More learnable than thou?

Empirically testing linguistic knowledge representations

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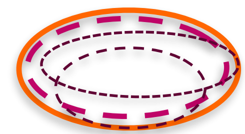

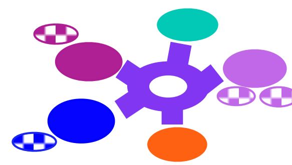

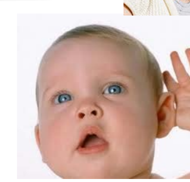

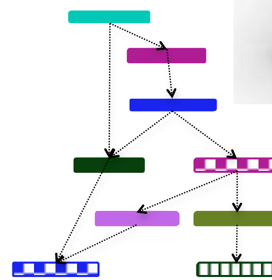

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Logic & Philosophy of Science Colloquium

University of California, Irvine

Knowledge

What exactly do you know when you know a language?

There are many types of linguistic knowledge, including knowledge of sounds (phonology)…

gá blɪnz

g ɑ b l ɪ n z

Knowledge

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There are many types of linguistic knowledge, including knowledge of sounds (phonology), words (lexicon, morphology) …

goblins

goblin + s = goblin (plural)

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What exactly do you know when you know a language?

There are many types of linguistic knowledge, including knowledge of sounds (phonology), words (lexicon, morphology), sentences (syntax)…

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Goblins steal children.

goblin + s = goblin (plural)

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Knowledge

What exactly do you know when you know a language?

There are many types of linguistic knowledge, including knowledge of sounds (phonology), words (lexicon, morphology), sentences (syntax), meanings (semantics)…

goblins

steal(goblins, children)

Goblins steal children.

goblin + s = goblin (plural)

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g ɑ b l ɪ n z

Knowledge

What exactly do you know when you know a language?

There are many types of linguistic knowledge, including knowledge of sounds (phonology), words (lexicon, morphology), sentences (syntax), meanings (semantics), and how language is used to convey certain types of information (pragmatics).

goblins

Don’t goblins steal children?

steal(goblins, children)

Goblins steal children.

goblin + s = goblin (plural)

gá blɪnz

g ɑ b l ɪ n z

Knowledge

What exactly do you know when you know a language?

Some things you can do when you know these different types of linguistic knowledge:

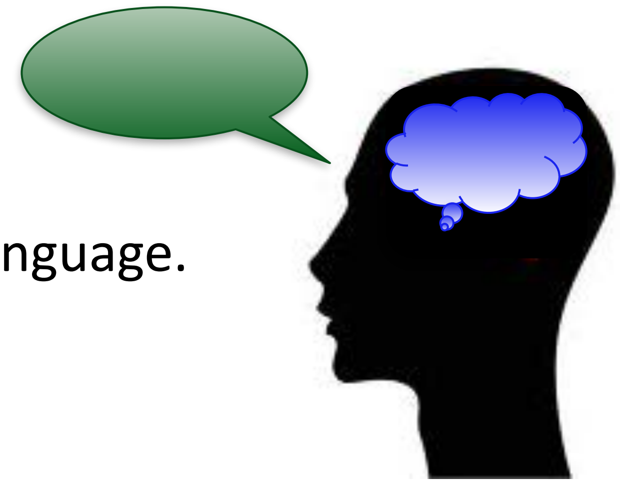
Novel comprehension: You can understand utterances in the language, even if you haven't heard the specific utterance before.

Novel generation: You can create new utterances to express whatever thoughts you have.

Knowledge = Grammar

What exactly do you know when you know a language?

How can you do these things?

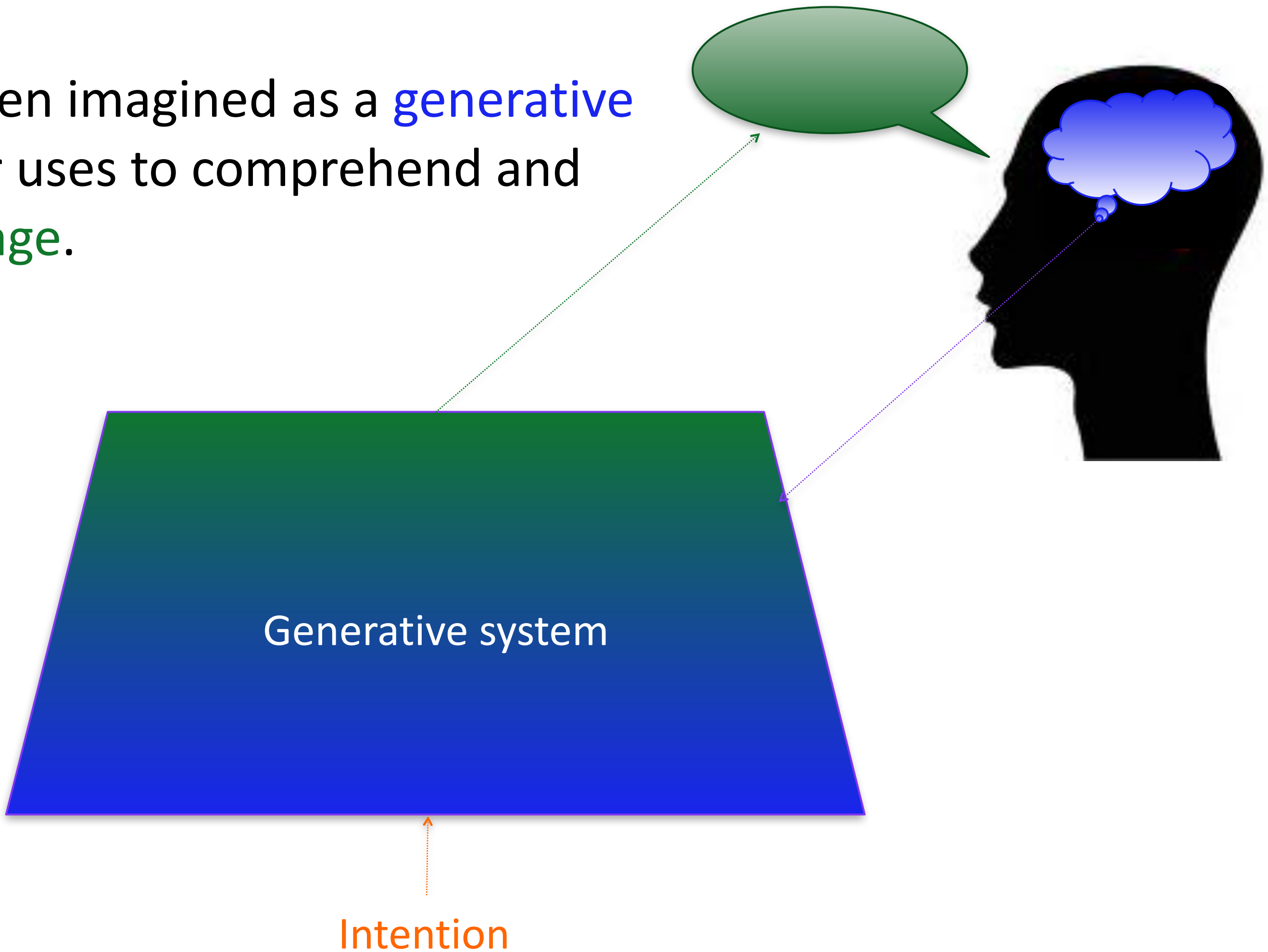


You have an underlying system that compactly describes the regularities and patterns of the language. This is your grammar for the language.

Grammar = Generative system

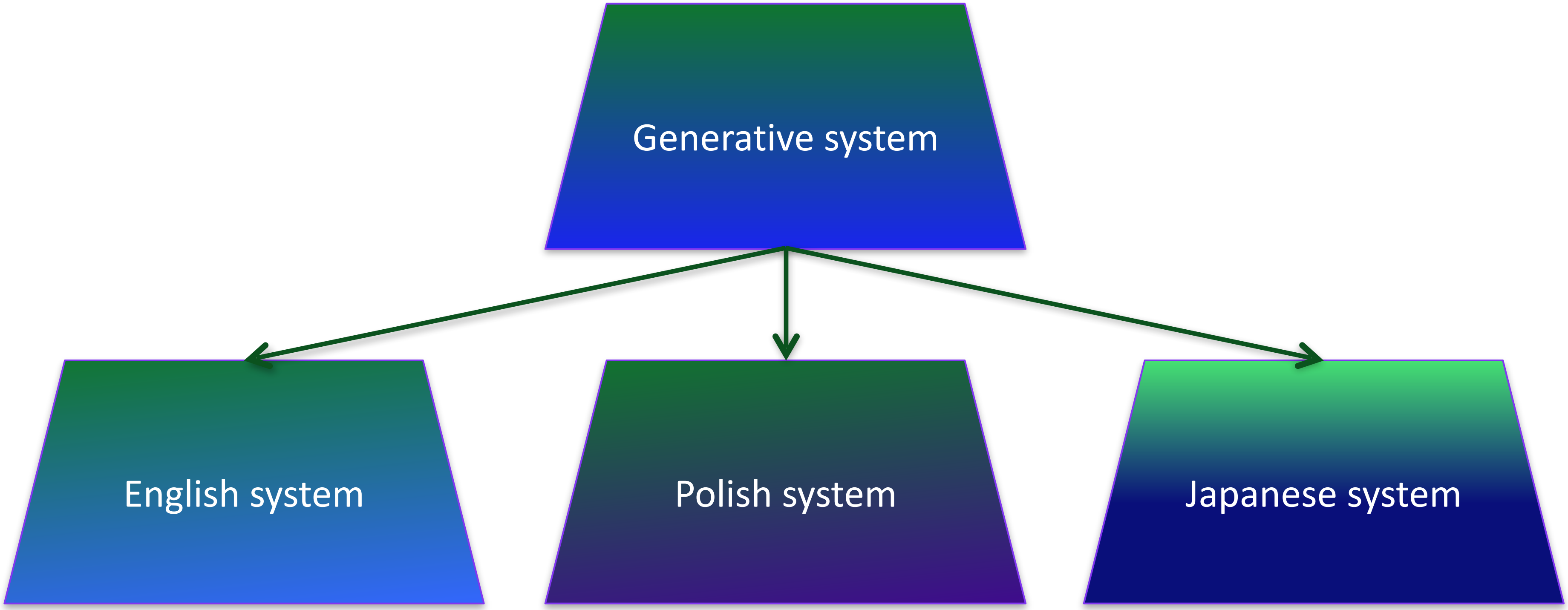
What exactly do you know when you know a language?

The grammar is often imagined as a generative system the speaker uses to comprehend and produce the language.



Generative system variation

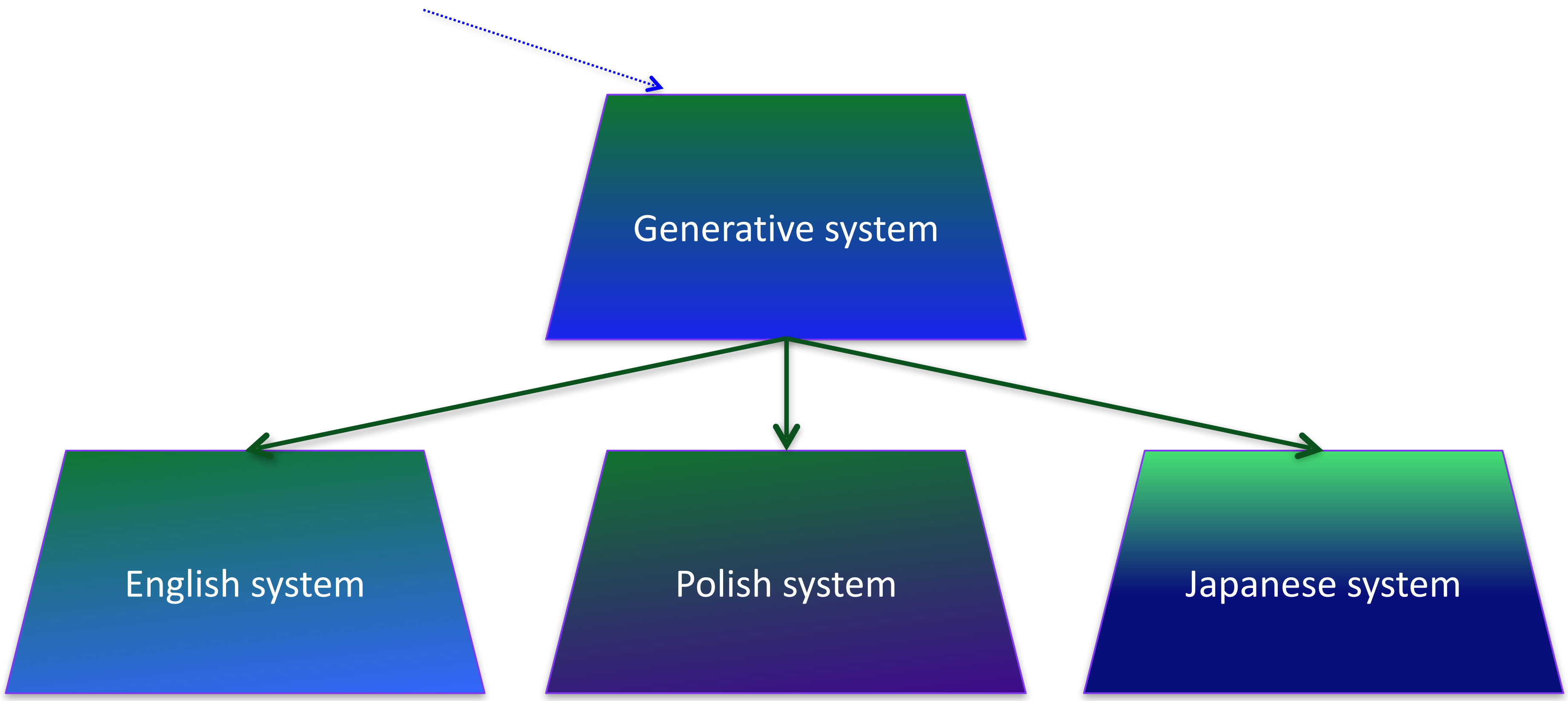
Ideally, this generative system can be instantiated in various ways so that it can handle any of the world's languages.



Grammar instantiations = Knowledge representation

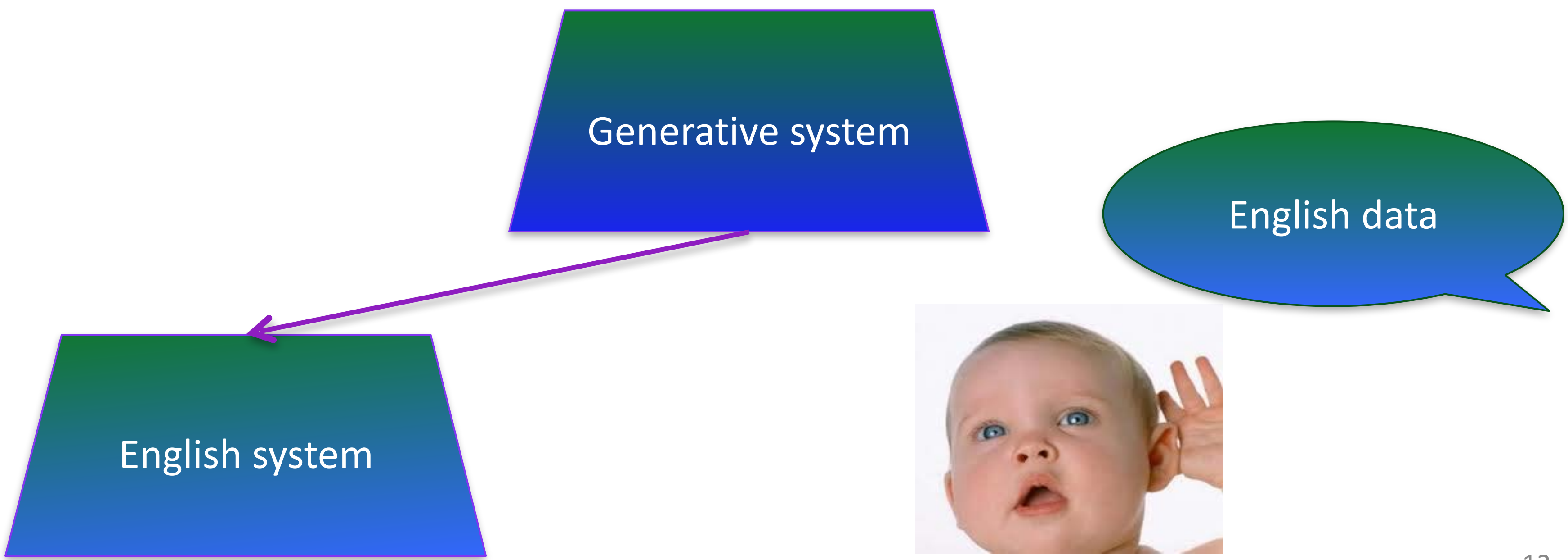
What are the possible ways a grammar can be instantiated?

The knowledge representation encodes information about the general form that grammars for human languages can have.



Grammar instantiations = Knowledge representation

Idea: If the child already knows the general form that grammars for human languages can have, all she needs to do is learn to instantiate her language's grammar appropriately, based on the input data from her language.



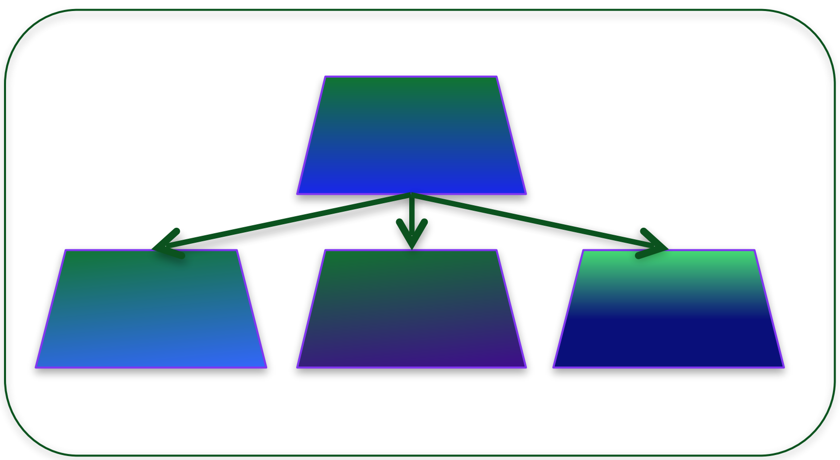
Knowledge representations

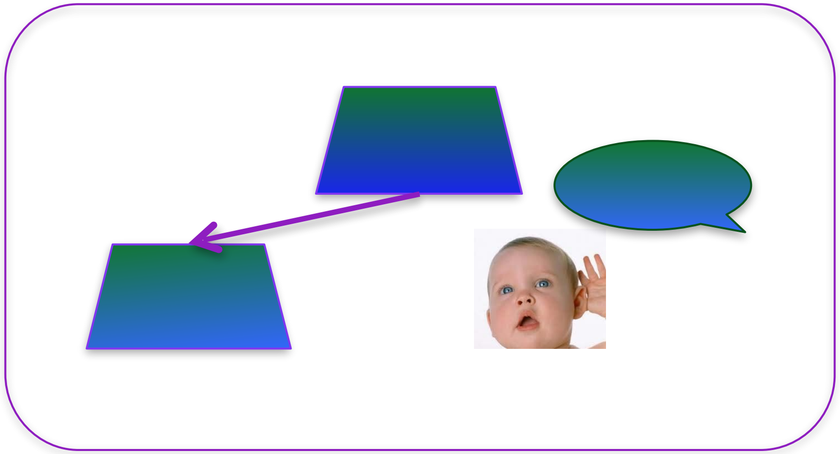
What does a knowledge representation look like?

This demonstrates two checkpoints for any knowledge representation:

(1) it should explain cross-linguistic variation

(2) its language-specific grammar should be learnable from the data children encounter

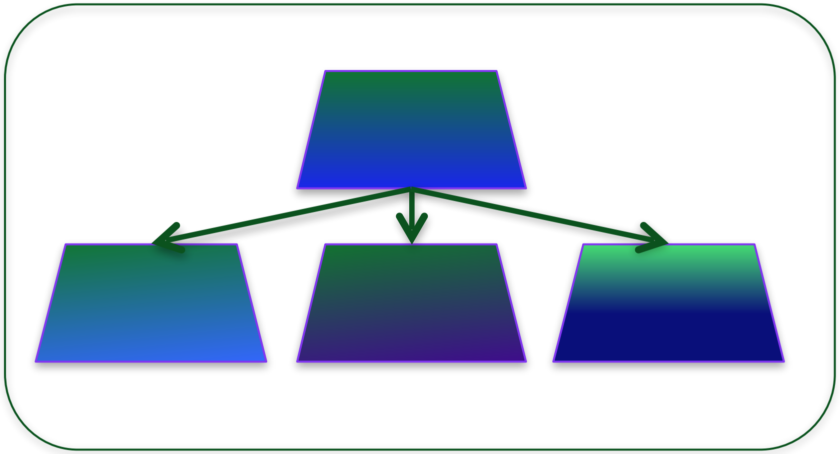


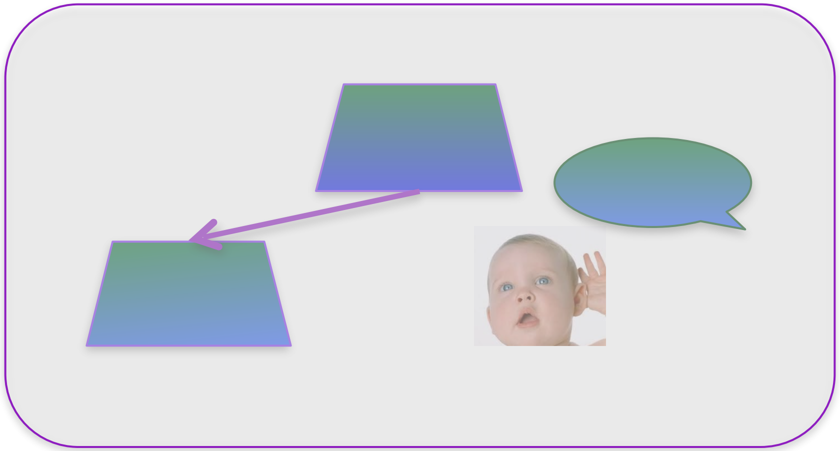


Knowledge representations

What does a knowledge representation look like?

Argument from cross-linguistic variation:
Traditionally, proposals for the general form of knowledge representations have focused on optimizing the first checkpoint of accounting for cross-linguistic variation, with the (often implicit) assumption that the second checkpoint of learnability would be easily satisfied.





Knowledge representations

What does a knowledge representation look like?

Assumption of learnability:
If a child has the right knowledge representation, this makes learning the grammar of a language easy and fast.

Why? The child is just learning the specific instantiation, instead of having to figure out all the relevant variables from scratch.

