Harder, K., & Lennertz, T. (2011). Phonological universals in early childhood: Evidence from sonority restrictions. *Language Acquisition*, 18, 281-293.
- **mb>md**
 - Bregert, I., Lennertz, T., Smolensky, P., & Vakis-Nusbaum, V. (2009). Listeners' knowledge of phonological universals: Evidence from nasal clusters. *Phonology*, 26, 75-108.
 - Bregert, I., Balaban, E., Lennertz, T., & Vakis-Nusbaum, V. (2010). Phonological universals constrain the processing of non-speech. *Journal of Experimental Psychology: General*, 139, 418-435.
 - Bregert, I., Lennertz, T., & Balaban, E. (2012). Language universals and misidentification: A two way street. *Language and Speech*, 1-20.
- **pu>fu**
 - Lennertz, T., & Bregert, I. (2012). People's knowledge of phonological universals: Evidence from fricatives and stops. *manuscript submitted for publication*.
- **bz>bd**
 - Lamas, K., & Bregert, I. (2014). Sensitivity to phonological universals: The case of fricatives and stops. *Journal of Psycholinguistic Research*.

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Phonological universals: UG or domain-general pressures?

Part 2

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Next question: Why are ill-formed syllables misidentified?

- Functional constraints (domain-general)
 - Audition
 - Articulation
- Linguistic experience
- Universal grammar

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How we go about it?

- Strategy: if we can reject the non-UG explanations, then *by elimination*, we can support UG
- Our plan:
 - test each of the alternative explanations (color coded)
 - See if UG “remains standing”

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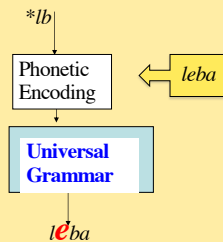
An auditory/phonetic account



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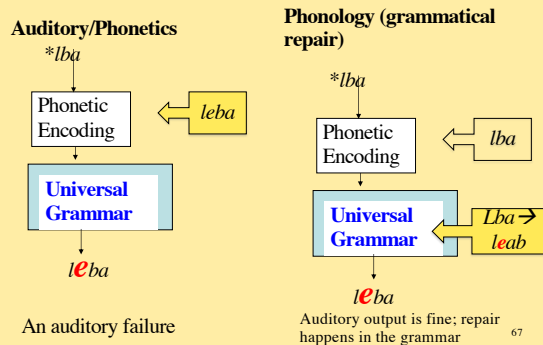
An auditory/phonetic account

- Misidentification is a failure in audition
 - People cannot extract the correct phonetic form to *lbif*
- *Not* due to abstract grammatical constraints in phonology



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Two competing accounts of repair



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Two challenges to the auditory account

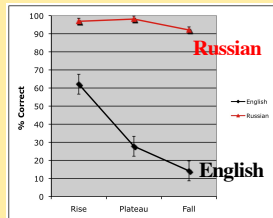
- Russian speakers encode these clusters correctly
 - Ill-formed syllables *can* be identified by *some* speakers
- English speakers obey the sonority hierarchy with *printed* materials

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Challenge 1: Russian speakers

- Russian speakers can identify all monosyllables accurately (>90%)

Syllable count: monosyllables



Berent, Steriade, Lennertz & Vakinin, *Cognition*, 2007

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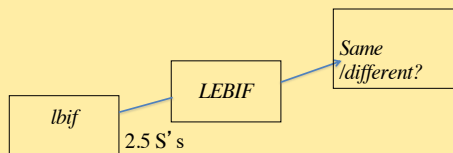
Challenge 2: English speakers fail to identify *printed* words

- Why use *printed* words?
- Previous research shows that, when people read silently, they decode the phonology of printed words
 - E.g., flower?
 - People say “yes” to
Rose, Roze, Rows
- Significance: reading can allow us to test for phonology *while controlling for auditory demands* (none)
- Question: are people sensitive to the syllable hierarchy in silent reading?

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Testing the auditory account: Identity task with *printed* words



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Predictions of competing accounts

- *Auditory account*: no difficulties with ill-formed syllables
- *Linguistic account*: Ill-formed syllables should be misidentified

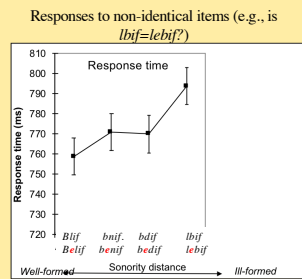
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Why are ill-formed onsets misidentified?