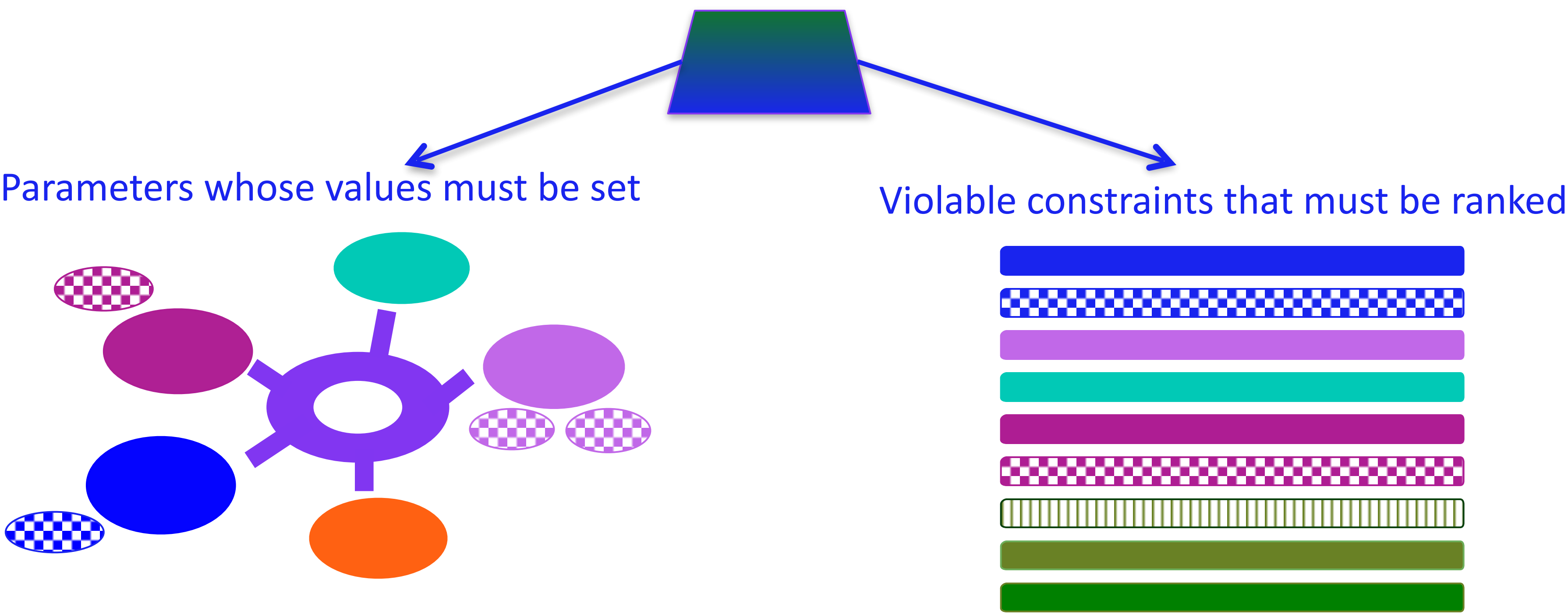
Basic point: The right knowledge representation is helpful for acquisition
(Chomsky 1981, Crain & Pietroski 2002, Dresher 1999)

Knowledge representations

What does a knowledge representation look like?

Argument from cross-linguistic variation:

This has led to several knowledge representations for the different aspects of linguistic knowledge. For example, proposals in metrical phonology have included both parametric and constraint-ranking systems.

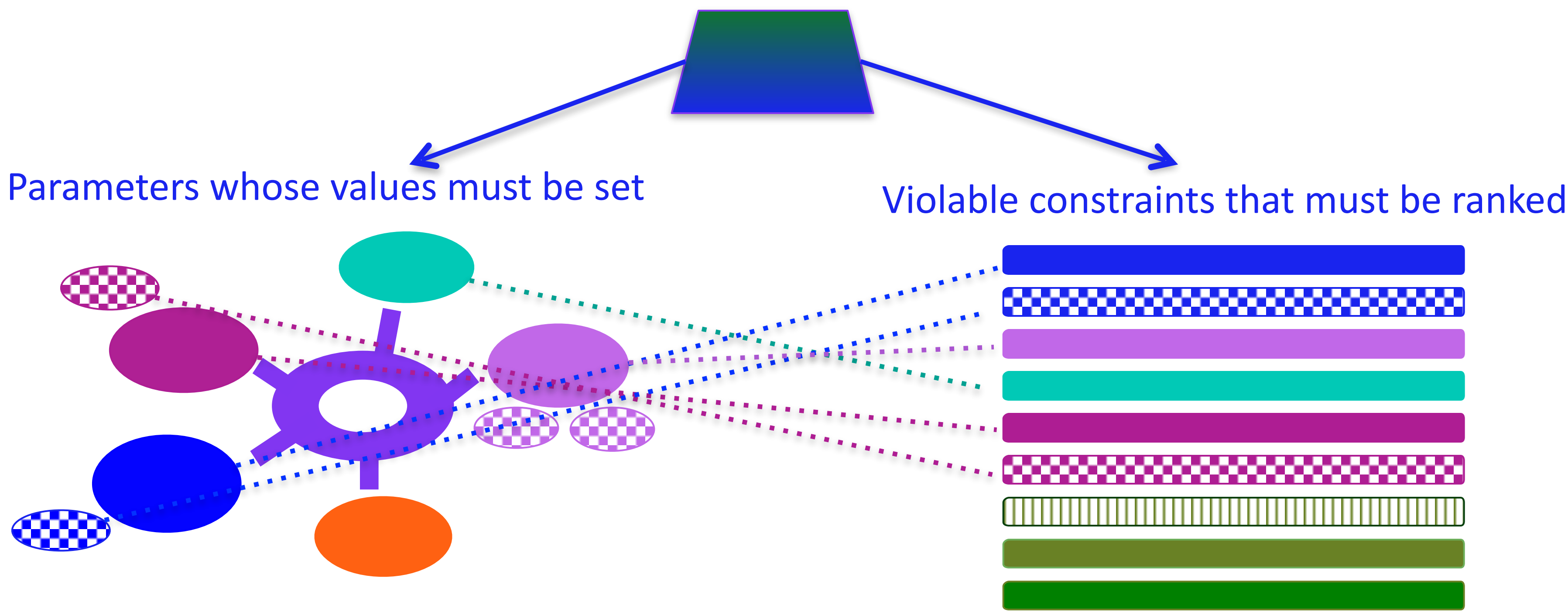


Knowledge representations

What does a knowledge representation look like?

Argument from cross-linguistic variation:

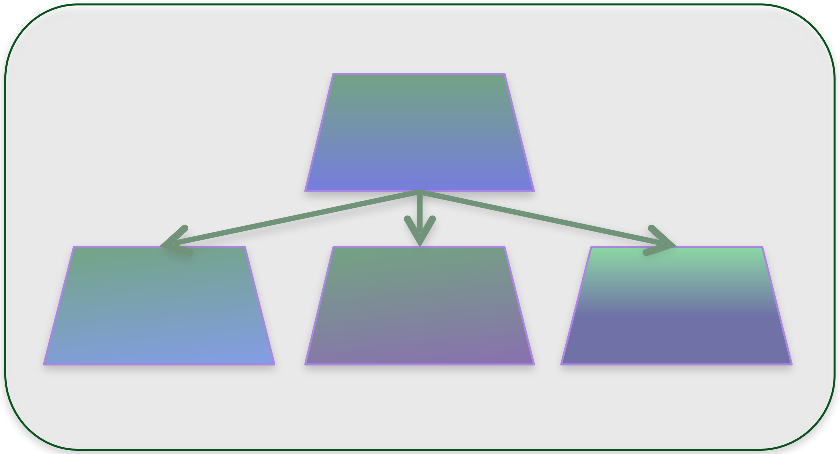
These knowledge representations often overlap on some aspects of their representation components, but generally are not identical.

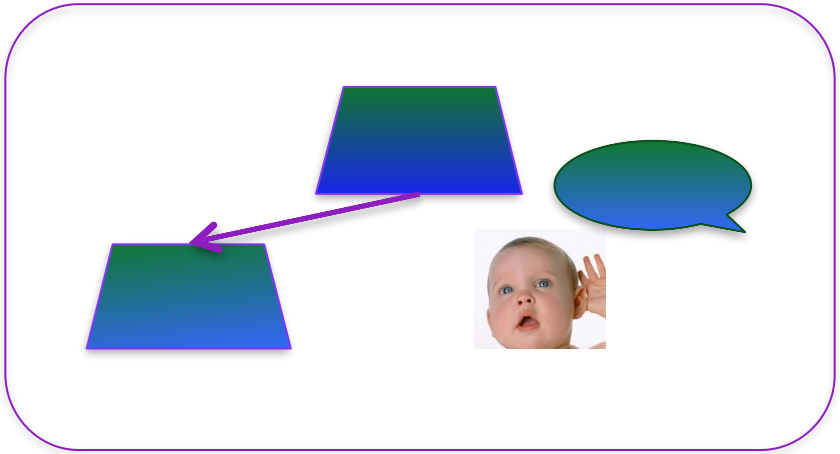


Knowledge representations

What does a knowledge representation look like?

When we have several proposals that satisfy the first criterion (accounting for cross-linguistic variation), it seems sensible to focus on the second criterion (learnability).

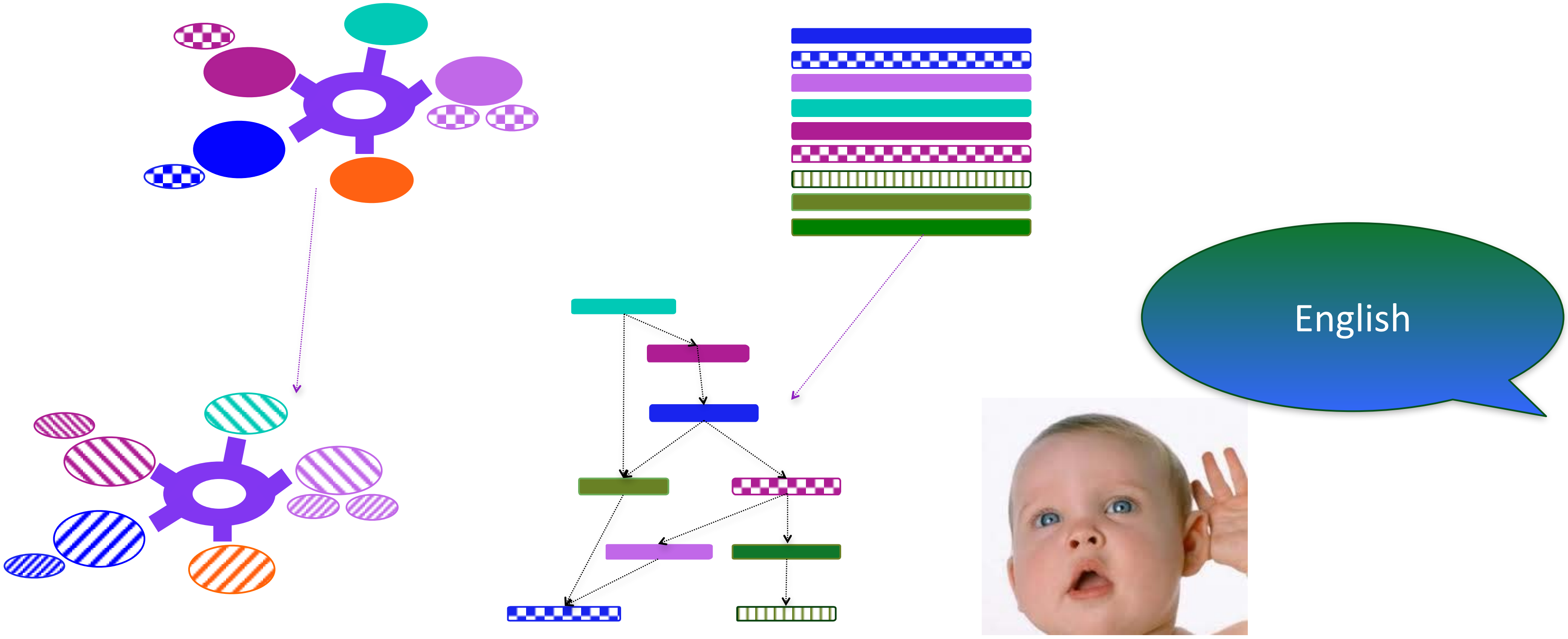




Knowledge representations

What does a knowledge representation look like?

Argument from acquisition: Is a language's specific grammar in that knowledge representation learnable from the kind of data children of the language encounter?



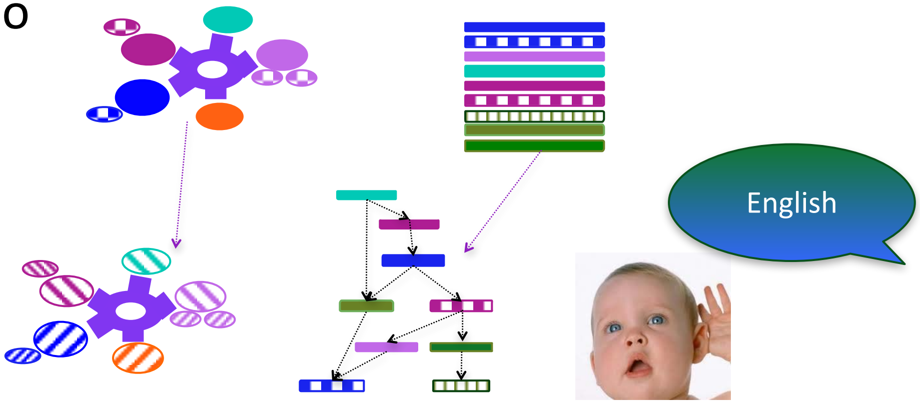
Road map

Empirically grounding & quantifying learnability

Case study:

Knowledge representations in metrical phonology

- ❖ Knowledge representation comparison
- ❖ English as a tricky learning scenario
- ❖ Learnability results & implications



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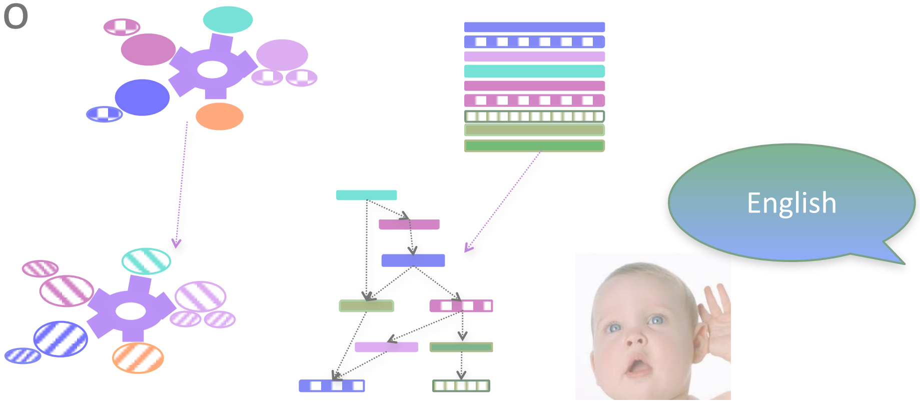

Learnability

How easily does a knowledge representation allow children to learn their specific language's grammar, when given realistic data?

Learnability analysis provides a quantitative way to compare competing knowledge representations (Pearl 2011, Legate & Yang 2012)

Working premise: Rational learners

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A learner trying to learn which grammar is the right one for the language will choose the grammar perceived to be the best.

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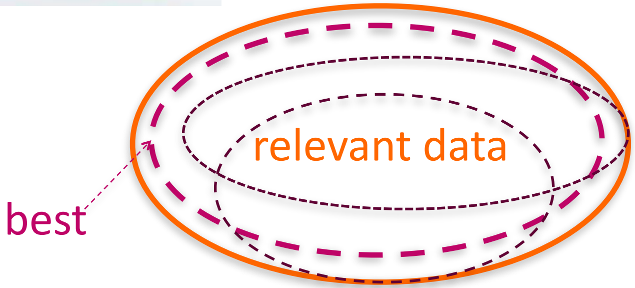
able to account for the most data perceived as relevant



To empirically ground a learnability analysis, we need to draw on a variety of methods.

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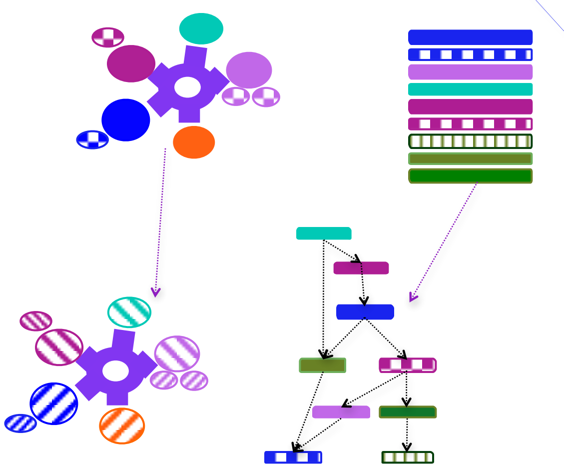
Theoretical methods will define the knowledge representations, the set of grammars defined by a knowledge representation, and the language-specific grammar for a knowledge representation.

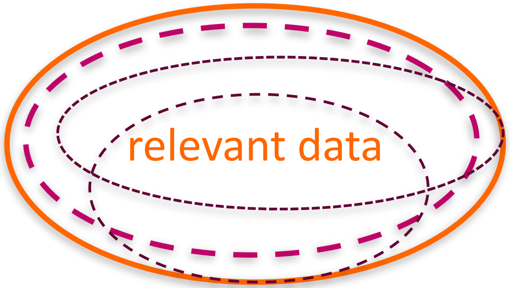


To empirically ground a learnability analysis, we need to draw on a variety of methods.

Field work methods will define the set of data that a language's grammar should maximally account for, while experimental methods can define the data children are learning from.

To empirically ground a learnability analysis, we need to draw on a variety of methods.

Computational methods can analyze how much data any grammar defined by a knowledge representation can account for, including the one that's intended to be that language's grammar.



Quantifying learnability

Once we define the data set the child is learning from, we can then ask which grammar in the hypothesis space defined by the knowledge representation is best, assuming a rational learner that will choose the grammar compatible with the most data.

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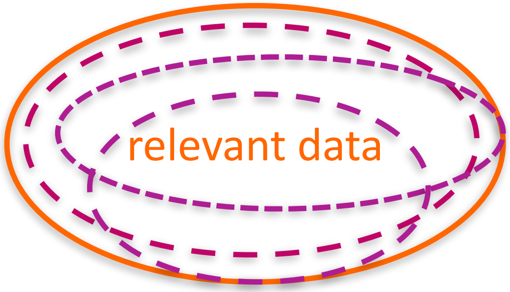
Compatibility with a data point: A grammar is compatible with a data point if the grammar can account for that data point.

A grammar that can account for 70% of the data is better than a grammar that can only account for 55% of the data.



Quantifying learnability

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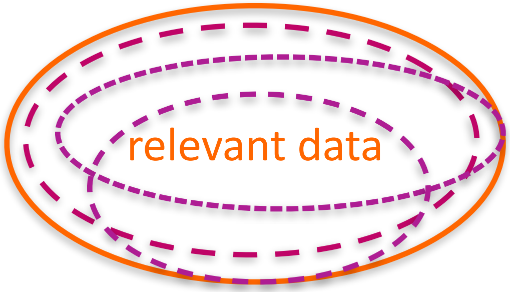
Raw compatibility for a grammar: The amount of data that grammar can account for.

Example: A grammar that can account for 70% of the data has an raw compatibility of 0.70.

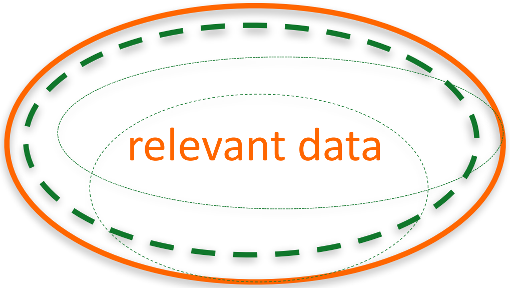


Quantifying learnability

Once we define the data set the child is learning from, we can then ask which grammar in the hypothesis space defined by the knowledge representation is best, assuming a rational learner that will choose the grammar compatible with the most data.

Relative compatibility for a grammar: The proportion of other grammars that this grammar is better than. This indicates how easy it would be for a rational learner looking for the best grammar to choose it.

Example: A grammar with 1.00 relative compatibility is better than all other grammars defined by the knowledge representation.

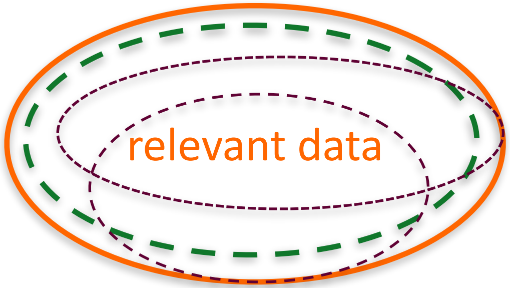


Quantifying learnability

Once we define the data set the child is learning from, we can then ask which grammar in the hypothesis space defined by the knowledge representation is best, assuming a rational learner that will choose the grammar compatible with the most data.

Learnability potential for a knowledge representation: The amount of data the best grammar (relative compatibility = 1.00) is compatible with. This is how much of the data that knowledge representation is capable of accounting for.

Example: If the best grammar can account for 70% of the data, this knowledge representation can account for 70% of the data at best.

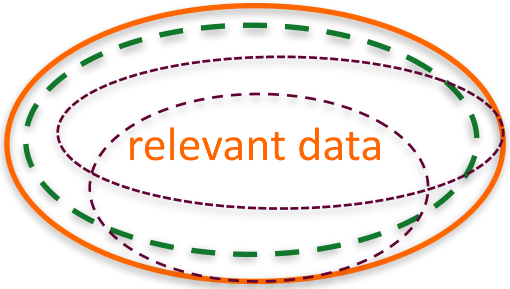


Quantifying learnability

Once we define the data set the child is learning from, we can then ask which grammar in the hypothesis space defined by the knowledge representation is best, assuming a rational learner that will choose the grammar compatible with the most data.

Working assumption:
The language-specific grammar should be the best grammar (relative compatibility = 1.00) for the data of that language, assuming a rational learner that's looking for the best grammar.

It would be good if this grammar also had a high raw compatibility so that it would be useful to have, once learned.



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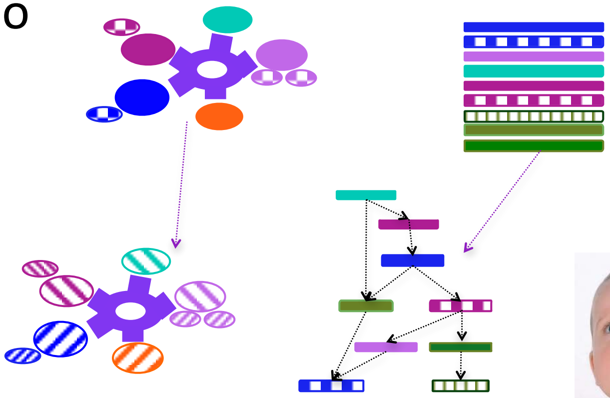

Case study:
A generative system of metrical phonology

Observable data: stress contour OCtopus

Underlying representation determined by grammar?

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A generative system of metrical phonology

Observable data: stress contour

OCtopus

Underlying representation determined by grammar?

? ? ? ?

(H L) H
OC to pus

(S S) S
OC to pus

(S S S)
OC to pus

(H L L)
OC to pus

Involves metrical feet:
Units larger than syllables
but (often) smaller than words

Three knowledge representations

Parametric systems

Correct grammar builds compatible contour

OCtopus

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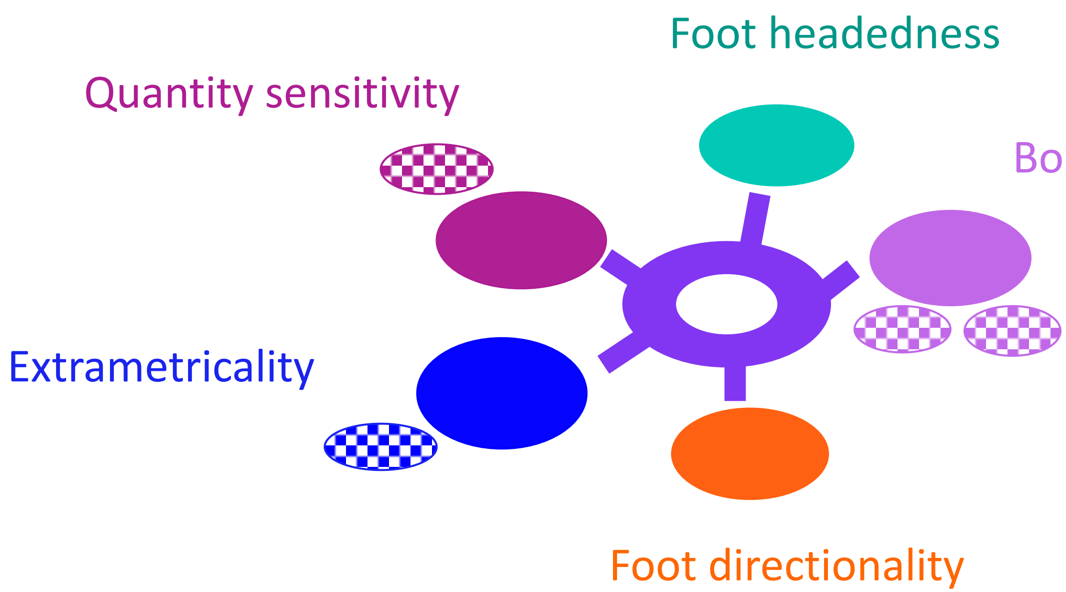
Correct grammar builds compatible contour

OCtopus

HV: Halle & Vergnaud 1987, Dresher 1999

5 parameters & 4 sub-parameters

Hypothesis space: 156 grammars



Grammar = Set of parameter & sub-parameter values

Three knowledge representations

Parametric systems

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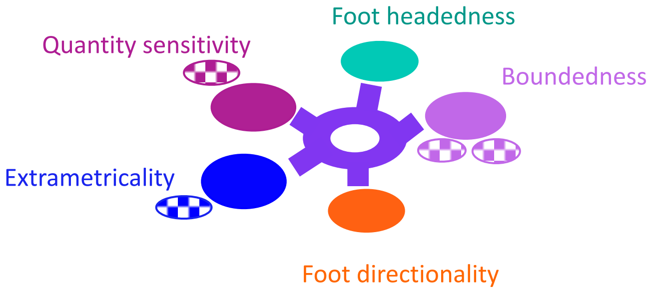

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oc to pus

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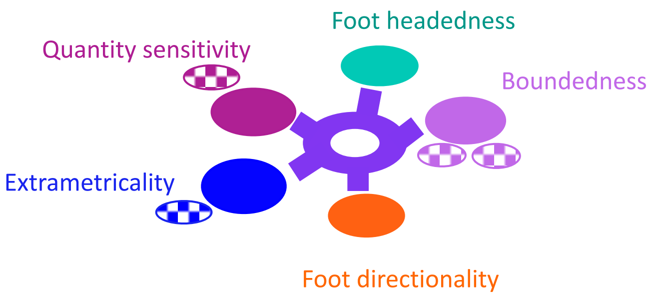

H L H

oc to pus

Are syllables all identical, or are they differentiated by syllable weight (into Heavy and Light syllables)?

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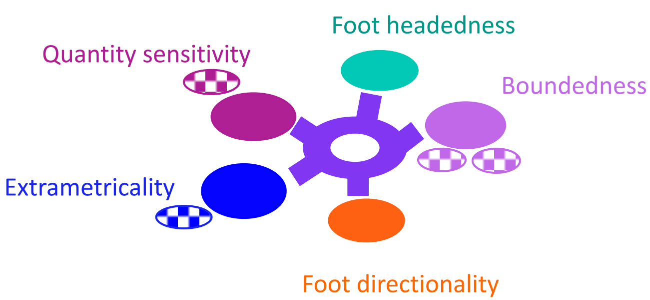

H L ~~H~~

oc to pus

Are all syllables included in the larger units of metrical feet, or are some excluded?

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Correct grammar builds compatible contour

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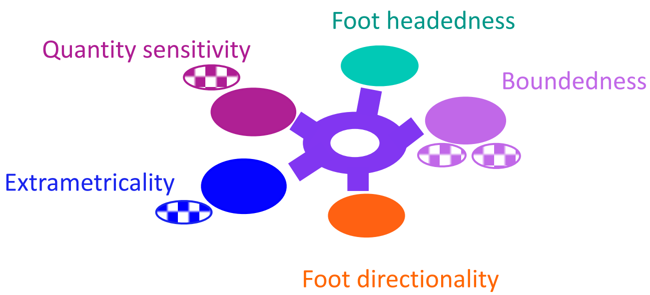

H L) H

oc to pus

Are feet constructed from the left or from the right?

Three knowledge representations

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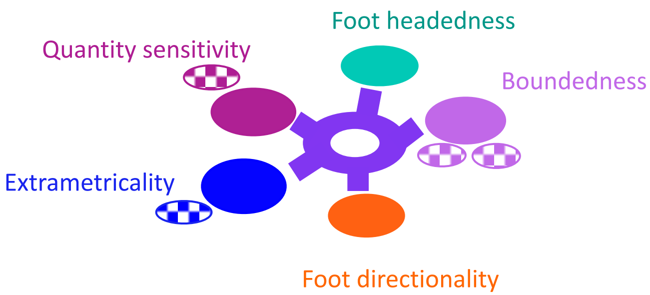

How big are metrical feet?

Correct grammar **builds** compatible contour

OCtopus

(H L) ~~H~~

oc to pus

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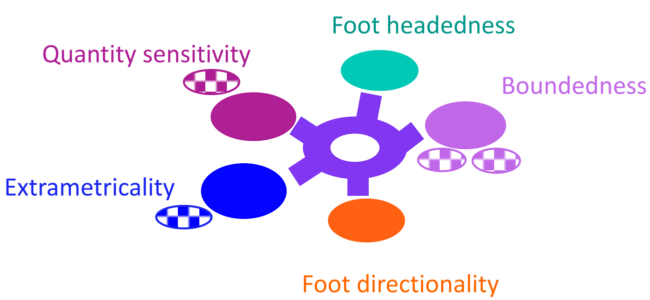

Correct grammar builds compatible contour

OCtopus

(H L) H
oc to pus

Which syllable in a foot is stressed?

Three knowledge representations

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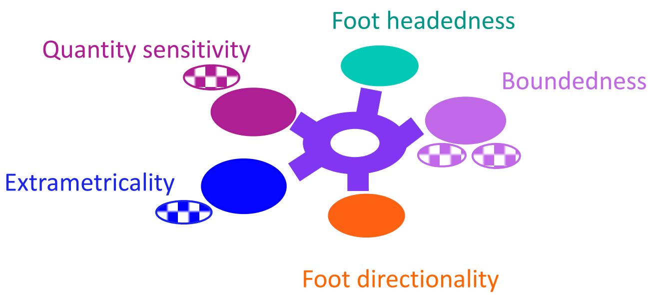


Correct grammar builds compatible contour

OCtopus

This grammar, comprised of particular parameter values, generates the correct stress contour.

(H L) H
OC to pus

Three knowledge representations

Parametric systems

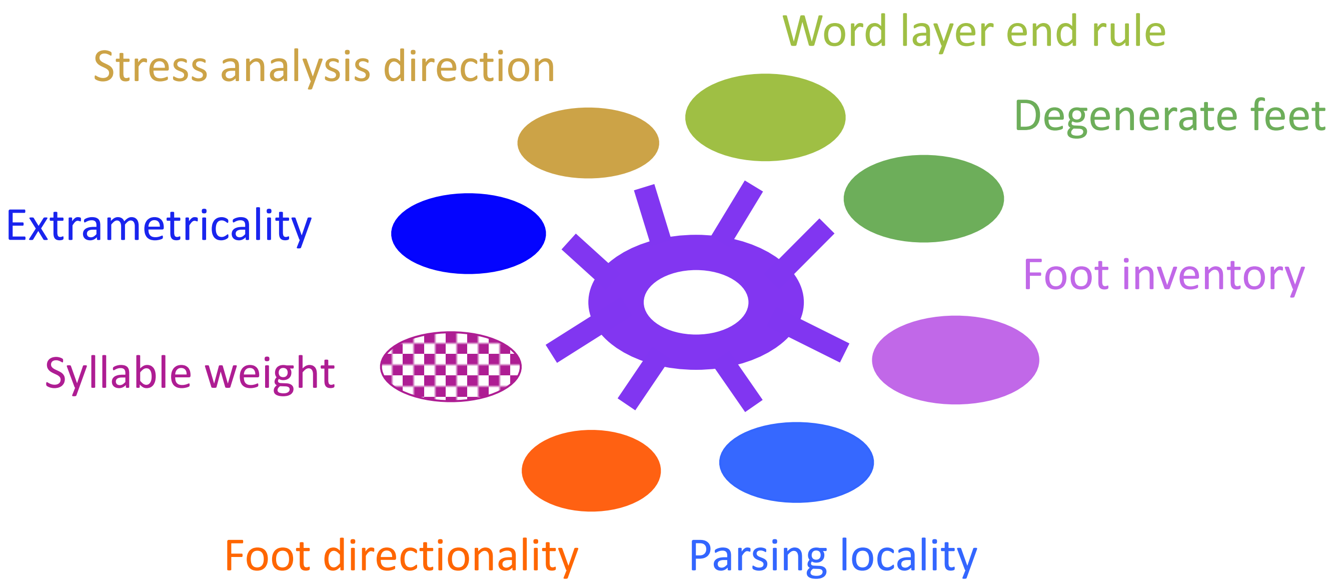
Hayes: Hayes 1995

8 parameters

Hypothesis space: 768 grammars

Correct grammar builds compatible contour

OCtopus



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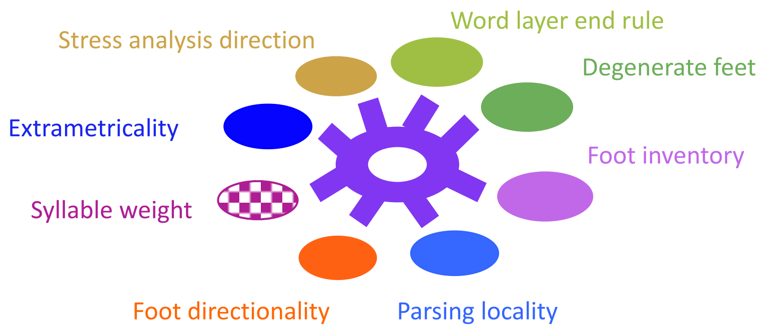

Correct grammar builds compatible contour

OCtopus

Grammar = set of parameter values used to build a stress contour

Three knowledge representations

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Hayes: Hayes 1995

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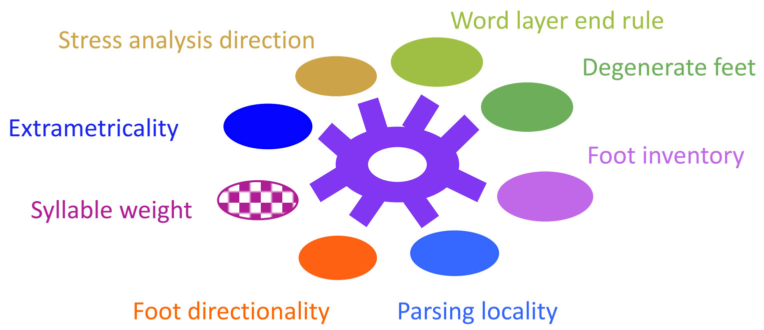
Hypothesis space: 768 grammars



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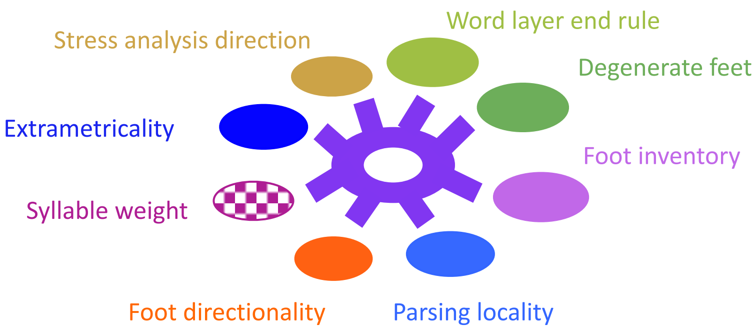

Correct grammar builds compatible contour

OCtopus

(...feet first...)

oc to pus

Are metrical feet created before word-level stress is assigned to the edge syllables or after?

Three knowledge representations

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Correct grammar builds compatible contour

OCtopus

Hayes: Hayes 1995

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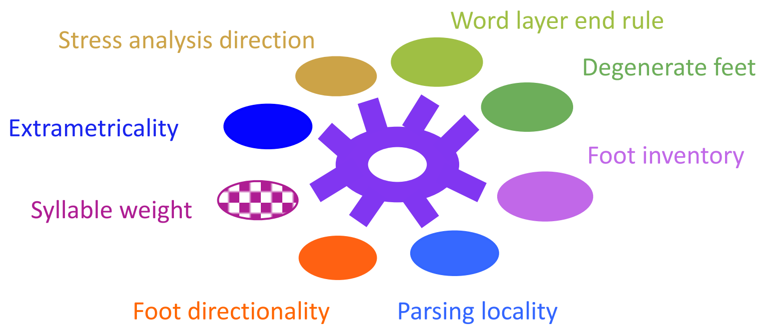
Hypothesis space: 768 grammars



oc to pus

Are syllables on the edge (or parts of syllables) excluded from metrical feet?

Three knowledge representations

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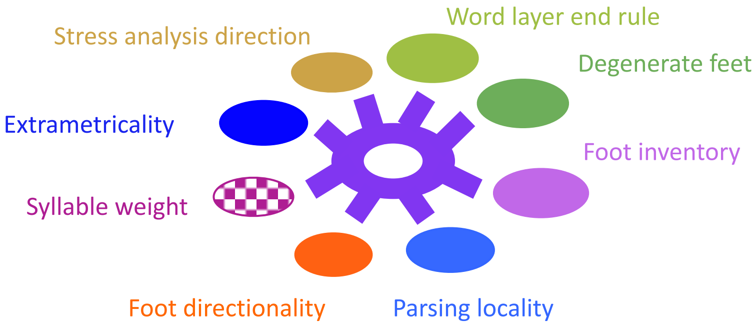
8 parameters

Hypothesis space: 768 grammars



Correct grammar builds compatible contour

OCtopus

H L L

oc to pus

Syllables are distinguished into Heavy and Light. Are syllables ending in VC (like <u>*oc*</u>) Heavy or Light?

Three knowledge representations

Parametric systems

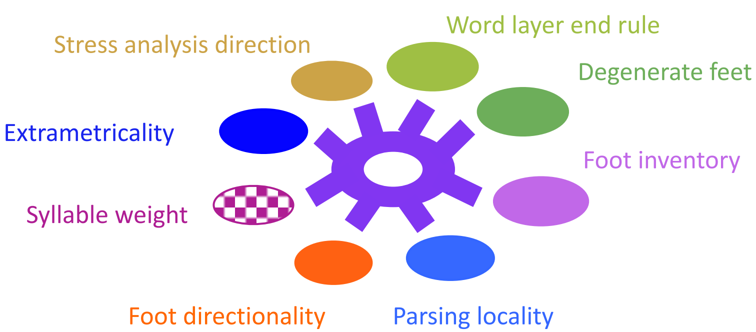
Correct grammar **builds** compatible contour

OCtopus

Hayes: Hayes 1995

8 parameters

Hypothesis space: 768 grammars



H L L)

oc to pus

Are metrical feet constructed from the left or the right?

Three knowledge representations

Parametric systems

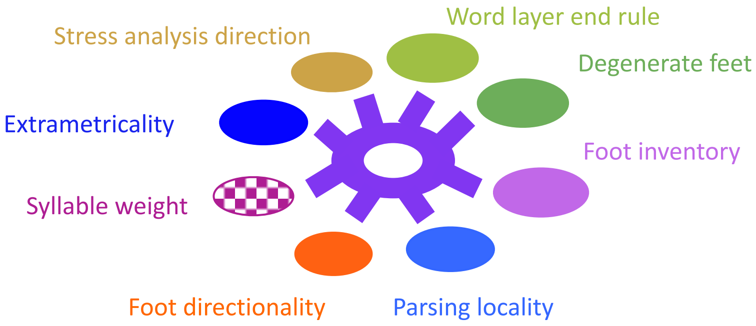
Correct grammar builds compatible contour

OCtopus

Hayes: Hayes 1995

8 parameters

Hypothesis space: 768 grammars



H L L)

oc to pus

Are Light syllables skipped when building feet?

Three knowledge representations

Parametric systems

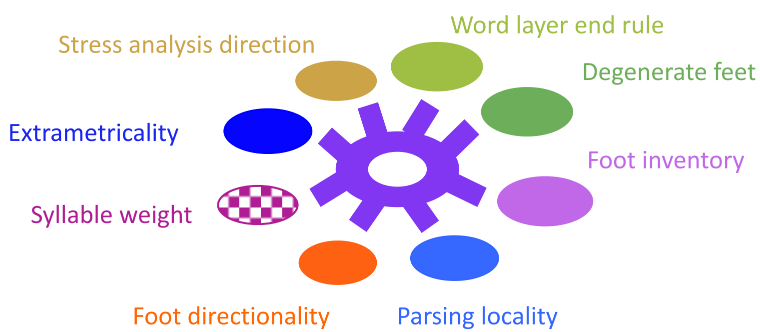
Correct grammar builds compatible contour

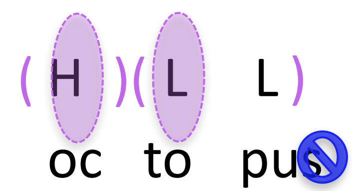
OCtopus

Hayes: Hayes 1995

8 parameters

Hypothesis space: 768 grammars





How big are metrical feet?
Where does the stress fall within them?

Three knowledge representations

Parametric systems

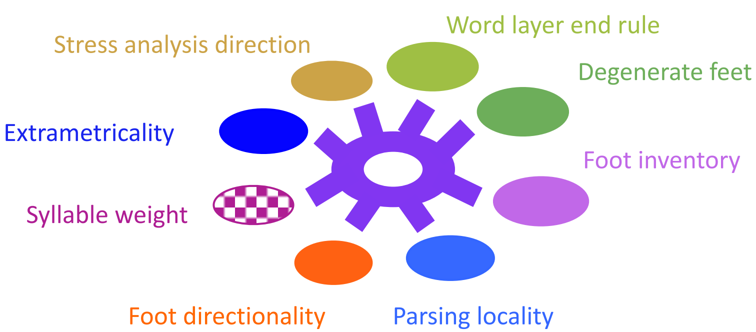
Correct grammar builds compatible contour

OCtopus

Hayes: Hayes 1995

8 parameters

Hypothesis space: 768 grammars



(H)(L L)

oc to pus

What do you do with leftover Light syllables if you have any?

Three knowledge representations

Parametric systems

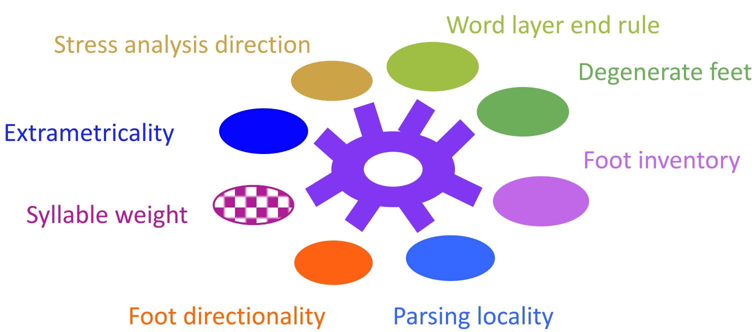
Correct grammar builds compatible contour

OCtopus

Hayes: Hayes 1995

8 parameters

Hypothesis space: 768 grammars



(H)(L L)

oc to pus

Where does word-level stress go if there are multiple stressed syllables? Can leftover Light syllables have word-level stress?

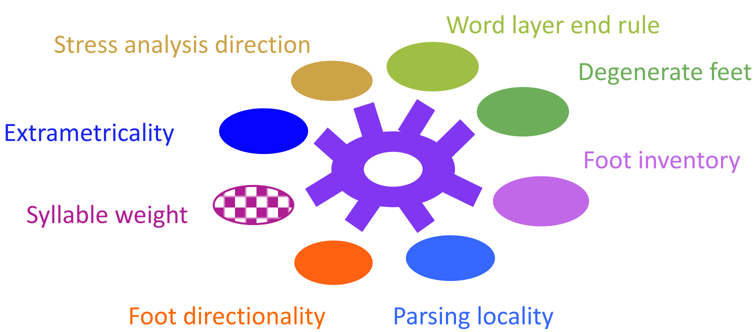
Three knowledge representations

Parametric systems

Hayes: Hayes 1995

8 parameters

Hypothesis space: 768 grammars



Correct grammar builds compatible contour

OCtopus

This grammar, comprised of particular parameter values, generates an incorrect stress contour.

(H)(L L)

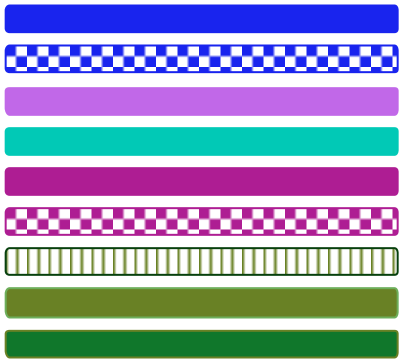
OC TÓ pus

Three knowledge representations

Constraint-ranking systems

OT: Hammond 1999, Pater 2000, Tesar & Smolensky 2000

9 violable constraints



Three knowledge representations

Constraint-ranking systems

Best candidate for the correct grammar has a compatible contour

OCtopus

OT: Hammond 1999, Pater 2000, Tesar & Smolensky 2000

9 violable constraints

Premise: Many different candidates for a word's stress representation and contour are generated and then ranked according to which constraints are violated. Violating higher-ranked constraints is worse than violating lower-ranked constraints.

	C1	C2	C3	C4
(OC to) pus			*	*
oc (TO pus)	*		*	
(oc TO) pus		*	*	

Three knowledge representations

Best candidate for the correct grammar has a compatible contour

OCtopus

Constraint-ranking systems

OT: Hammond 1999, Pater 2000, Tesar & Smolensky 2000

9 violable constraints

Hypothesis space: 9! rankings = 362,880 grammars

Grammar = ranked ordering of all constraints

Three knowledge representations

Best candidate for the correct grammar has a compatible contour

OCtopus

Constraint-ranking systems

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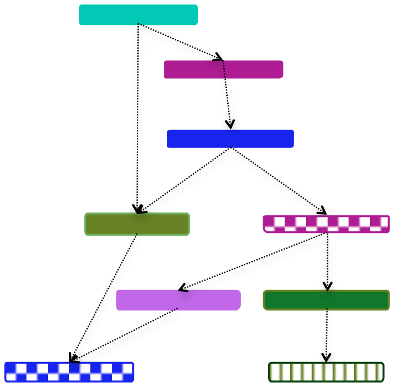
9 violable constraints

Hypothesis space: 9! rankings = 362,880 grammars

Official grammars for actual languages are often described as partial orderings of constraints.