Results

- As the cluster becomes worse, response is slower
- People are sensitive to the syllable hierarchy even when words are printed (no auditory demands)
- **Conclusion:** The difficulty with *lbif* is not only auditory



Becent, & Leman, *Journal of Experimental Psychology: Human Perception & Performance* (2010)

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Summary: challenges to the auditory/phonetic account

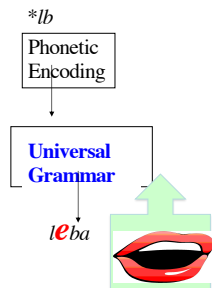
- Russian speakers *can* encode these syllables
- English speakers *cannot*, even with **printed** materials

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Why are ill-formed onsets misidentified?

← Auditory failure

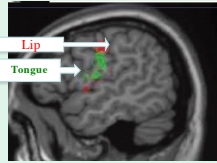
- Subvocal articulation
 - Hypothesis: speech perception requires motor *simulation*



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Speech perception triggers articulatory action

Speech production & perception (fMRI)



- Motor areas are activated in production *and* perception
 - *p* activates the lip motor area
 - *t* activates the tongue motor area

Pulvermüller, F., Haux, M., Khafiz, F., Muscoso del Prado Martin, F., Hauk, O., & Shrivastava, V. (2006). Motor cortex maps articulatory features of speech sounds. *Proceedings of the National Academy of Sciences*, 103, 7965-7970.

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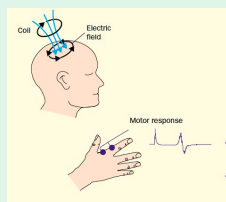
Speech perception triggers articulatory action

- Implication to syllable structure:
 - To perceive *lbif*, you must simulate its production
 - Could people misperceive *lbif* because they fail to simulate it?
- Test: TMS (transcranial magnetic stimulation)

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What is TMS?

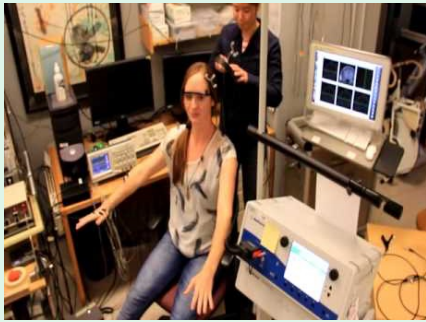


Kohyashi, M., & Pascual-Leone, A. (2003). Transcranial magnetic stimulation in neurology. *Lancet Neurology*, 2, 145-156.

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What is TMS?

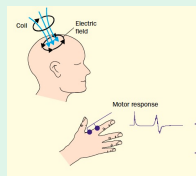


https://www.youtube.com/watch?v=qkNbYHu_STU

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TMS and the syllable hierarchy



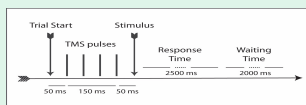
Kobayashi, M., & Pascual-Leone, A. (2003). Transcranial magnetic stimulation in neurology. *Lancet Neurol*, 2, 145-156.

- Logic: Use TMS to disrupt motor activity in articulatory motor areas (e.g., lip):
- If the difficulty with ill-formed syllables is due to difficulty with motor simulation, then disrupting motor activity should *disrupt* sensitivity to the syllable hierarchy

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Testing the articulatory account



- Two conditions:
- TMS
 - Sham (control)



blif
belif

One/two
syllables?

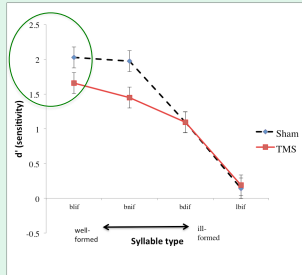
Berent, I., Bram, A. K., Zhao, X., Seligson, E. Pan, H., Epstein, J., Stern, E., Galaburda, A., & Pascual-Leone, A. Role of the motor system in language knowledge. (2015). *PNAS*.