Three knowledge representations

Best candidate for the correct grammar has a compatible contour

OCtopus

Constraint-ranking systems

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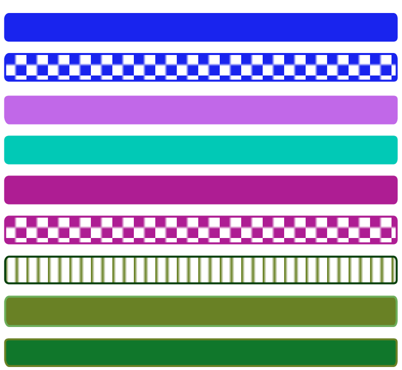
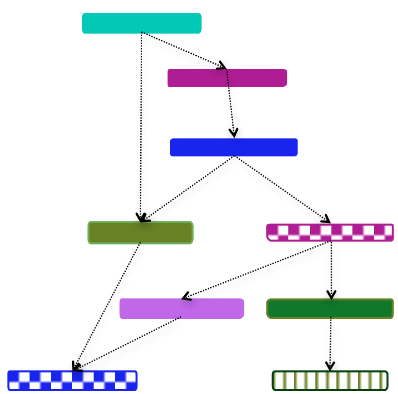
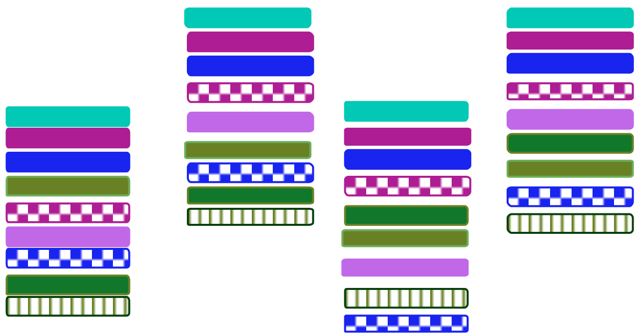
This means the "grammar" for a language is often a set of the possible rankings (grammars) that obey those orderings.





Ex: The English "grammar" is compatible with 26 rankings.



Three knowledge representations

Constraint-ranking systems

Best candidate for the correct grammar has a compatible contour

OCtopus

OT: Hammond 1999, Pater 2000, Tesar & Smolensky 2000

9 violable constraints

Hypothesis space: 9! rankings = 362,880 grammars

Principle (Rooting): All words must have stress

Nonfinality, Parse-σ

Foot binarity

Trochaic

Weight-to-Stress

Align left, Align right

*Sonorant nucleus

Three knowledge representations

Constraint-ranking systems

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Should the final syllable not be in a metrical foot?

(OC to) (PUS)	✓ (OC to) pus
(oc TO) (PUS)	oc (TO pus)

Three knowledge representations

Constraint-ranking systems

Best candidate for the correct grammar has a compatible contour

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Should all syllables be in metrical feet?

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Three knowledge representations

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OCtopus

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Principle (Rooting): All words must have stress

Should all metrical feet consist of two units?

(OC to) (PUS)

(OC to) pus

(oc TO) (PUS)

oc (TO pus)

Three knowledge representations

Constraint-ranking systems

OT: Hammond 1999, Pater 2000, Tesar & Smolensky 2000

9 violable constraints

Hypothesis space: 9! rankings = 362,880 grammars

Principle (Rooting): All words must have stress

Best candidate for the correct grammar has a compatible contour

OCtopus

Should metrical feet have stress on the leftmost syllable?

✓ (OC to) (PUS)

(oc TO) (PUS)

✓ (OC to) pus

✓ oc (TO pus)

Three knowledge representations

Constraint-ranking systems

Best candidate for the correct grammar has a compatible contour

BAby

OT: Hammond 1999, Pater 2000, Tesar & Smolensky 2000

9 violable constraints

Hypothesis space: 9! rankings = 362,880 grammars

Principle (Rooting): All words must have stress

Should all VV syllables be stressed?

(ba BY) ✓ (BA) (BY)

(BA) by (BA by)

Three knowledge representations

Best candidate for the correct grammar has a compatible contour

OCtopus

Constraint-ranking systems

OT: Hammond 1999, Pater 2000, Tesar & Smolensky 2000

9 violable constraints

Hypothesis space: 9! rankings = 362,880 grammars

Principle (Rooting): All words must have stress

Should all VC syllables be stressed?

✓ (OC to) (PUS)

(OC to) pus

(oc TO) (PUS)

oc (TO pus)

Three knowledge representations

Constraint-ranking systems

Best candidate for the correct grammar has a compatible contour

OCtopus

OT: Hammond 1999, Pater 2000, Tesar & Smolensky 2000

9 violable constraints

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Principle (Rooting): All words must have stress

- Nonfinality, Parse-σ
- Foot binarity
- Trochaic
- Weight-to-Stress
- Align left, Align right
- *Sonorant nucleus

Should metrical feet include the leftmost syllable?

✓ (OC to) (PUS)

✓ (OC to) pus

✓ (oc TO) (PUS)

oc (TO pus)

Three knowledge representations

Best candidate for the correct grammar has a compatible contour

OCtopus

Constraint-ranking systems

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9 violable constraints

Hypothesis space: 9! rankings = 362,880 grammars

Principle (Rooting): All words must have stress

Should metrical feet include the rightmost syllable?

✓ (OC to) (PUS)

(OC to) pus

✓ (oc TO) (PUS)

✓ oc (TO pus)

Three knowledge representations

Constraint-ranking systems

Best candidate for the correct grammar has a compatible contour

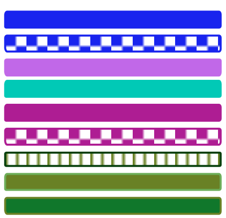
yourSELF

OT: Hammond 1999, Pater 2000, Tesar & Smolensky 2000

9 violable constraints

Hypothesis space: 9! rankings = 362,880 grammars

Principle (Rooting): All words must have stress



Should syllables not have sonorants (m, n, ŋ, l, r) as the nucleus?

✓ your (SELF)	(yr SELF)
✓ (YOUR) (SELF)	(YOUR slf)

Three knowledge representations

Constraint-ranking systems

Best candidate for the correct grammar has a compatible contour

OCtopus

OT: Hammond 1999, Pater 2000, Tesar & Smolensky 2000

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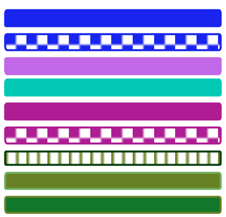
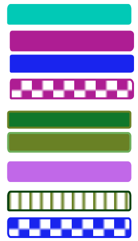
Principle (Rooting): All words must have stress



Nonfinality, Parse-σ
Foot binarity
Trochaic
Weight-to-Stress
Align left, Align right
*Sonorant nucleus

A sample grammar:



Sample candidates

(OC to) (PUS) (OC to) pus

(oc TO) (PUS) oc (TO pus)

Three knowledge representations

Best candidate for the correct grammar has a compatible contour

OCtopus

Constraint-ranking systems

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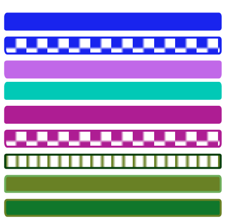
Principle (Rooting): All words must have stress



Nonfinality, Parse-σ

Foot binarity

Trochaic

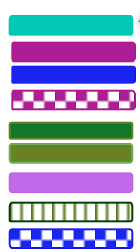
Weight-to-Stress

Align left, Align right

*Sonorant nucleus

Most important: Metrical feet have stress on the leftmost syllable.

A sample grammar:



Sample candidates

(OC to) (PUS)

(OC to) pus

~~(oc TO) (PUS)~~

oc (TO pus)

Three knowledge representations

Best candidate for the correct grammar has a compatible contour

OCtopus

Constraint-ranking systems

OT: Hammond 1999, Pater 2000, Tesar & Smolensky 2000

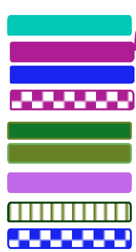
9 violable constraints

Hypothesis space: 9! rankings = 362,880 grammars

Principle (Rooting): All words must have stress

Next important: VV syllables are stressed.

A sample grammar:



Sample candidates

(OC to) (PUS)

(OC to) pus

(oc TO) (PUS)

oc (TO pus)

Three knowledge representations

Constraint-ranking systems

Best candidate for the correct grammar has a compatible contour

OCtopus

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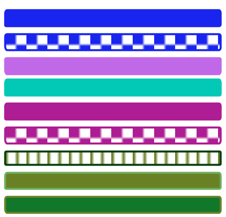


Nonfinality, Parse-σ

Foot binarity

Trochaic

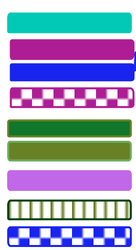
Weight-to-Stress

Align left, Align right

*Sonorant nucleus

Next important: The final syllable is not included in a foot.

A sample grammar:



Sample candidates

~~(OC to) (PUS)~~

(OC to) pus

~~(oc TO) (PUS)~~

~~oc (TO pus)~~

Three knowledge representations

Constraint-ranking systems

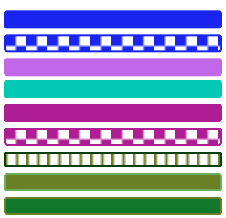
Best candidate for the correct grammar has a compatible contour

OT: Hammond 1999, Pater 2000, Tesar & Smolensky 2000

9 violable constraints

Hypothesis space: 9! rankings = 362,880 grammars

Principle (Rooting): All words must have stress

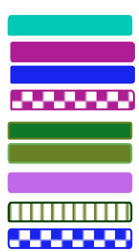


OCtopus

Only one candidate left, and it has a compatible contour.

Sample candidates

A sample grammar:



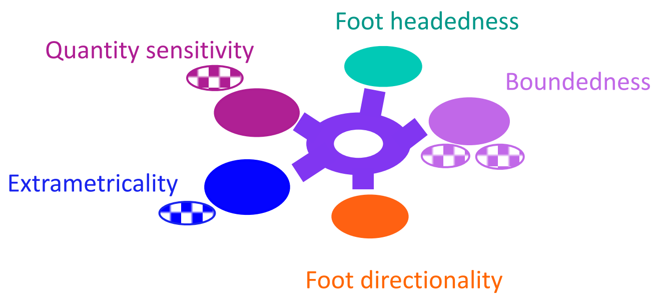
~~(OC to) (PUS)~~

(OC to) pus

~~(oc TO) (PUS)~~

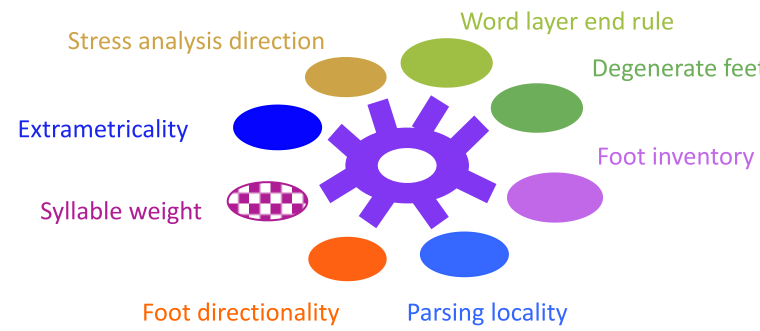
~~oc (TO pus)~~

Knowledge representation comparison



HV: 5 parameters & 4 sub-parameters

Hypothesis space: 156 grammars



Hayes: 8 parameters

Hypothesis space: 768 grammars

OT: 9 violable constraints

Hypothesis space: 362,880 grammars

Learning English metrical phonology: Non-trivial

Non-trivial because there are many data that are ambiguous for which parameter value or constraint ranking they implicate

OCtopus ?

This is generally a problem for acquisition.

Learning English metrical phonology: Non-trivial

Non-trivial because there are many irregularities. This is less common for acquisition – usually there aren't a lot of exceptions to the system being acquired.

Learning English metrical phonology: Non-trivial

Non-trivial because there are many irregularities. This is less common for acquisition – usually there aren't a lot of exceptions to the system being acquired.

Some causes of irregularity:

Interactions with morphology (Chomsky & Halle 1968, Hayes 1982, Kiparsky 1979)

Example: Adding productive morphology doesn't change the stress pattern, even though all grammars base their stress patterns on the syllables present in the word.

EARly	PREtty	senSAtion
EARlier	PREttiest	senSAtional
		senSAtionally

Learning English metrical phonology: Non-trivial

Non-trivial because there are many irregularities. This is less common for acquisition – usually there aren't a lot of exceptions to the system being acquired.

Some causes of irregularity:

Interactions with grammatical category (Hammond 1999, Hayes 1982, Cassidy & Kelly 2001, Christiansen & Monaghan 2006)

Stress contours may be different across grammatical categories, even though the syllabic word form doesn't change.

NOUNS	VERBS
CONduct	conDUCT
DEsert	deSERT
SUspect	suSPECT

Learning English metrical phonology: Non-trivial

These irregularities can cause multiple stress contours to be associated with a syllabic word form. This is problematic for the grammars in these knowledge representations…

Syllabic word form: V VV

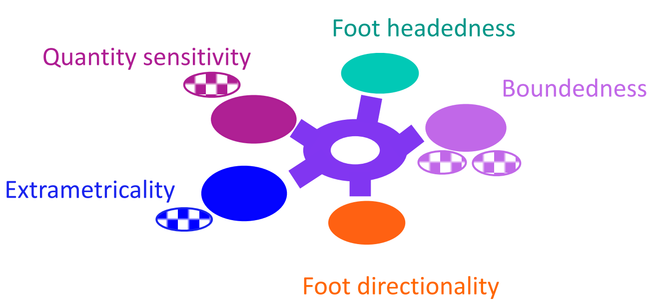
KI tty	a WAY	UH OH
V vv	v VV	V VV

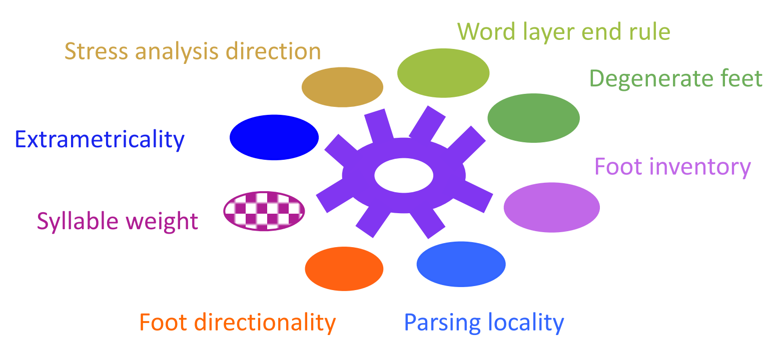
Learning English metrical phonology: Non-trivial

These irregularities can cause multiple stress contours to be associated with a syllabic word form. This is problematic for the grammars in these knowledge representations, since a grammar can only generate a single stress contour per syllabic word form…

Syllabic word form: V VV

Generate one of these…	KI tty	a WAY	UH OH
	V vv	v VV	V VV





Learning English metrical phonology: Non-trivial

These irregularities can cause multiple stress contours to be associated with a syllabic word form. This is problematic for the grammars in these knowledge representations, since a grammar can only generate a single stress contour per syllabic word form or select a single stressed syllabic word form as the best candidate.

Syllabic word form: V VV

Select one of these…	KI tty	a WAY	UH OH
	V vv	v VV	V VV

Learning English metrical phonology: Non-trivial

Upshot of multiple stress contours: No one grammar can account for all the stressed words in the input.

But how big of a problem is this in English child-directed speech?

Syllabic word form: V VV

KI tty	a WAY	UH OH
V vv	v VV	V VV

Learning English metrical phonology: Non-trivial

Analysis of Brent corpus (CHILDES database): 4780 word types (99,968 tokens) of American English speech directed at children between the ages of 6 and 12 months

Syllabic word form: V VV

KI tty	a WAY	UH OH
V vv	v VV	V VV

Multiple stress contours

HV: 95 of 186 syllabic word forms

Hayes: 86 of 149 syllabic word forms

OT: 166 of 452 syllabic word forms

This occurs a lot!

Learning English metrical phonology

So what's the best any grammar in a given knowledge representation actually does, given these data?

Learnability potential = proportion of data the best grammar (relative compatibility = 1.00) can account for

Learning English metrical phonology

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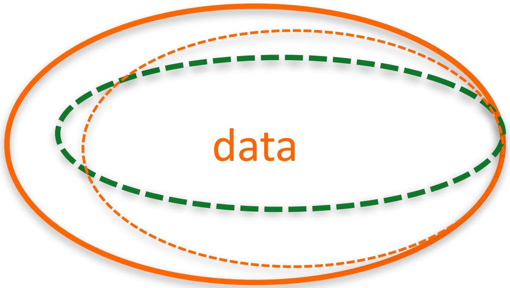
Raw compatibility of best grammar

HV: 0.668 types (0.739 tokens)

Hayes: 0.683 types (0.750 tokens)

OT: 0.657 types (0.729 tokens)

Around 2/3 of the word types



Learning English metrical phonology

Implication:

The best grammar is pretty useful to have. It allows a learner to account for a good proportion of the input, even if there's a significant chunk that can't be accounted for.

Raw compatibility of best grammar

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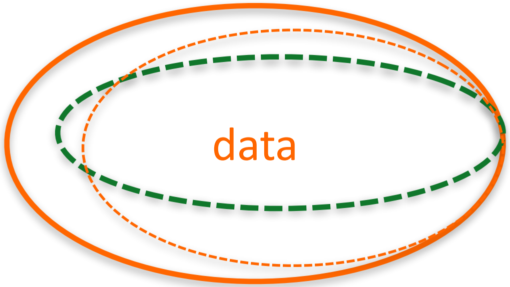
Around 2/3 of the word types



Learning English metrical phonology

So how does the (best) English grammar in a given knowledge representation do, given these data?

Raw compatibility of the English grammar = proportion of data the (best) English grammar can account for

Learning English metrical phonology

So how does the (best) English grammar in a given knowledge representation do, given these data?

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Raw compatibility of English grammar

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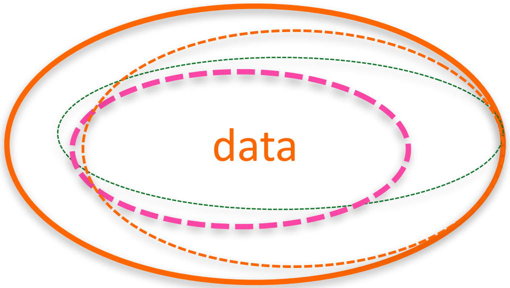
Significantly less than the best grammar



Learning English metrical phonology

So how does the (best) English grammar in a given knowledge representation do, given these data?

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Raw compatibility of English grammar

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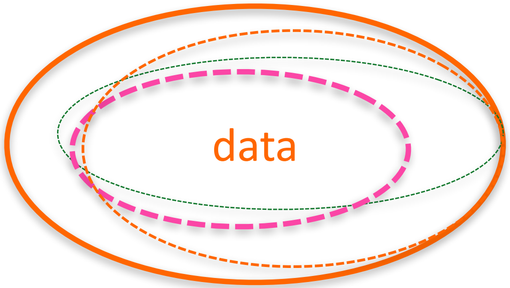

Learning English metrical phonology

Implication:

A rational learner would not pick the English grammar for any of these knowledge representations. It would pick the best grammar instead.

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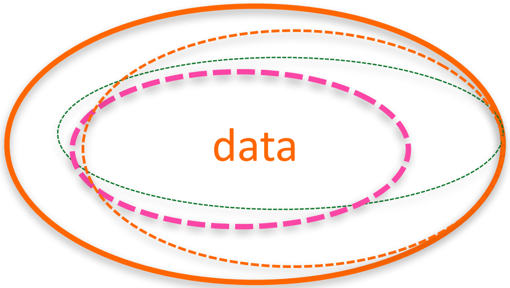
Hayes: 0.683 types (0.750 tokens)
OT: 0.657 types (0.729 tokens)



Learning English metrical phonology

So how does the (best) English grammar compare to the other grammars defined by the knowledge representation?

Relative compatibility of the English grammar = proportion of grammars in the hypothesis space the (best) English grammar is better than

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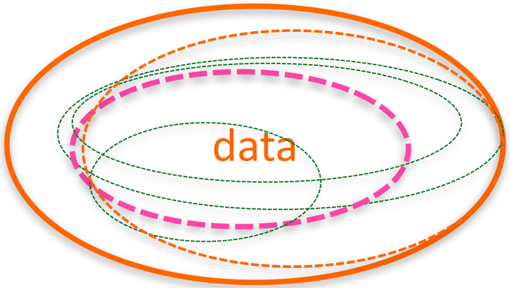
Better than many…but many are still better



Learning English metrical phonology

Implication:

There are many other grammars in the hypothesis space that are more compatible with the data. Even if children aren't optimal learners, it would be easier to pick one of these other more compatible grammars.

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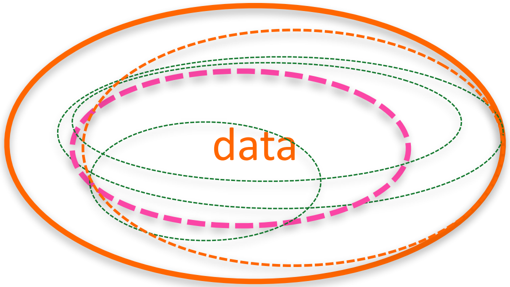
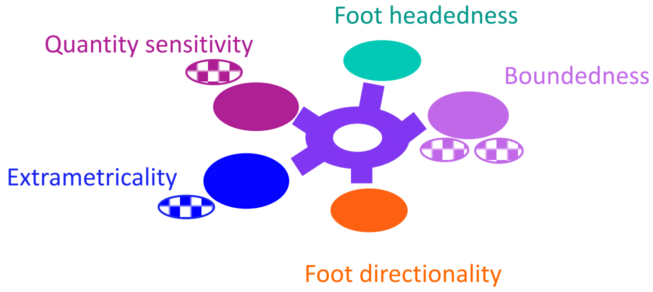
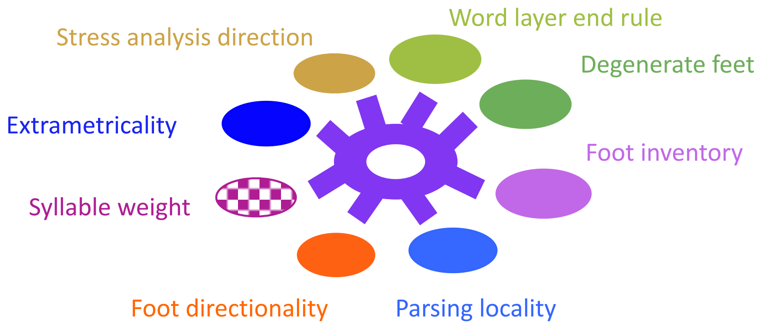


Learning English metrical phonology

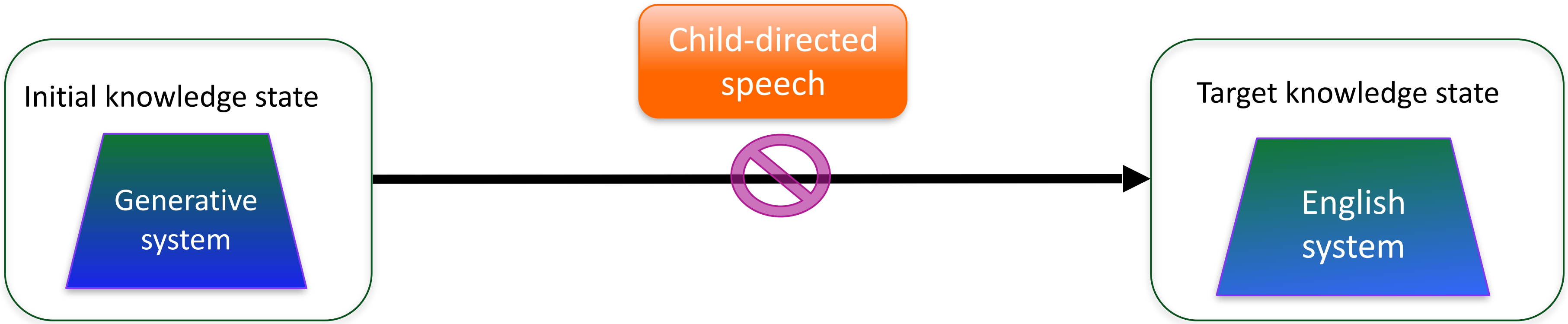
Interim conclusion:

Learnability issues exist for the English grammar in all three knowledge representations.

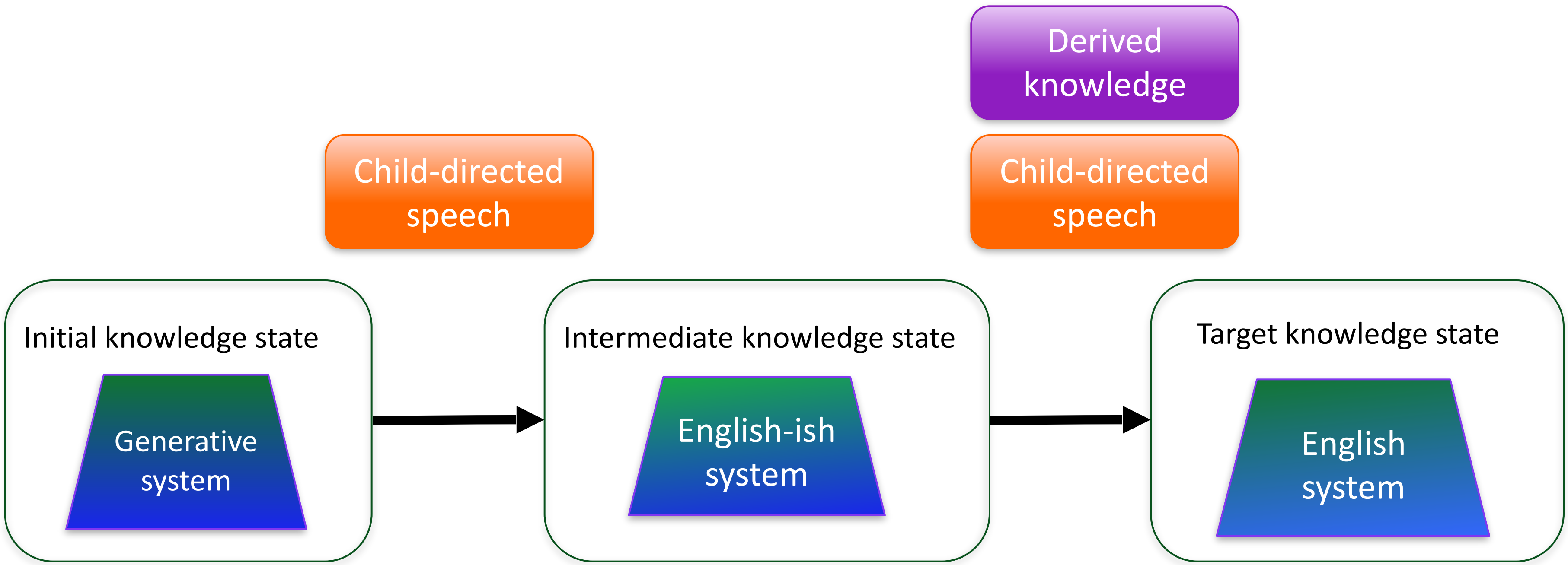




The learnability problem



The learnability problem: One option



Change the (immediate) target state. Assume there is a transitory state in learning that the learner reaches and then leaves once additional knowledge is acquired.

Learning English metrical phonology

One solution: The learner has derived additional knowledge that helps guide learning.

General knowledge: Interactions with morphology

(Chomsky & Halle 1968, Hayes 1982, Kiparsky 1979)

Specific knowledge: Adding productive morphology doesn't change the stress pattern, even though all grammars base their stress patterns on the syllables present in the word.

EARly

EARlier

PREtty

PREttiest

senSAtion

senSAtional

senSAtionally

Learning English metrical phonology

One solution: The learner has derived additional knowledge that helps guide learning.

English children seem to use inflectional morphology productively around 3 (Brown 1973) – so they may be aware it doesn't get stressed, based on their prior linguistic experience.

EARly

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Learning English metrical phonology

So what's the best any grammar in a given knowledge representation actually does, given these data and the knowledge that inflectional morphology is stressless?

Learnability potential = proportion of data the best grammar (relative compatibility = 1.00) can account for

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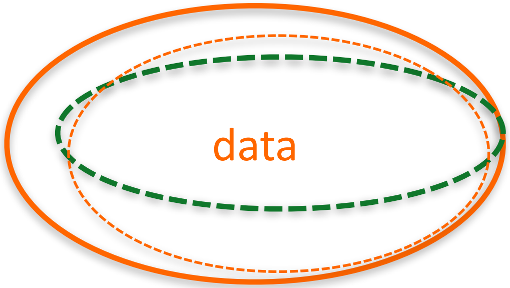

Learning English metrical phonology

Implication:

The best grammar is still pretty useful to have. It allows a learner to account for a good proportion of the input, even if there's a significant chunk that can't be accounted for. However, knowing inflectional morphology is stressless doesn't seem to help it account for any more than it could before…

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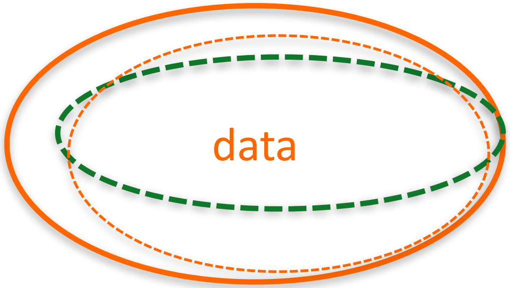

Learning English metrical phonology

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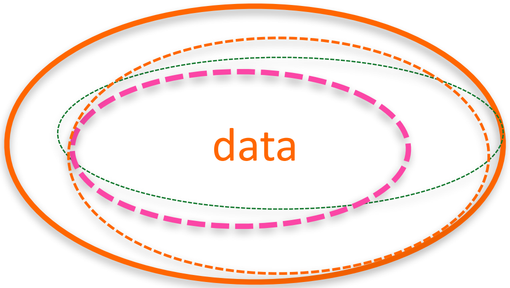
Still significantly less than the best grammar



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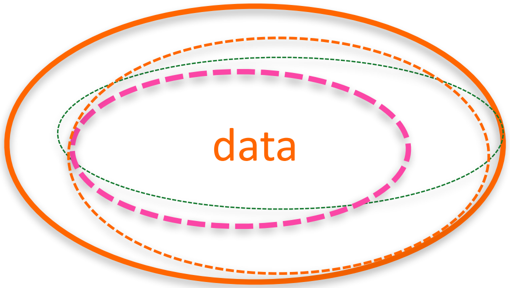

Learning English metrical phonology

Implication:

A rational learner would still not pick the English grammar for any of these knowledge representations, even with knowledge that inflectional morphology is stressless. It would pick the best grammar instead.

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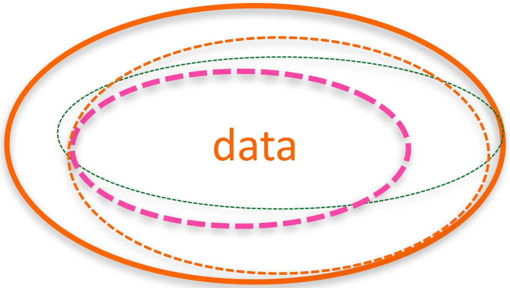

Learning English metrical phonology

So how does the (best) English grammar compare to the other grammars defined by the knowledge representation, once the learner knows inflectional morphology is stressless?

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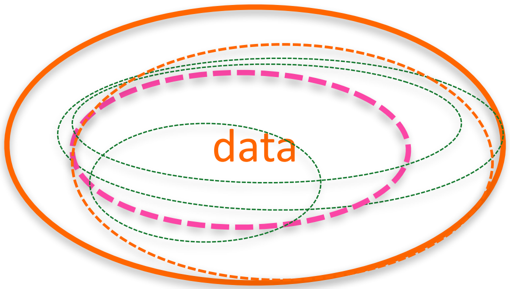

Learning English metrical phonology

Implication:

There remain many other grammars in the hypothesis space that are more compatible with the data, even though the learner knows inflectional morphology is stressless. Even if children aren't optimal learners, it would be easier to pick one of these other more compatible grammars.

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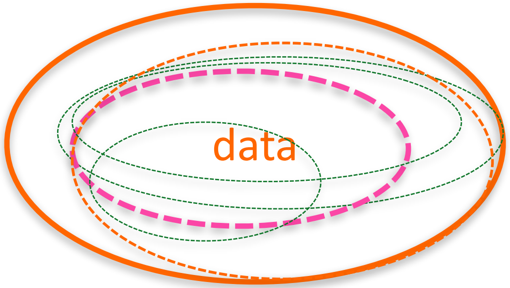
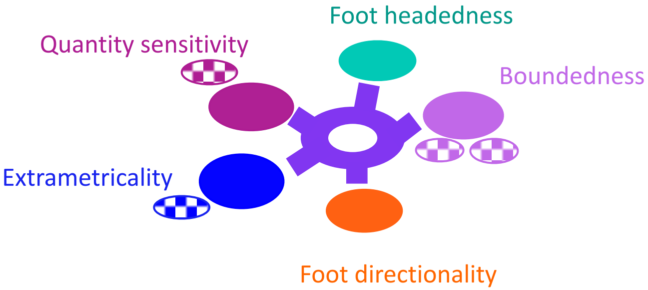
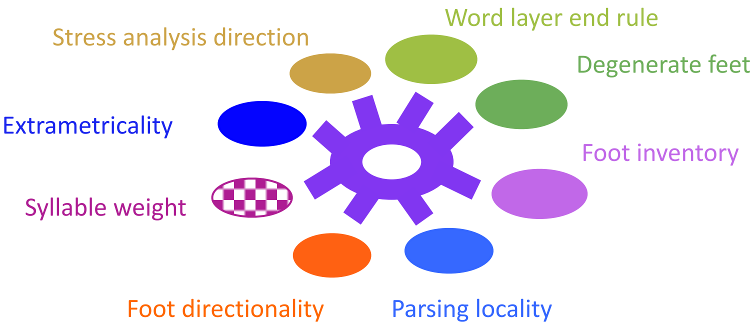


Learning English metrical phonology

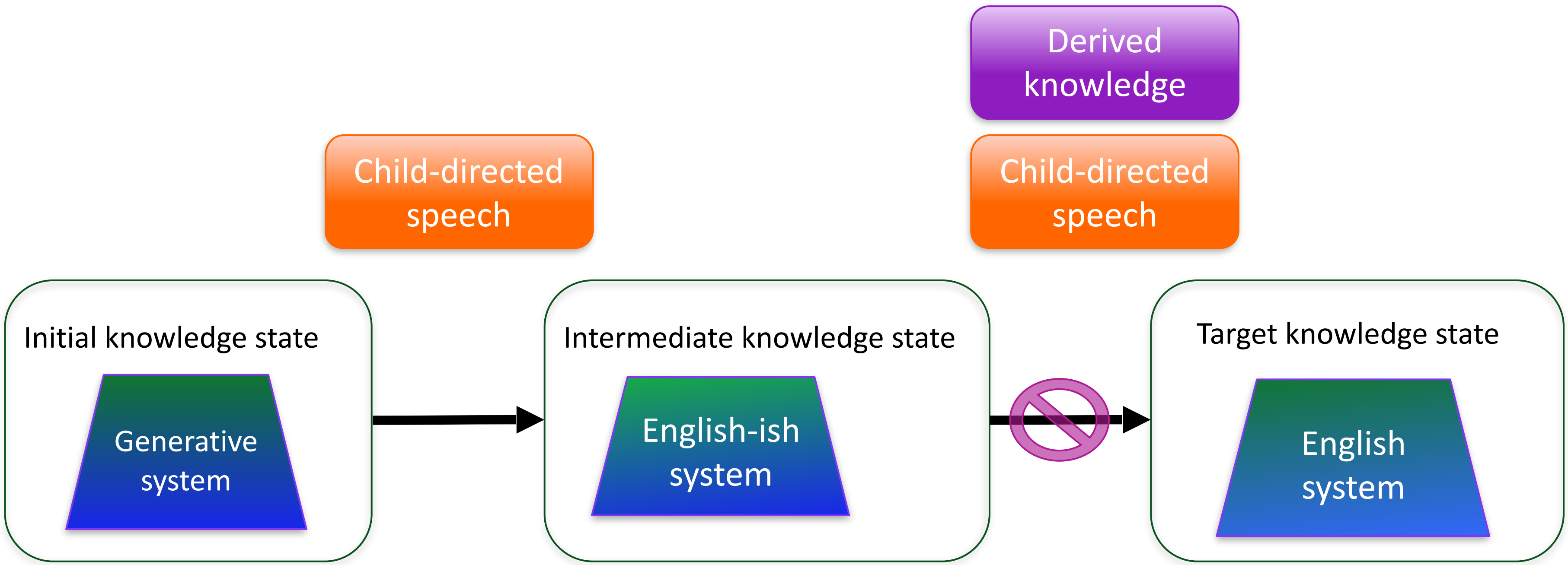
Continuing conclusion:

The same learnability issues persist for the English grammar in all three knowledge representations, even when the learner has some knowledge of the interactions between morphology and metrical phonology.





The learnability problem: One option that didn't work



Additional knowledge that inflectional morphology is stressless in English didn't seem to help. Why not?

The learnability problem: One option that didn't work

One problem:

All English grammars generally want long syllables (VV syllable nucleus) to be stressed (though the HV parametric grammar allows some exceptions). However, many English words have long syllables that aren't stressed. These remain problematic even with knowledge about inflectional morphology.

proper names	diminuitives	
EL mo	KI tty	SWEE tie
MAN dy	DA ddy	DO ggie
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unstressed long syllables

The learnability problem: One option that didn't work

…yet

One solution: Additional knowledge

Perhaps children learn that the /i/ ("ee") diminuitive ending behaves like inflectional morphology. Then, syllables containing this ending are expected to be stressless.

✓

proper names	**diminuitives**	
EL mo	KI tty	SWEE tie
MAN dy	DA ddy	DO ggie
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unstressed long syllables

The learnability problem: One option that didn't work

…yet

One solution: Additional knowledge

Perhaps children learn that proper names are a coherent (semantic) class that may have different stress properties. This is similar to recognizing that grammatical categories may have different effects on stress.

✓ ✓

proper names

EL mo

MAN dy

diminuitives

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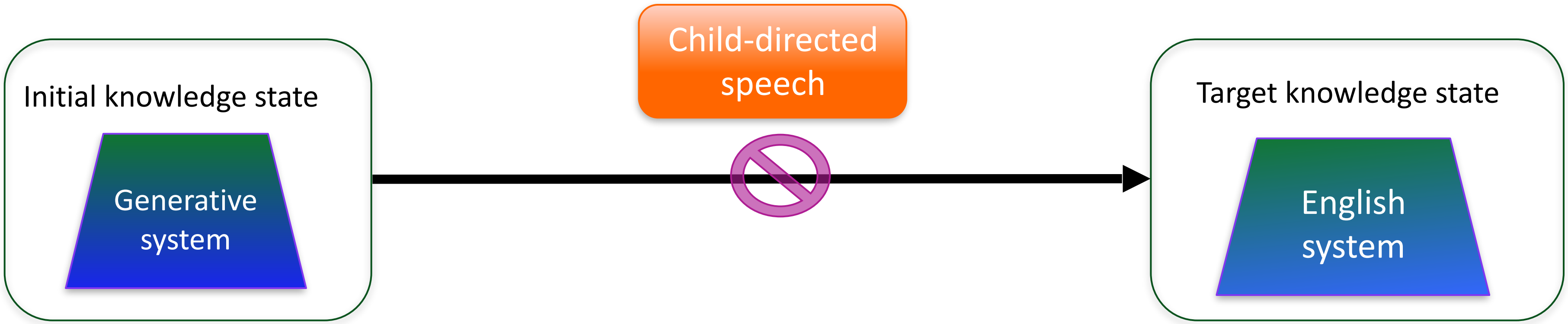
The learnability problem: Another option



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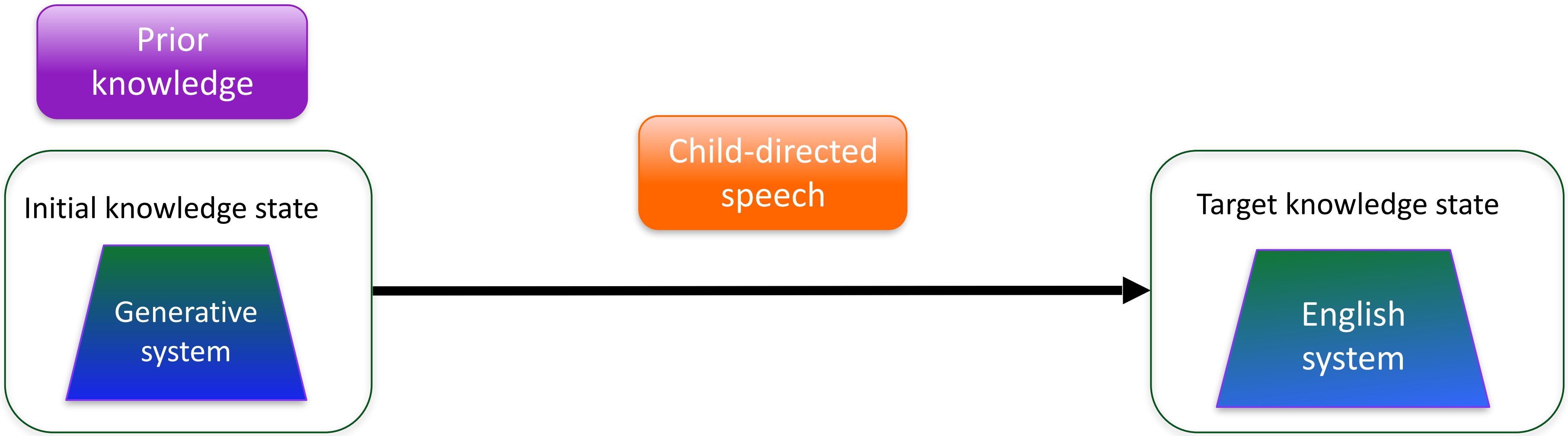
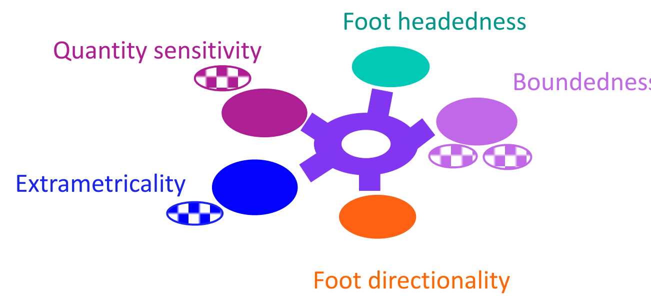


The initial state of the learner includes prior knowledge that helps the learner learn in a more sophisticated way.

What kind of prior knowledge?

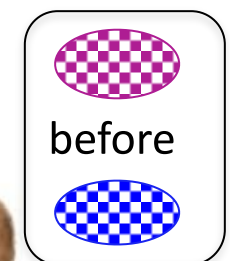
Helpful prior knowledge: Learning biases

Pearl 2008: The HV parametric English grammar can be learned from child-directed speech (in principle) if children are biased to learn only from data perceived as unambiguous for a particular parameter value.



In addition, children must learn the parameter values in particular orders (obeying certain order constraints).

OCtopus

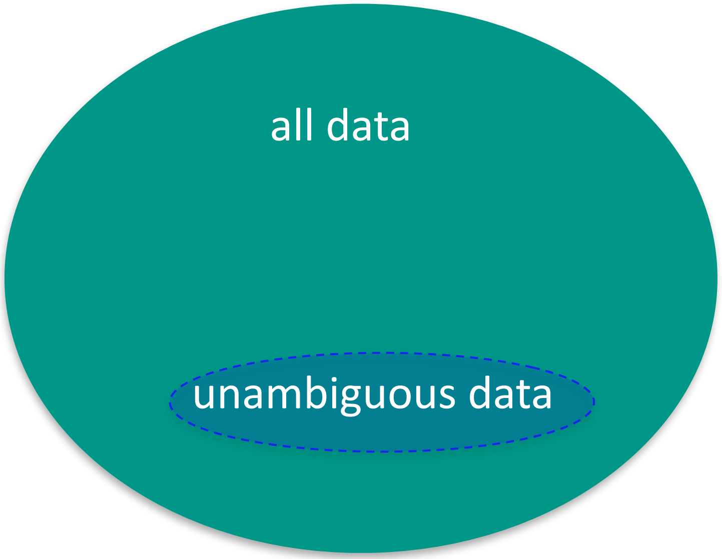


Unambiguous data filter

Previous working assumption: The learner will try to learn a generative system that can account for all the data encountered.

Unambiguous data filter

Updated working assumption: The learner will try to learn a generative system that can account for all the unambiguous data encountered.



This is a small subset of the available data which can be viewed as maximally informative.

Unambiguous data filter

Updated working assumption: The learner will try to learn a generative system that can account for all the unambiguous data encountered.

Why would this occur?

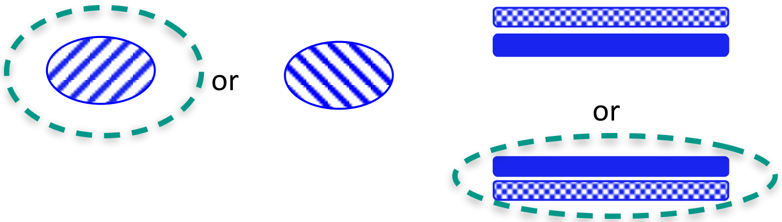
Perhaps the learner prioritizes data that are viewed as highly informative. The goal then becomes to learn a system that can account for all these data.

Unambiguous data filter

Updated working assumption: The learner will try to learn a generative system that can account for all the unambiguous data encountered.

How would this occur?

The learner may look for cues that signal a data point is unambiguous for a particular parameter value or constraint ordering (Pearl 2008, Pearl 2011). These cues may be derived from attempting to analyze a data point with the existing parametric/constraint-ordering options (Fodor 1998, Pearl 2007) – if only one parameter value or constraint ordering is present in successful analyses, this is a cue.



What kind of prior knowledge?

Helpful prior knowledge: Learning biases

Potentially helpful: A bias to learn only from data viewed as regular (Legate & Yang 2012).

✓

COO kie

DA ddy

FU nny

✗

a WAY

be LOW

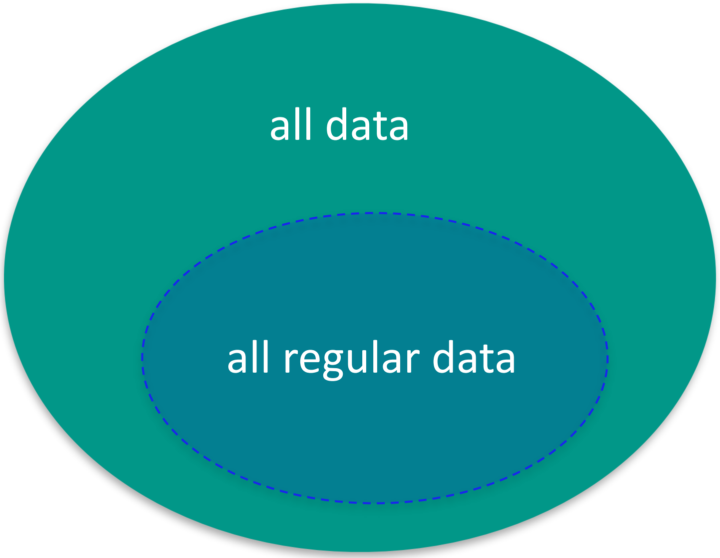
to DAY

Regular data filter

Previous working assumption: The learner will try to learn a generative system that can account for all the data encountered.