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Testing the articulatory account

Results

- TMS disrupts responses only to the best formed-clusters (*blif*)
- People remain sensitive to the syllable hierarchy even when articulation is suppressed (by TMS)
- **Conclusion:**
 - People do rely on simulation as part of speech perception, generally (more on this later)
 - Simulation is not the *cause* of the syllable hierarchy
 - Against the articulatory account

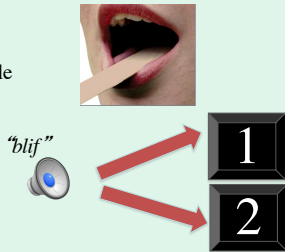


Berent, I., Bram, A. K., Zhao, X., Scigson, E., Pan, H., Epstein, J., Stern, E., Galaburda, A., & Pascual-Leon, A. (2015). *PNAS*. Role of the motor system in language knowledge.

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Another challenge to the articulatory account

- Mechanical suppression:
 - People also remain sensitive to the syllable hierarchy when articulation is suppressed mechanically



Zhao, Xu & Iris Berent, 2017. The basis of the syllable hierarchy: articulatory pressures or universal phonological constraints? *Journal of Psycholinguistic Research*.
Berent, I & Platt, M (in press). Is phonology embodied? *J. of Psycholinguistic Research*.

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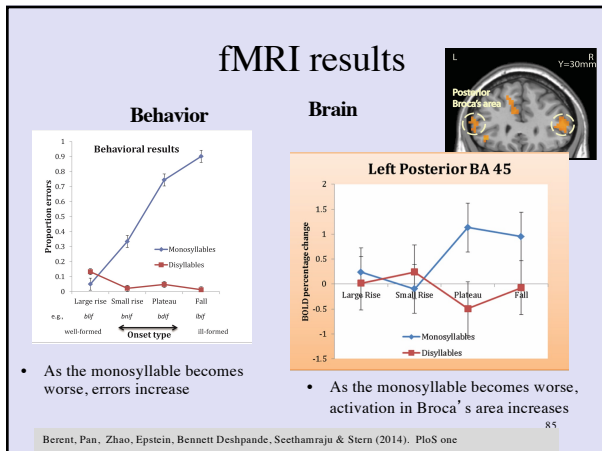
Does the syllable hierarchy engage “classical” brain areas? an fMRI experiment

- Syllable count under the magnet

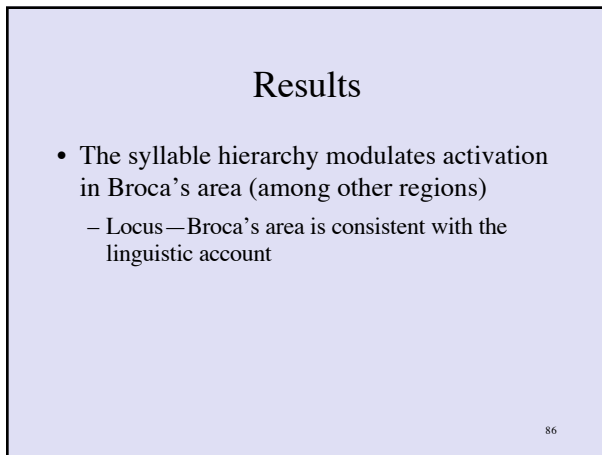


Berent, Pan, Zhao, Epstein, Bennett Deshpande, Seethamraju & Stern (2014). *PLoS one*

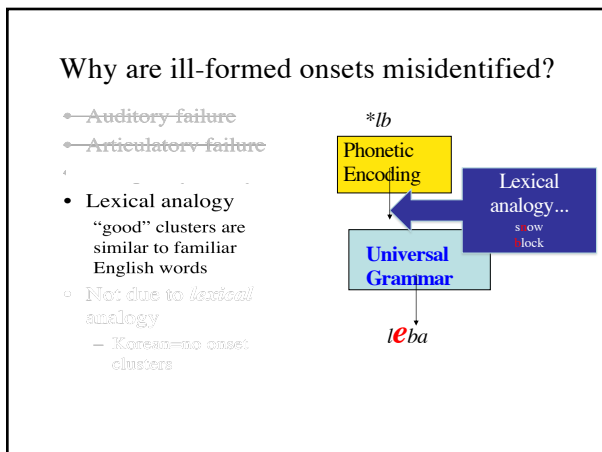
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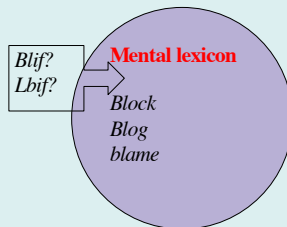
Why?