Regular data filter

Updated working assumption: The learner will try to learn a generative system that can account for all the regular data encountered.



Regular data filter

Updated working assumption: The learner will try to learn a generative system that can account for all the regular data encountered.

Why would this occur?

Perhaps the learner realizes that some data are irregular and therefore unpredictable. The goal then becomes to learn a system that can account for all the data that are regular and therefore predictable.

Regular data filter

Updated working assumption: The learner will try to learn a generative system that can account for all the regular data encountered.

How would this occur?

For every syllable word form (ex: V VV) that has multiple stress patterns associated with it, the learner assumes that one of these patterns may be the regular pattern and the others are exceptions to this general “rule”.

Regular data filter

Updated working assumption: The learner will try to learn a generative system that can account for all the regular data encountered.

How would this occur?

A formal way for identifying if there is a dominant rule for a set of items is the Tolerance Principle (Yang 2005, Legate & Yang 2012). This is used to estimate how many exceptions a rule can tolerate in a set before it’s no longer useful for the learner to have the rule. If there are too many exceptions, it’s better not to have a rule and learn patterns on an individual item basis instead of having a rule that keeps getting violated.

Regular data filter

Updated working assumption: The learner will try to learn a generative system that can account for all the regular data encountered.

How would this occur?

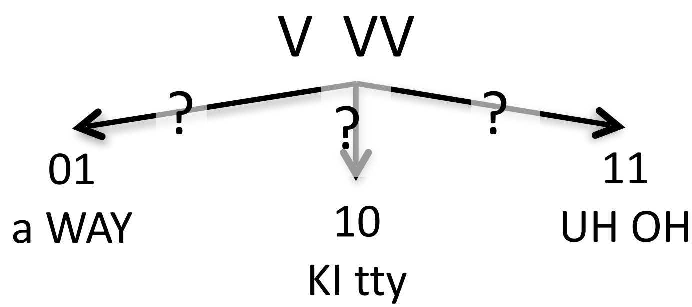
The number of exceptions a rule can tolerate for a set of N items is

$$\frac{N}{ln(N)}$$

(Yang 2005, Legate & Yang 2012)

The Tolerance Principle in action

For every syllable word form with multiple stress patterns, the learner could assess whether any of those patterns is the dominant pattern (the “rule” for that syllable word form), using the Tolerance Principle.



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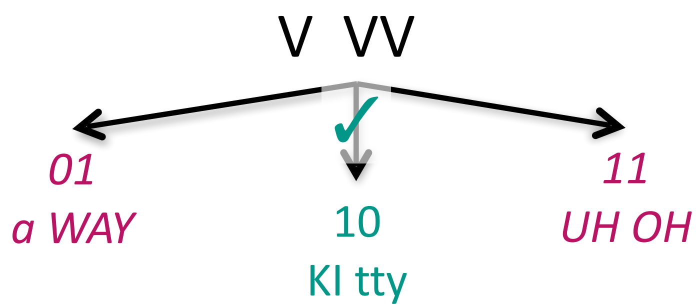

If one pattern is dominant, the learner should focus on accounting for that pattern, since it's regular. The underlying generative system should be able to generate it. The other patterns can be ignored for purposes of learning the system.

The Tolerance Principle in action

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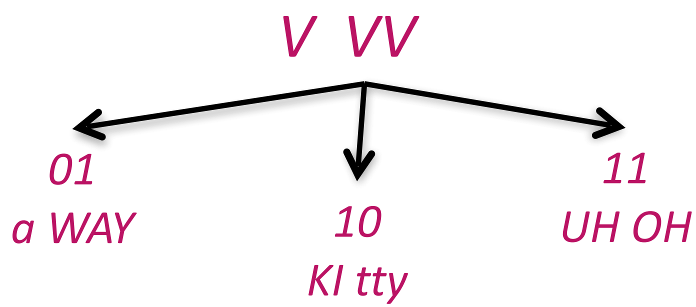
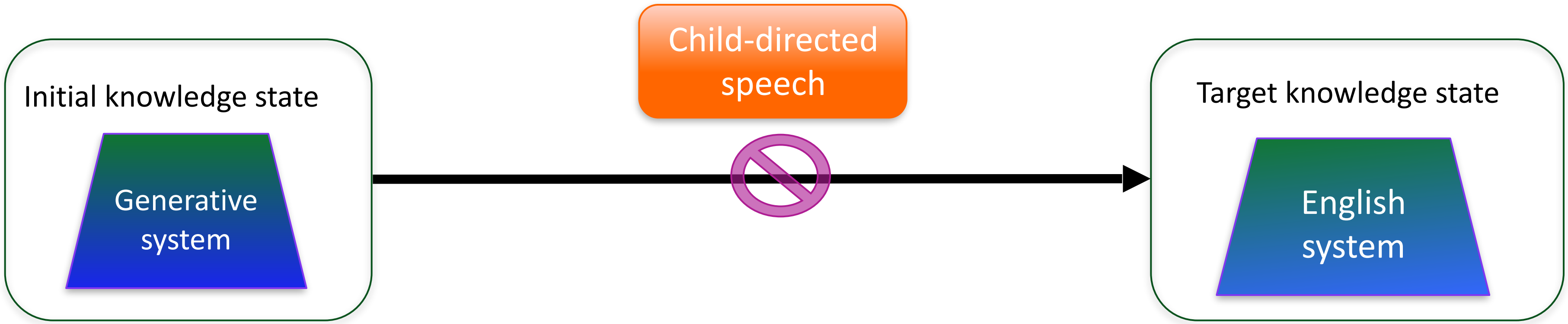


If no pattern is dominant, the learner should ignore this syllable word form for the purposes of learning the underlying generative system since there is no obvious regularity to account for.

The learnability problem: A third option

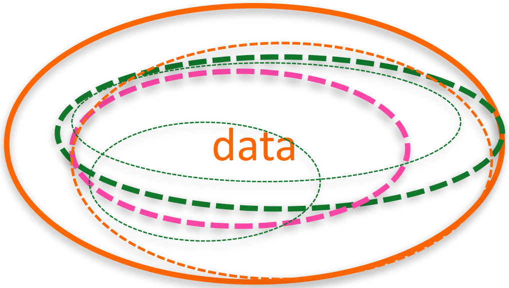


The learnability problem: A third option

The target grammar is different than we think, and we should update our theories about the definition of the English grammar.

What should the target grammar be?

One approach: What values/constraint rankings do the grammars have that are more compatible with the data than the official English grammar?

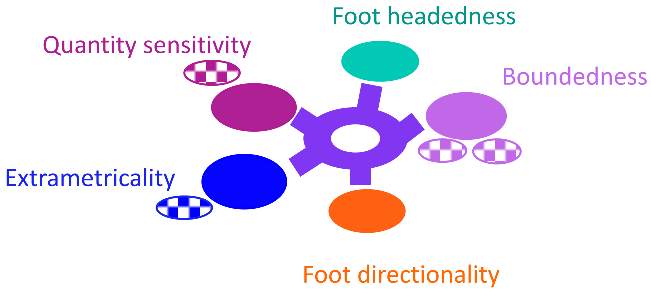


What should the target grammar be?

English system

One approach: What values/constraint rankings do the grammars have that are more compatible with the data than the official English grammar?

Parametric: HV



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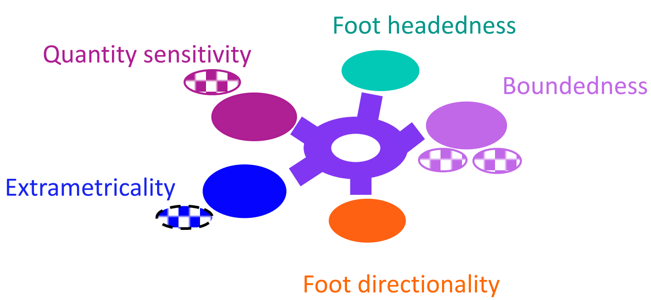
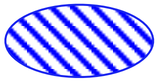


If we examine the grammars with high compatibility, it turns out that the values used by the English grammar are the values used by the majority of these grammars.

Example: 

Extrametricality on the rightmost syllable is used by 53 of 58 high compatibility grammars.

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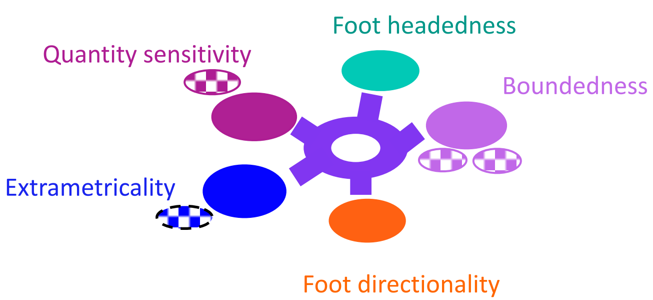

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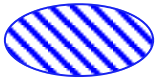


Extrametricality on the rightmost syllable is used by 53 of 58 high compatibility grammars.

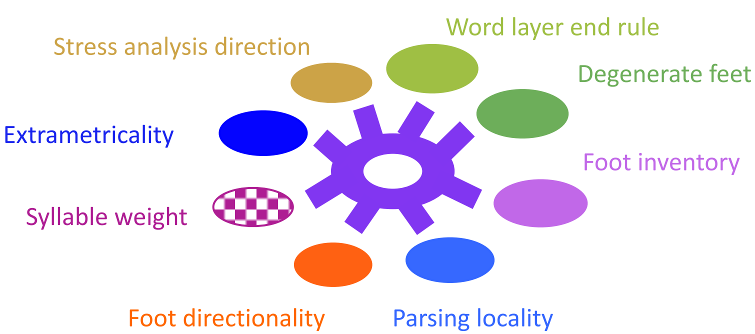
Upshot: Unclear for the HV knowledge representation that the learning problem can be fixed by simply switching one parameter value here or there.

What should the target grammar be?

English system

One approach: What values/constraint rankings do the grammars have that are more compatible with the data than the official English grammar?

Parametric: Hayes



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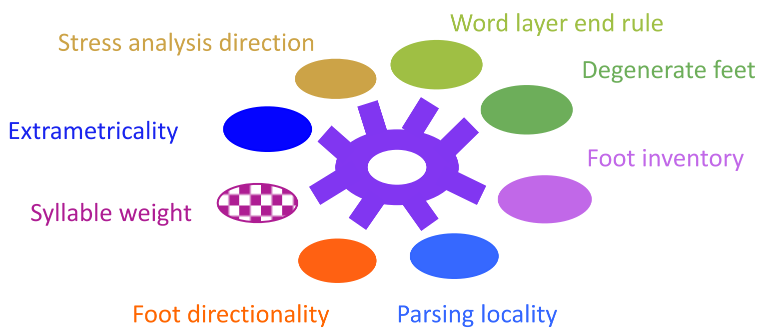

If we examine the grammars with high compatibility, it turns out that there are some parameter values that the majority of high compatibility grammars use, but which the English grammar does not use.

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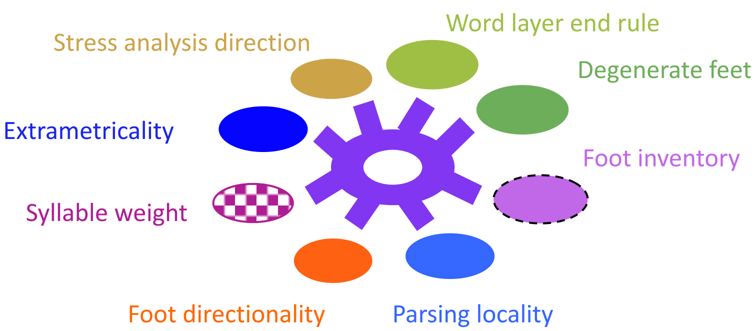


Optimal: 0.683 types (0.750 tokens)

If we examine the grammars with high compatibility, it turns out that there are some parameter values that the majority of high compatibility grammars use, but which the English grammar does not use.

(1) Change the Foot inventory value.

This boosts compatibility from 0.485 types (0.531 tokens) to 0.644 types (0.733 tokens).

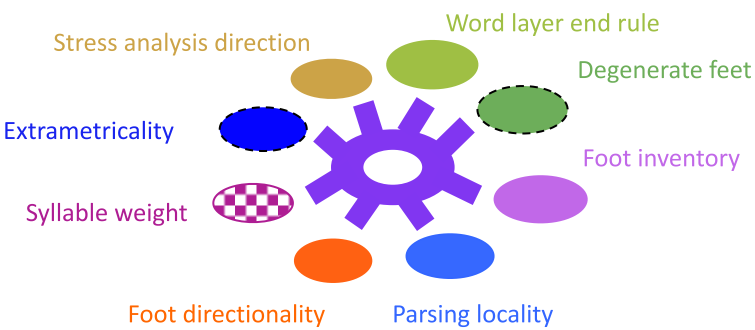
Relative compatibility = 0.910

What should the target grammar be?

English system

One approach: What values/constraint rankings do the grammars have that are more compatible with the data than the official English grammar?

Parametric: Hayes



Optimal: 0.683 types (0.750 tokens)

If we examine the grammars with high compatibility, it turns out that there are some parameter values that the majority of high compatibility grammars use, but which the English grammar does not use.

(1) Change the Foot inventory value.

(2) Change the Extrametricality and Degenerate feet values.

This boosts compatibility from 0.485 types (0.531 tokens) to 0.652 types (0.729 tokens).

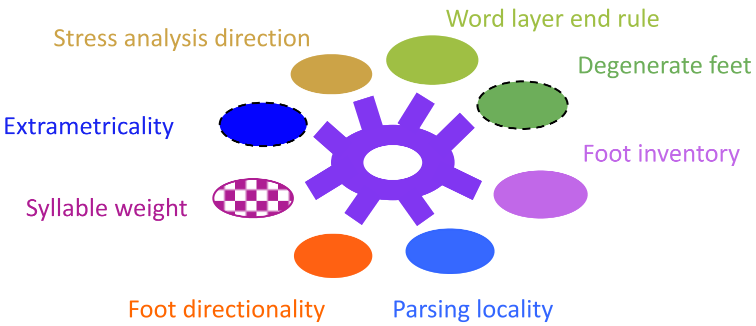
Relative compatibility = 0.923

What should the target grammar be?

English system

One approach: What values/constraint rankings do the grammars have that are more compatible with the data than the official English grammar?

Parametric: Hayes



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(1) Change the Foot inventory value.

(2) Change the Extrametricality and Degenerate feet values.

Upshot: For the Hayes knowledge representation, the learning problem could be ameliorated by simply switching a small number of parameter values.

What should the target grammar be?

English system

One approach: What values/constraint rankings do the grammars have that are more compatible with the data than the official English grammar?

Constraint-based: OT

What should the target grammar be?

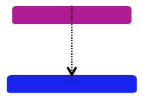
English system

One approach: What values/constraint rankings do the grammars have that are more compatible with the data than the official English grammar?

Constraint-based: OT

If we examine the grammars with high compatibility, it turns out that there is one constraint ordering English uses which none of these grammars use.

Weight-to-Stress VV >> Nonfinality



(Effect: Prefer long syllables to be stressed, even if they’re at the right edge of the word)

BA by ← problematic

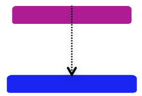
What should the target grammar be?

English system

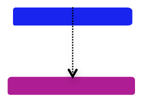
One approach: What values/constraint rankings do the grammars have that are more compatible with the data than the official English grammar?

Constraint-based: OT

If we examine the grammars with high compatibility, it turns out that there is one constraint ordering English uses which none of these grammars use.



Implication: This ranking may be better for English data.



What should the target grammar be?

English system

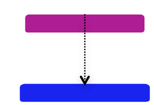
One approach: What values/constraint rankings do the grammars have that are more compatible with the data than the official English grammar?

Constraint-based: OT

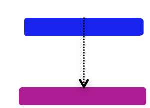
Optimal: 0.657 types (0.729 tokens)

If we examine the grammars with high compatibility, it turns out that there is one constraint ordering English uses which none of these grammars use.

Best English grammar compatibility with the original ranking is 0.574 types (0.573 tokens).



Best English grammar compatibility with this swapped ranking is 0.655 types (0.729 tokens).



Relative compatibility = 0.988

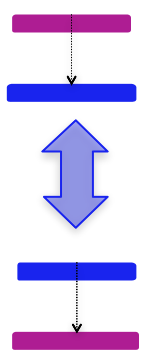
What should the target grammar be?

English system

One approach: What values/constraint rankings do the grammars have that are more compatible with the data than the official English grammar?

Constraint-based: OT

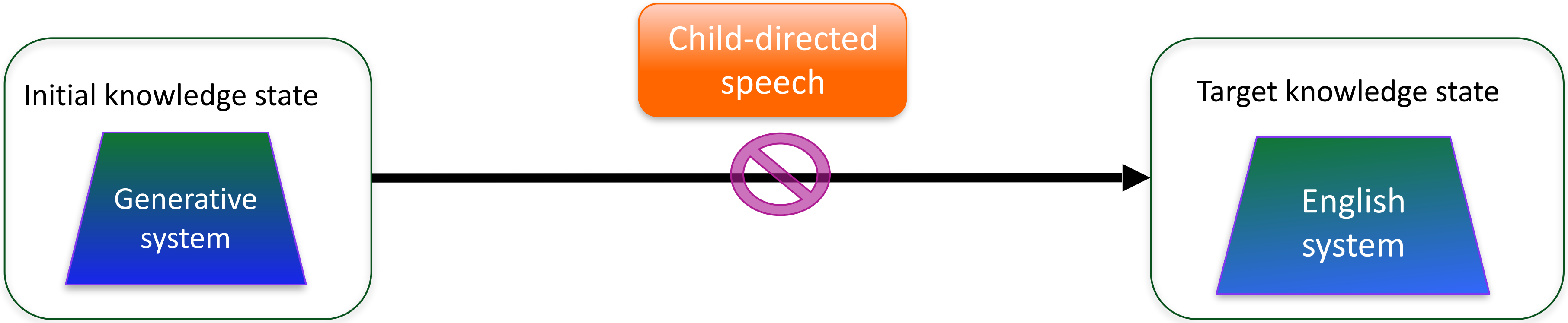
If we examine the grammars with high compatibility, it turns out that there is one constraint ordering English uses which none of these grammars use.



Upshot: For the OT knowledge representation, the learning problem could be alleviated by simply switching one constraint ordering.

Learnability implication recap

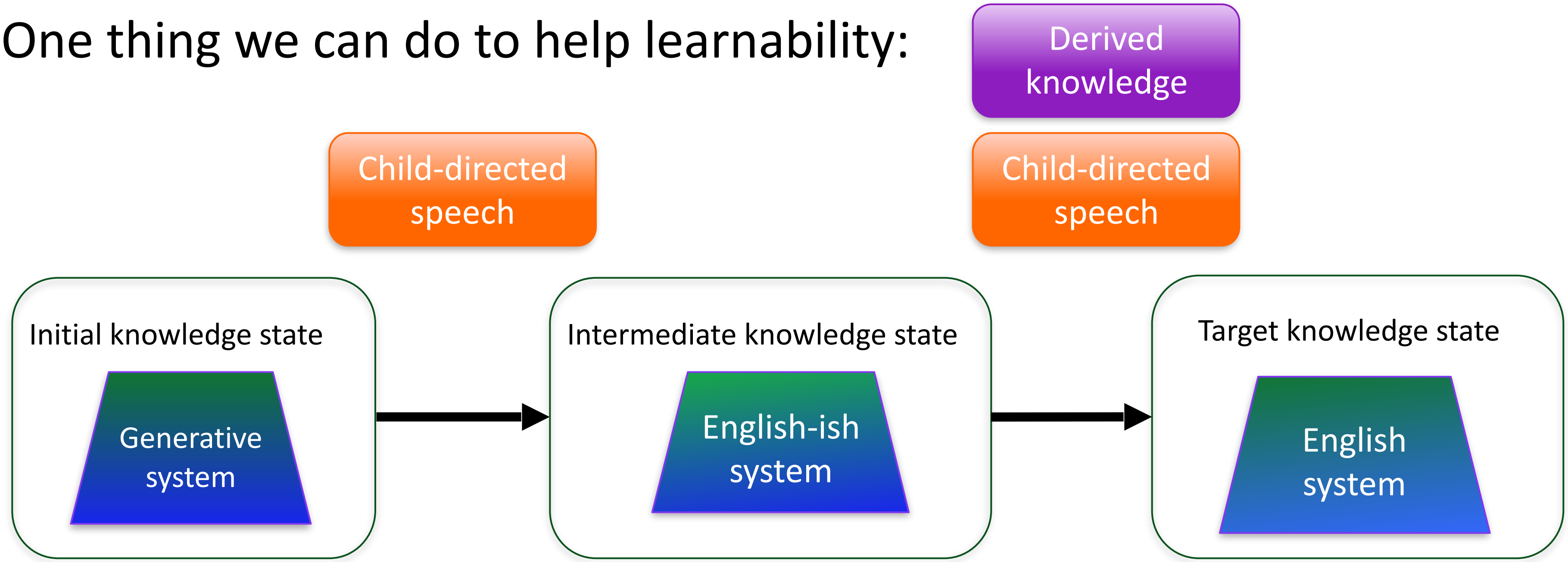
Since learnability issues exist for all three knowledge representations, something else must be going on.



As it stands, they can explain cross-linguistic variation, but the Engilsh grammars don't seem to be learnable from English data.

Learnability implication recap

One thing we can do to help learnability:

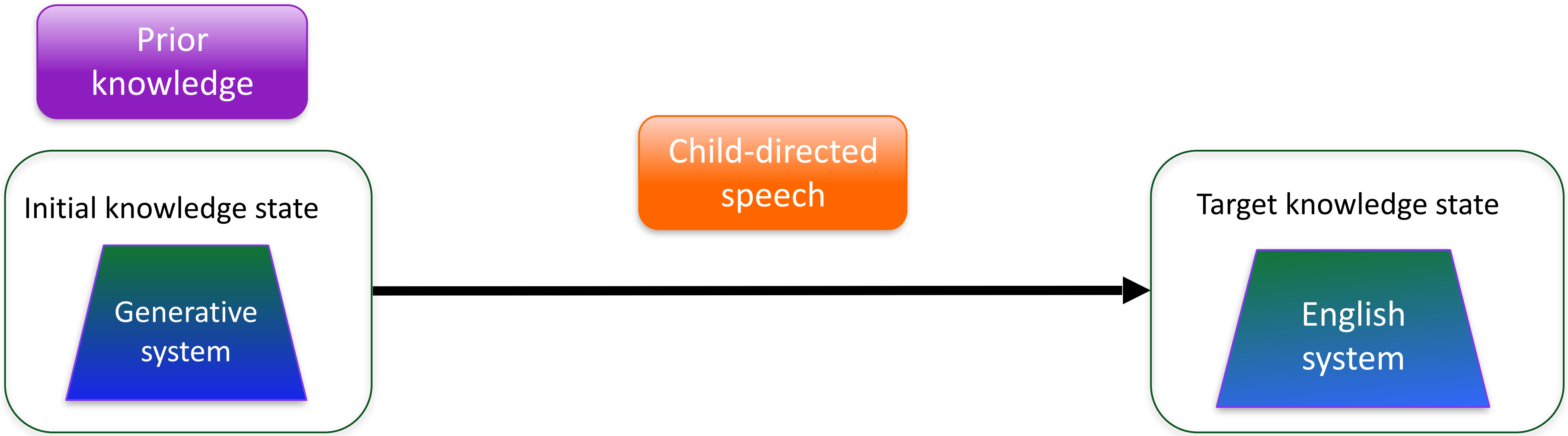


Assume there is a transitory state in learning that the learner reaches and then leaves once additional knowledge is acquired.

Adding some knowledge about the interaction of stress with inflectional morphology is insufficient on its own, however.

Learnability implication recap

Another thing we can do to help learnability:



Add in prior knowledge that helps the child perceive the input in a helpful way. Two potentially useful learning biases involve learning a system that accounts for a subset of the available data, rather than all of it. One parametric system (HV) has been shown to be learnable this way.

Learnability implication recap

A third thing we can do to help learnability:

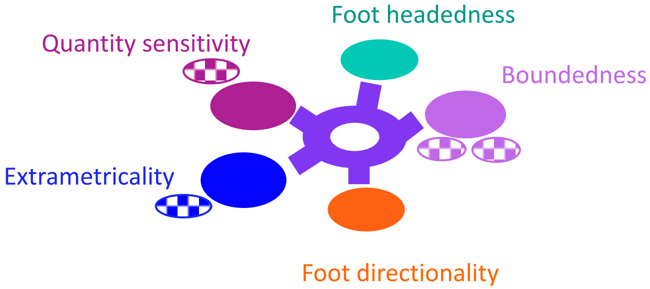
Update our ideas about the target grammar slightly (alter certain parameter values or constraint rankings).

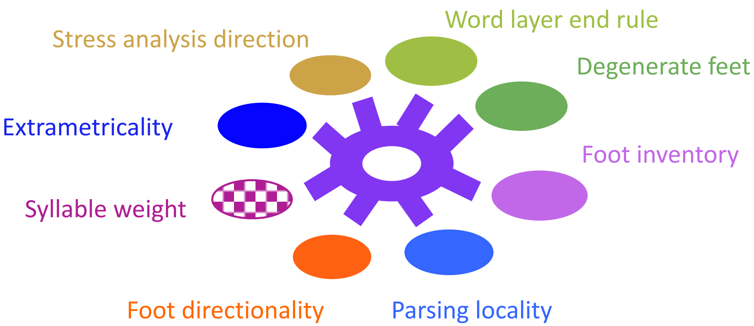
Big picture

Big picture

Establishing a methodology for quantitatively evaluating competing linguistic knowledge representations

- based on an argument from acquisition (how learnable are they from realistic data?)





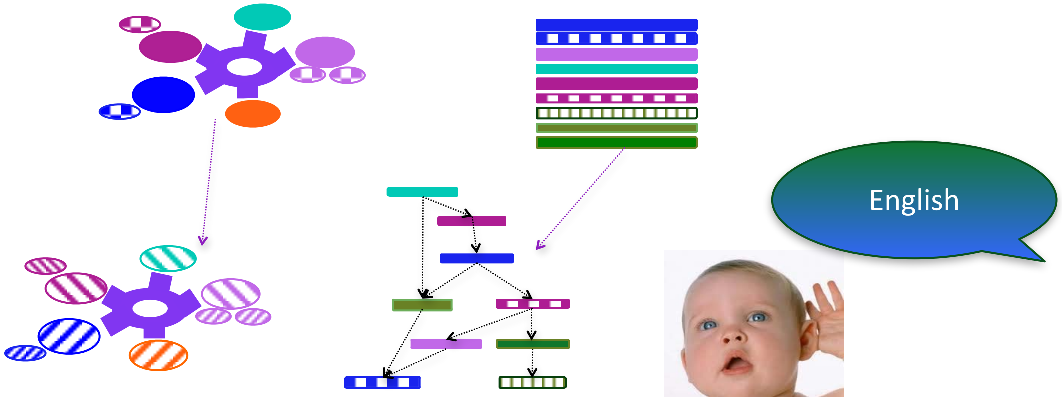
Big picture

Establishing a methodology for quantitatively evaluating competing linguistic knowledge representations

- based on an argument from acquisition (how learnable are they from realistic data?)

Testing against hard cases, like learning English

Idea: If a representation can handle the hard cases, it can handle anything



Big picture

Establishing a methodology for quantitatively evaluating competing linguistic knowledge representations

- based on an argument from acquisition (how learnable are they from realistic data?)

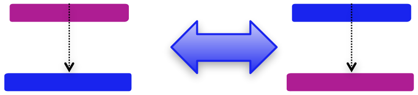
Testing against hard cases, like learning English

Idea: If a representation can handle the hard cases, it can handle anything

Provide insight on why current instantiations fail and what can be done about it

- alter theory about how learning proceeds

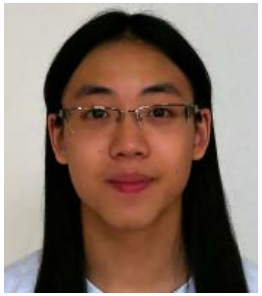
- alter theory of language-specific grammars defined by knowledge representations



Thank you!

Zephyr Detrano

Tim Ho

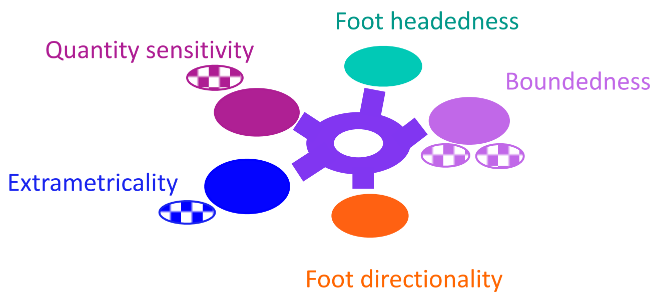


Computation of Language Laboratory

UC Irvine

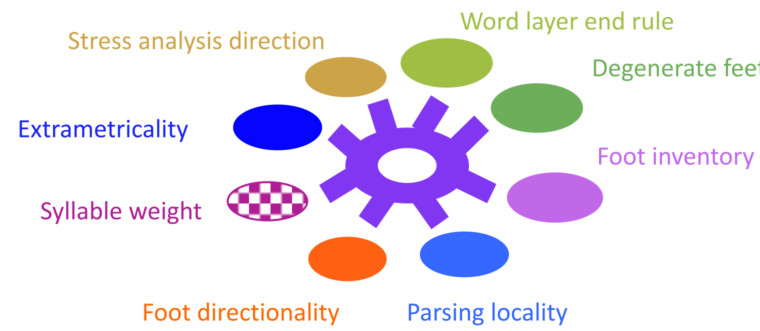
Extra material

Knowledge representation comparison



HV: 5 parameters & 4 sub-parameters

Hypothesis space: 156 grammars



Hayes: 8 parameters

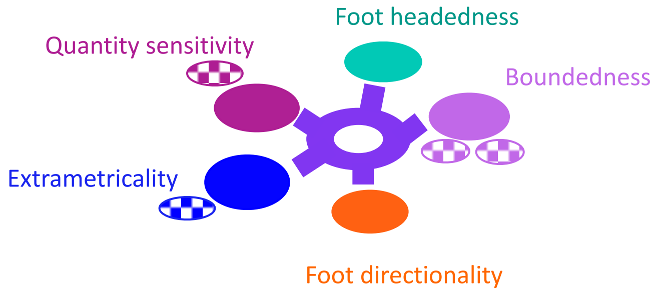
Hypothesis space: 768 grammars

Each representation assumes certain syllabic distinctions.

OT: 9 violable constraints

Hypothesis space: 362,880 grammars

Knowledge representation comparison

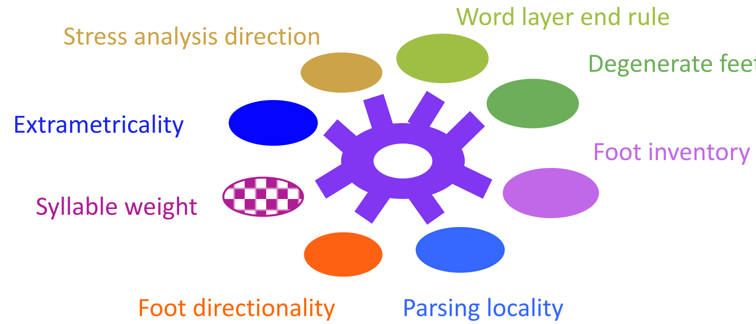


HV: 5 parameters & 4 sub-parameters

Hypothesis space: 156 grammars

Syllabic distinctions: 3

(short, closed, long)



Hayes: 8 parameters

Hypothesis space: 768 grammars

Syllabic distinctions: 4

(short, potentially short, closed, long)

OT: 9 violable constraints

Hypothesis space: 362,880 grammars

Syllabic distinctions: 8

(short, sonorant, 4 closed variants, long, super-long)

Learning English metrical phonology: Non-trivial

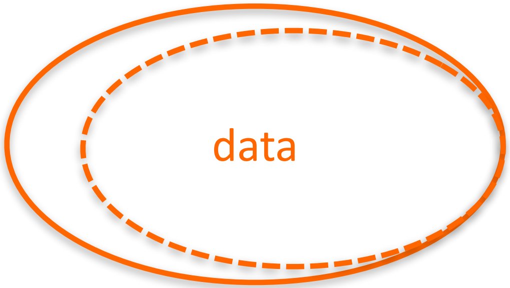
So what's the best any grammar could possibly do, given these data?

Answer: Syllabic learnability potential

Account for the most frequent stress pattern for each syllabic word form.

Syllabic word form: V VV

KI tty	a WAY	UH OH
V vv	v VV	V VV



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V vv	v VV	V VV

Syllabic learnability potential by knowledge representation (proportion accounted for)

HV: 0.711 types (0.766 tokens)

Hayes: 0.719 types (0.769 tokens)

OT: 0.795 types (0.829 tokens)

Pretty good potential coverage, even if it isn't perfect

Learning English metrical phonology

So what's the best any grammar could possibly do, given these data and the knowledge that inflectional morphology is stressless?

Syllabic learnability potential

Accounting for the most frequent stress pattern for each syllabic word form.

Syllabic word form: V VV

KI tty	a WAY	UH OH
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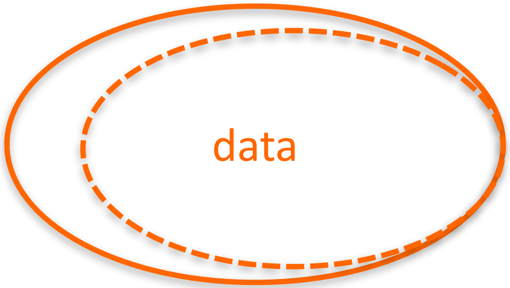

Learning English metrical phonology

So what's the best any grammar could possibly do, given these data and the knowledge that inflectional morphology is stressless?

Syllabic learnability potential

Accounting for the most frequent stress pattern for each syllabic word form.

Syllabic word form: V VV

KI tty	a WAY	UH OH
V vv	v VV	V VV

Syllabic learnability potential by knowledge representation (proportion accounted for)

HV: 0.708 types (0.766 tokens)
Hayes: 0.711 types (0.768 tokens)
OT: 0.820 types (0.852 tokens)

Still pretty good potential coverage…but it's also still not perfect.

Learning English metrical phonology

Why wouldn't the best grammar's compatibility be equivalent to the syllabic learnability potential? What's preventing it?

A grammar is constrained by the specific parameters or constraints defined by the KR. These parameters/constraints may not be compatible with the most frequent stress contour every time.

Syllabic word form: V VV

KI tty	a WAY
V vv	v VV
18	242

Syllabic word form: VV VV

BA by	o KAY
VV vv	vv VV
198	4

Syllabic learnability potential: Choose these stress contours (which are opposite)

Learning English metrical phonology

Why wouldn't the best grammar's compatibility be equivalent to the syllabic learnability potential? What's preventing it?

A grammar is constrained by the specific parameters or constraints defined by the KR. These parameters/constraints may not be compatible with the most frequent stress contour every time.

Syllabic word form: V VV		Syllabic word form: VV VV	
KI tty	a WAY	BA by	o KAY
V vv	v VV	VV vv	vv VV
18	242	198	4

Grammar compatibility (preferring same contour): Choose these stress contours...

Learning English metrical phonology

Why wouldn't the best grammar's compatibility be equivalent to the syllabic learnability potential? What's preventing it?

A grammar is constrained by the specific parameters or constraints defined by the KR. These parameters/constraints may not be compatible with the most frequent stress contour every time.

Syllabic word form: V VV

KI tty

V vv

18

a WAY

v VV

242

Syllabic word form: VV VV

BA by

VV vv

198

o KAY

vv VV

4

Grammar compatibility (preferring same contour): …or these stress contours.

Parametric knowledge representation comparison

- **HV English grammar outperforms Hayes English grammar in overall compatibility**

Raw compatibilities by type for English grammar in parameter systems (with no knowledge of inflection):

<u>**HV**</u>		<u>**Hayes**</u>		
59.33%	**-**	**48.05%**	**=**	**11.28% difference**

Which common stressed wordforms are contributing to the relatively high performance of the HV English grammar?

The 10 most common stressed wordforms by type constitute 58.32% of total types in the input.

Stressed wordform	# Types	Examples
Lp	***592***	***water, doing, going***
Xp	*472*	*little, getting, coming*
Ll	***334***	***baby, sweetie, mommy***
Xl	***309***	***kitty, daddy, very***
Ap	***235***	***goodness, handsome, helper***
LL	***188***	***okay, byebye, TV***
Al	***172***	***window, birdie, only***
La	***171***	***peanuts, secrets, highest***
Xa	***170***	***biggest, buckets, hiccups***
xL	***145***	***below, today, hurray***

HV English grammar derives **8** of the 10 most common stressed wordforms.

Stressed wordform	# Types	Examples	HV
Lp	***592***	***water, doing, going***	***Yes***
Xp	***472***	***little, getting, coming***	***Yes***
Ll	***334***	***baby, sweetie, mommy***	***Yes***
Xl	***309***	***kitty, daddy, very***	***Yes***
Ap	***235***	***goodness, handsome, helper***	***Yes***
LL	***188***	***okay, byebye, TV***	***No***
Al	***172***	***window, birdie, only***	***Yes***
La	***171***	***peanuts, secrets, highest***	***Yes***
Xa	***170***	***biggest, buckets, hiccups***	***Yes***
xL	***145***	***below, today, hurray***	***No***

Hayes English grammar derives **5** of the 10 most common stressed wordforms.

Stressed wordform	# Types	Examples	Hayes
Lp	***592***	***water, doing, going***	***Yes***
Xp	***472***	***little, getting, coming***	***Yes***
Ll	*334*	*baby, sweetie, mommy*	**No**
Xl	*309*	*kitty, daddy, very*	**No**
Ap	***235***	***goodness, handsome, helper***	***Yes***
LL	***188***	***okay, byebye, TV***	***Yes***
Al	*172*	*window, birdie, only*	**No**
La	*171*	*peanuts, secrets, highest*	**No**
Xa	*170*	*biggest, buckets, hiccups*	**No**
xL	***145***	***below, today, hurray***	***Yes***

The **Hayes English grammar** misses **Ll and Xl**, two common patterns that together account for **13%** of the input by type.

However, it derives **LL and xL**, alternate contours for these wordforms that are also frequent, accounting for **7%** of input by type.

Stressed wordform	# Types	Examples	HV
Lp	***592***	***water, doing, going***	***Yes***
Xp	***472***	***little, getting, coming***	***Yes***
Ll	*334*	*baby, sweetie, mommy*	***No***
Xl	*309*	*kitty, daddy, very*	***No***
Ap	***235***	***goodness, handsome, helper***	***Yes***
LL	***188***	***okay, byebye, TV***	***Yes***
Al	*172*	*window, birdie, only*	***No***
La	*171*	*peanuts, secrets, highest*	***No***
Xa	*170*	*biggest, buckets, hiccups*	***No***
xL	***145***	***below, today, hurray***	***Yes***

HV vs. Hayes
on most frequent word forms

Stressed wordform	# Types	Examples	HV	Hayes
Lp	***592***	*water, doing, going*	***Yes***	***Yes***
Xp	***472***	*little, getting, coming*	***Yes***	***Yes***
Ll	***334***	*baby, sweetie, mommy*	***Yes***	***No***
Xl	***309***	*kitty, daddy, very*	***Yes***	***No***
Ap	***235***	*goodness, handsome, helper*	***Yes***	***Yes***
LL	***188***	*okay, byebye, TV*	***No***	***Yes***
Al	***172***	*window, birdie, only*	***Yes***	***No***
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Xa	***170***	*biggest, buckets, hiccups*	***Yes***	***No***
xL	***145***	*below, today, hurray*	***No***	***Yes***

The impact of morphological knowledge

Example: What happens to words of the La stressform when the child gets morphological knowledge? (for the Hayes grammar, which can't account for it without morphological knowledge)

Stressed wordform	# Types	Examples	HV	Hayes
Lp	***592***	*water, doing, going*	***Yes***	***Yes***
Xp	***472***	*little, getting, coming*	***Yes***	***Yes***
Ll	***334***	*baby, sweetie, mommy*	***Yes***	***No***
Xl	***309***	*kitty, daddy, very*	***Yes***	***No***
Ap	***235***	*goodness, handsome, helper*	***Yes***	***Yes***
LL	***188***	*okay, byebye, TV*	***No***	***Yes***
Al	***172***	*window, birdie, only*	***Yes***	***No***
La	***171***	*peanuts, secrets, highest*	***Yes***	***No***
Xa	***170***	*biggest, buckets, hiccups*	***Yes***	***No***
xL	***145***	*below, today, hurray*	***No***	***Yes***

The impact of morphological knowledge

Example: What happens to words of the La stressform when the child gets morphological knowledge? (for the Hayes grammar, which can't account for it without morphological knowledge)

Pre Morphology

171 La (island, giant, moment)

Post Morphology

57 La (54 of the 171 + 3 added from Lp form)
– Hayes still can't account for these

100 Lp (father's → father, pockets→pocket, slobbered→slobber)
17 L (cutest →cute, nicest→nice, weirdest→weird)
- Hayes can now account for these

In this case, inflectional morphology helps!

The impact of morphological knowledge

In general, the Hayes English benefits from morphology knowledge (6.95% more types accounted for, due to 322 types), unlike the HV and OT English grammars.

Where are these changes happening?

- **28** types: incorrectly derived bisyllabics become monosyllabic
<u>Examples</u>: cleanest → clean (La→L); biggest → big (Xa→P); bestest → best (Aa→A)

- **100** types: incorrectly derived **La** becomes correctly-derived **Lp**
<u>Examples</u>: father's → father; pockets → pocket; slobbered → slobber

- **112** types: incorrectly derived **Xa** becomes correctly-derived **Xp**
<u>Examples</u>: sister's→ sister; apples→ apple; tickled→ tickle;

~ 92 types: Changes in less common wordforms
<u>Examples</u>: messages→ message; promises → promise; modeling → model

Regular data filter in action

Regular data filter in action

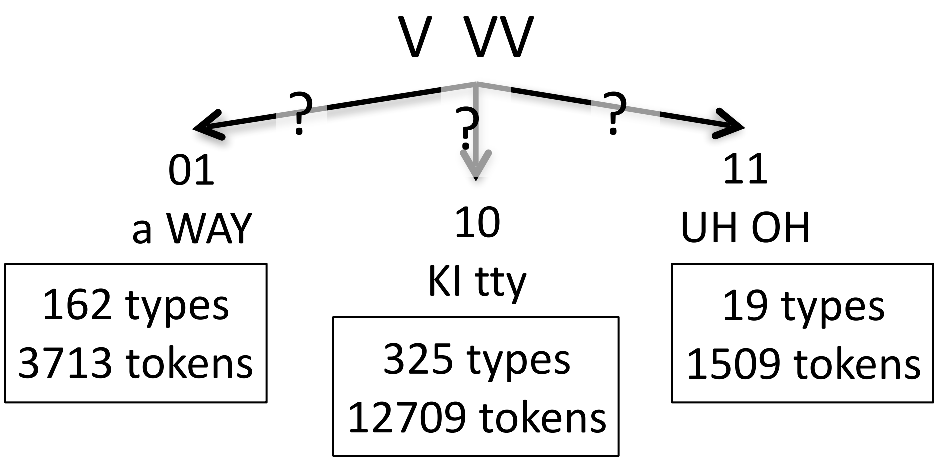
Parametric: HV & Hayes, with inflectional knowledge

HV: 148 syllable word forms

3 syllable distinctions

Hayes: 185 syllable words forms

4 syllable distinctions



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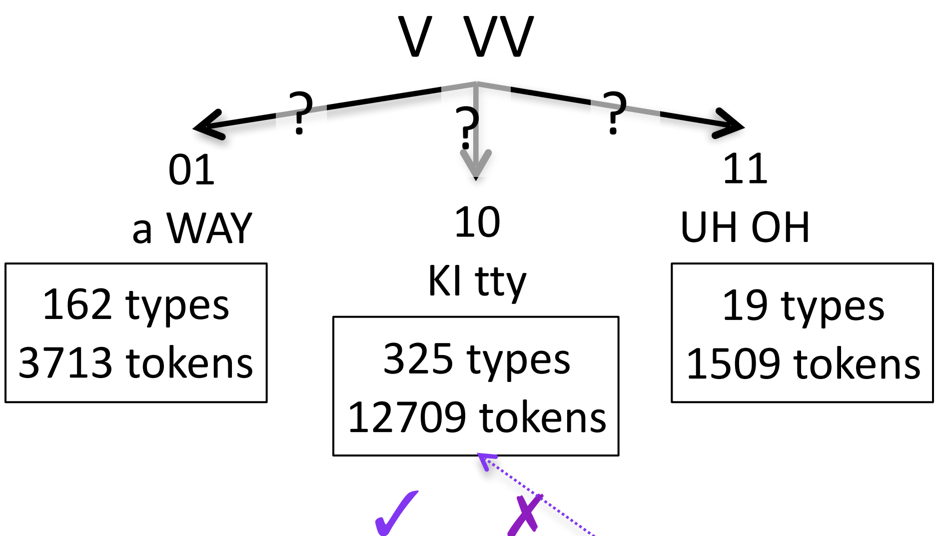

These items are good for the HV English grammar.

Regular data filter in action

Parametric: HV & Hayes, with inflectional knowledge

HV: 148 syllable word forms
3 syllable distinctions

Hayes: 185 syllable words forms
4 syllable distinctions

V VV

? ? ?

01
a WAY

162 types
3713 tokens

✗ ✓

10
KI tty

325 types
12709 tokens

✓ ✗

11
UH OH

19 types
1509 tokens

These items are good for the Hayes English grammar.

Regular data filter in action

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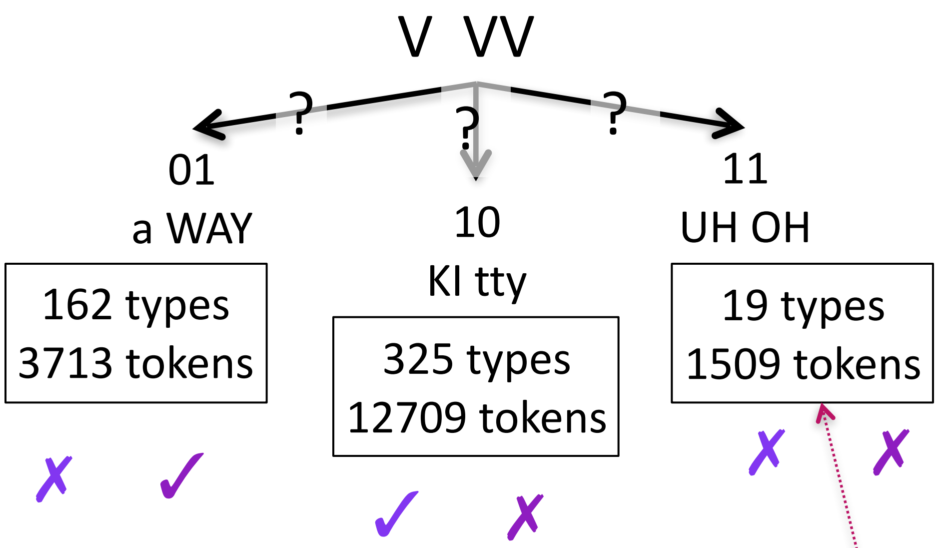
4 syllable distinctions



These items aren't good for either English grammar.