- Audition: marked clusters are hard to hear
 - Russian speakers have no such problems
 - English speakers do, even for printed words
- Articulation: marked clusters are hard to articulate (and people engage in subvocal articulation)
 - people remain sensitive to the syllable hierarchy even when...
 - The lip motor area is stimulated by TMS
 - When motor simulation is blocked mechanically
- The syllable hierarchy activates Broca's area ⁸⁸

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Lexical analogy

- To determine whether a novel word is well-formed, match it against familiar words stored in memory (lexicon)
- *Blif*-similar to many words
→ preferred
 - *Note*: no role to grammar!
- Is this the *only* source of syllable preferences?



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Two tests of lexical analogy

- Speakers of Korean/Mandarin
 - no syllables with onset clusters
- Newborns: No lexicon!

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Testing the lexical account (a)

- Korean=no onset clusters
- Korean speakers nonetheless misidentify ill-formed syllables

-So do speakers of Mandarin Chinese (Ren, Gao, & Morgan, 2010; Zhao & Berent, 2011)

Korean results

Non-identical items

Syllable Type	Errors	RT (ms)
Large rise	~0.3	~1050
Small rise	~0.35	~1050
Plateau	~0.55	~1150
Fall	~0.7	~1250

Berent, E., Lennertz, T., Joo, J., Moreno, M. A., & Smolensky, P. (2008). Language universals in human brains. *Proceedings of the National Academy of Sciences*, 105, 5321-5325.

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Testing the lexical account (b): language universals at birth

Well-formed
Blif
Prak
Krom

Ill-formed
Lbif
Rpak
rkom

Well-formed
Blif
Prak
Krom

Ill-formed
Lbif
Rpak
rkom

Gómez, Berent, Benavides-Varela, Bion, Cattarossi, Nespor, Mehler, (2014). *Proceedings of the National Academy of Sciences*.

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Ill-formed onsets are harder on the neonate brain

Δ (Ill-formed-well formed)
Δ lbif-blif

Δ (Ill-formed-well formed)
Δ bdif-blif

Gómez, Berent, Benavides-Varela, Bion, Cattarossi, Nespor, Mehler, (2014). *Proceedings of the National Academy of Sciences*.

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Challenges to lexical account: summary

- Korean and Mandarin speakers don't have experience with onset clusters (impoverished lexicon); still sensitive to the syllable hierarchy
- Neonate infants have no lexicon—still sensitive to the syllable hierarchy

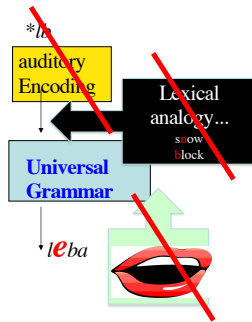
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Summary:

why are ill-formed onsets misidentified?

- Not due to **auditory** failure
 - Russian speakers encode these clusters
 - English speakers fail with *printed* materials
- Not due to **articulatory** simulation:
 - Sonority hierarchy maintained despite TMS and mechanical suppression
 - The hierarchy engages Broca's area (possibly, in line with linguistic function)
- Not due to **lexical** analogy
 - Korean=no onset clusters
 - Similar results with neonates



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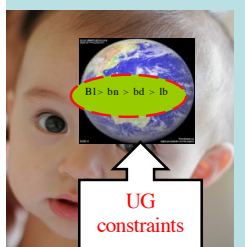
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UG explains the convergence between typology and individual speakers

• Cross-linguistically: onset typology



• individual speakers



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General conclusions

- Two sources of phonotactic knowledge
 - **Language-particular knowledge**
 - E.g., no coda in Japanese
 - Consequences: repair → perceptual illusions
 - **Universal:**
 - Across languages: *lba*-type syllables are dispreferred
 - People show similar preferences to novel syllables
 - These preferences are not solely due to experience or functional pressures
- Phonology might be shaped by UG

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