Regular data filter in action

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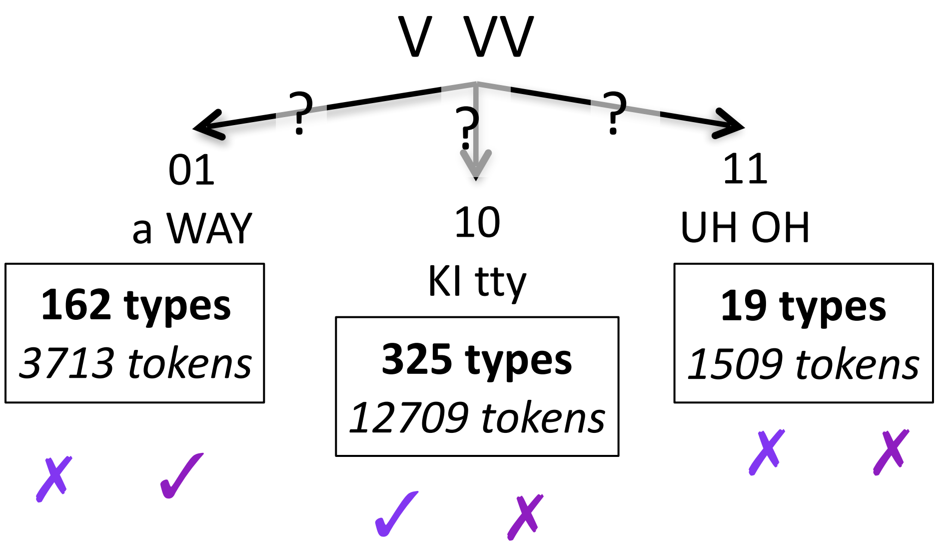
4 syllable distinctions



The Tolerance Principle looks at the **word types** with each stress pattern. Each represents an individual item that might follow the regular stress pattern rule (if there is one).

Regular data filter in action

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3 syllable distinctions

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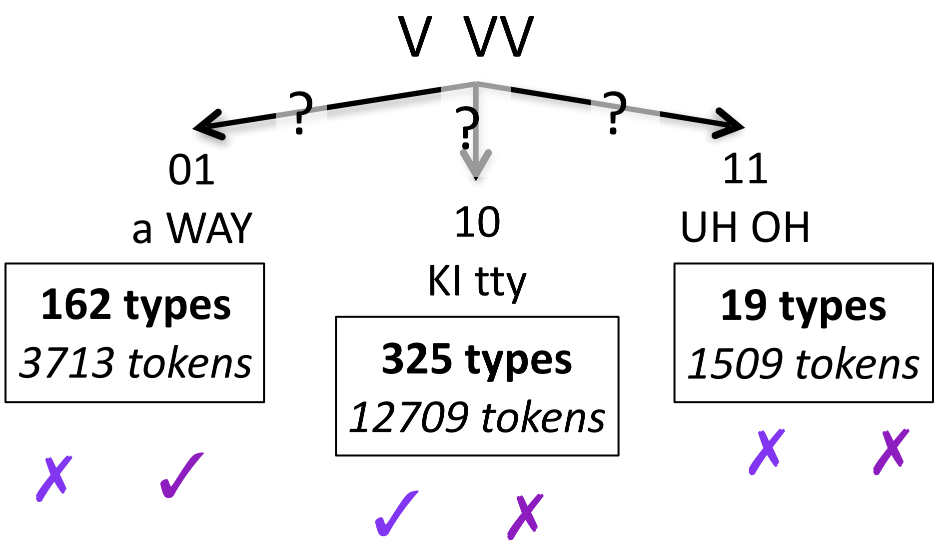
4 syllable distinctions



How many items should the stress “rule” apply to? N = 162 + 325 + 19 = 506

Regular data filter in action

Parametric: HV & Hayes, with inflectional knowledge

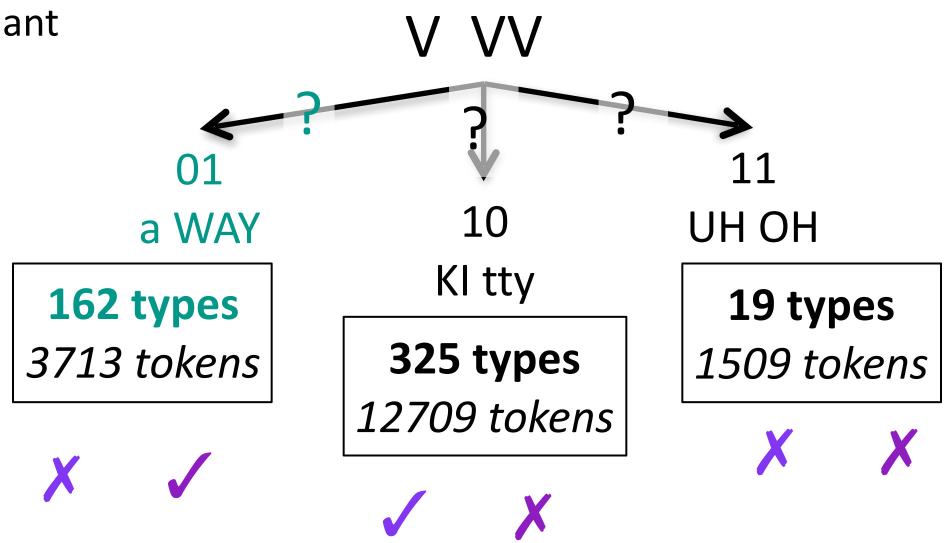
HV: 148 syllable word forms

3 syllable distinctions

Hayes: 185 syllable words forms

4 syllable distinctions

If this is the dominant pattern, too many exceptions:
325 + 19 > 81



How many exceptions are allowed? 506 / ln(506) = **81**

Regular data filter in action

Parametric: HV & Hayes, with inflectional knowledge

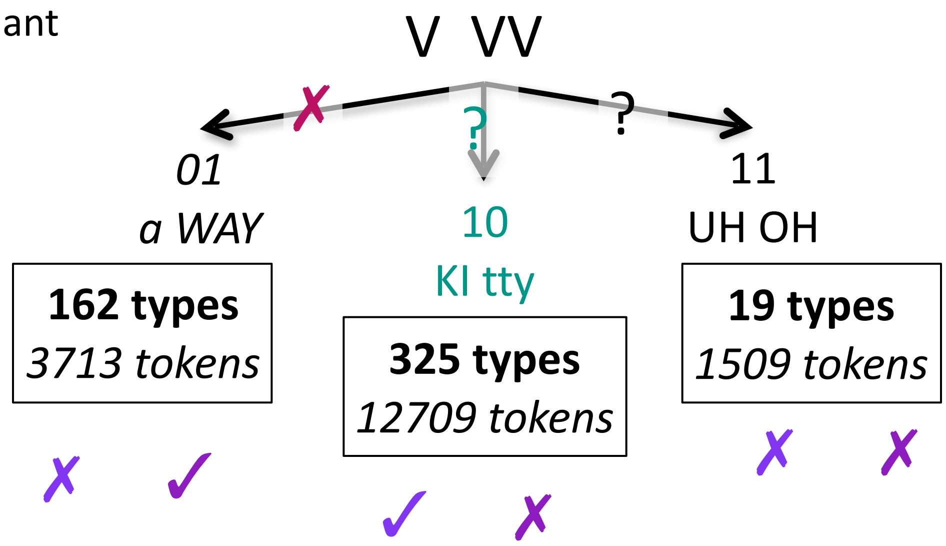
HV: 148 syllable word forms

3 syllable distinctions

Hayes: 185 syllable words forms

4 syllable distinctions

If this is the dominant pattern, too many exceptions:
162 + 19 > 81



How many exceptions are allowed? 506 / ln(506) = **81**

Regular data filter in action

Parametric: HV & Hayes, with inflectional knowledge

HV: 148 syllable word forms
3 syllable distinctions

Hayes: 185 syllable words forms
4 syllable distinctions

If this is the dominant pattern, way too many exceptions:
162 + 325 > 81

V VV

✗ ✗ ?

01
a WAY

162 types
3713 tokens

✗ ✓

10
KI tty

325 types
12709 tokens

✓ ✗

11
UH OH

19 types
1509 tokens

✗ ✗

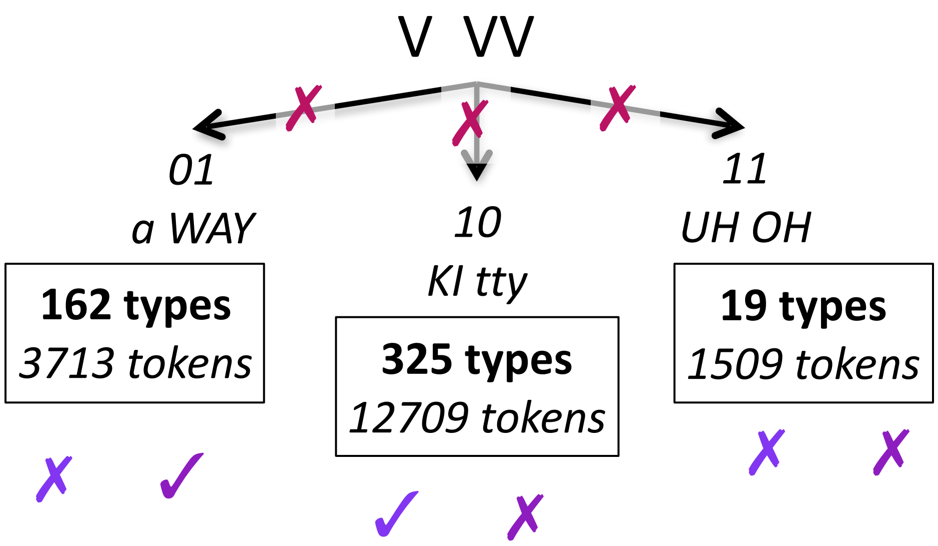
How many exceptions are allowed? 506 / ln(506) = **81**

Regular data filter in action

Parametric: HV & Hayes, with inflectional knowledge

HV: 148 syllable word forms
3 syllable distinctions

Hayes: 185 syllable words forms
4 syllable distinctions



Learner conclusion: No dominant stress pattern, so none of these syllable word form data should be used to learn the underlying generative system.

Regular data filter in action

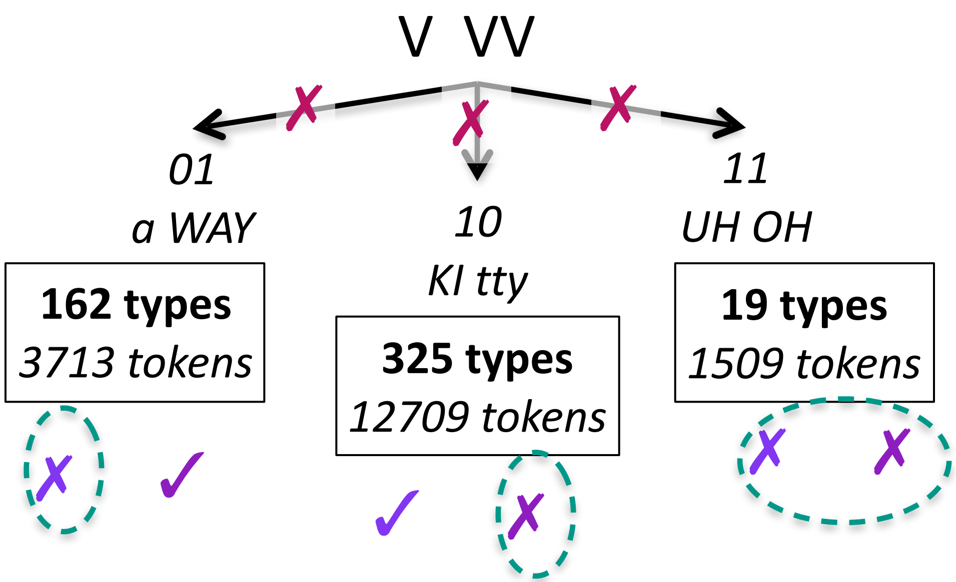
Parametric: HV & Hayes, with inflectional knowledge

HV: 148 syllable word forms

3 syllable distinctions

Hayes: 185 syllable words forms

4 syllable distinctions



This will end up helping both grammars, since they won't be penalized for the patterns they can't account for.

Regular data filter in action

Parametric: HV & Hayes, with inflectional knowledge

HV: 148 syllable word forms

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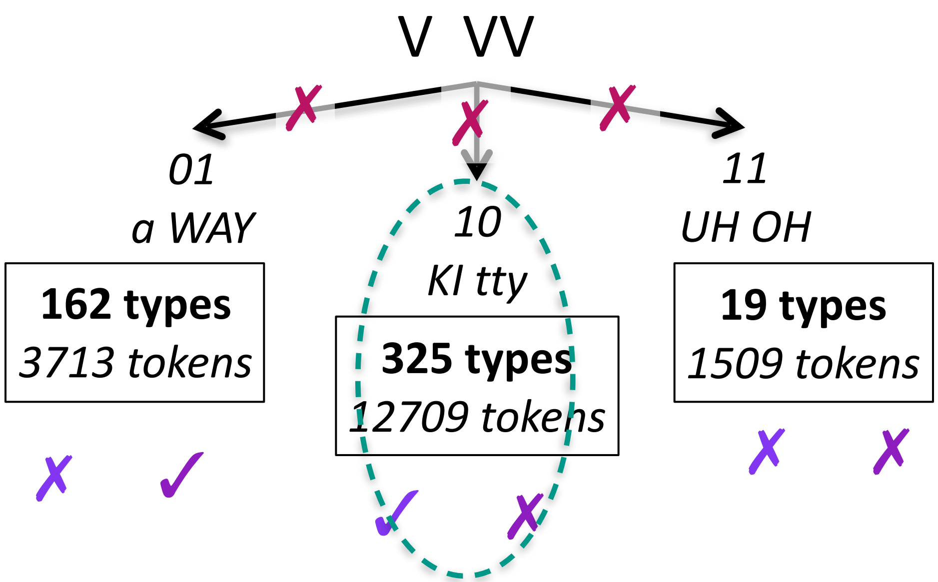
4 syllable distinctions



However, the Hayes grammar is helped a little more, since it couldn't account for the most frequent stress pattern before, while the HV grammar could.

Regular data filter in action

Constraint-based: OT, with inflectional knowledge

406 syllable word forms

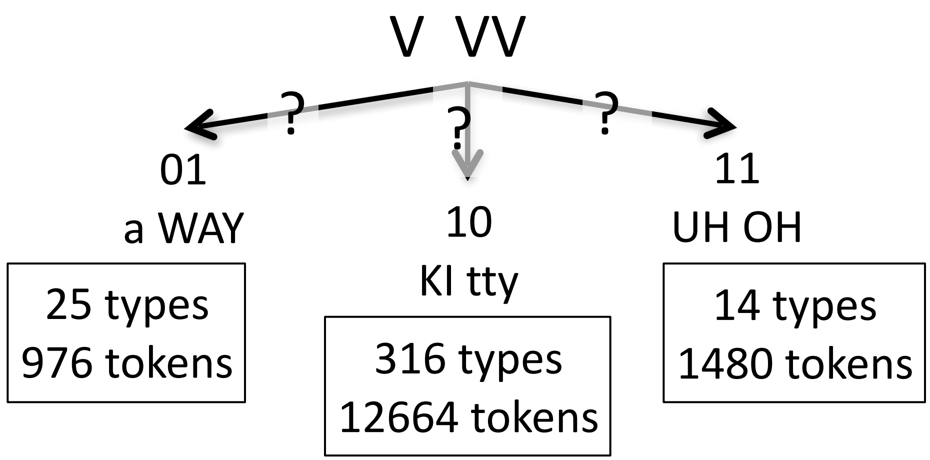
8 syllable distinctions

Regular data filter in action

Constraint-based: OT, with inflectional knowledge

406 syllable word forms

8 syllable distinctions

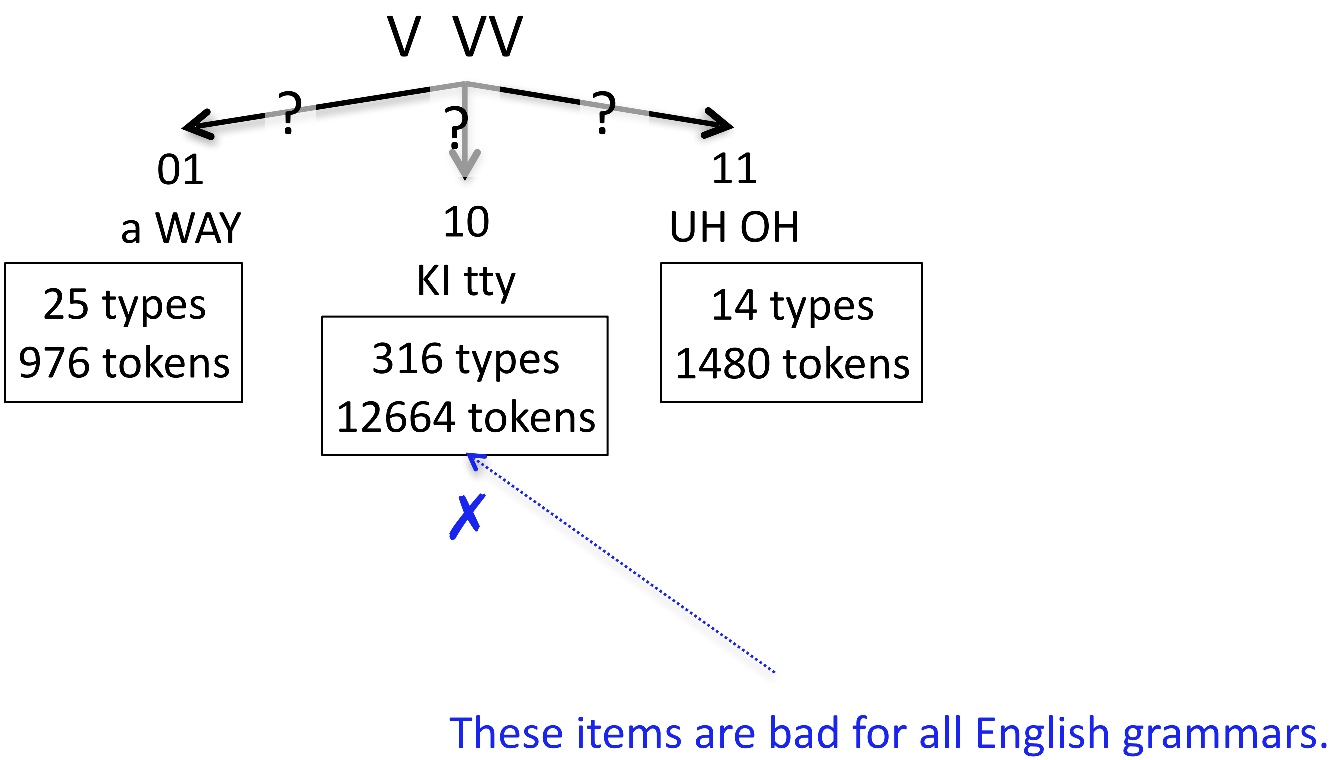


Regular data filter in action

Constraint-based: OT, with inflectional knowledge

406 syllable word forms

8 syllable distinctions

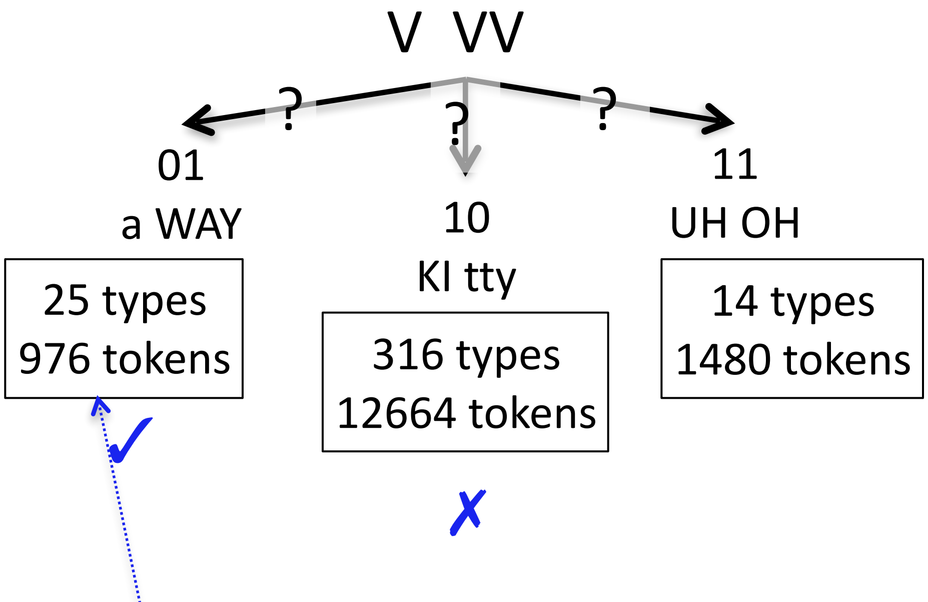


Regular data filter in action

Constraint-based: OT, with inflectional knowledge

406 syllable word forms

8 syllable distinctions



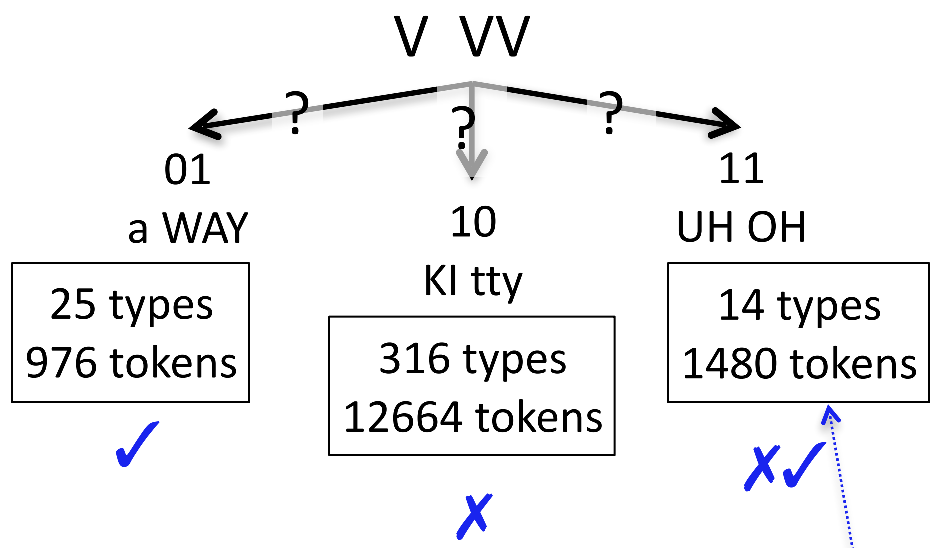
These items are good for most English grammars (21/26).

Regular data filter in action

Constraint-based: OT, with inflectional knowledge

406 syllable word forms

8 syllable distinctions



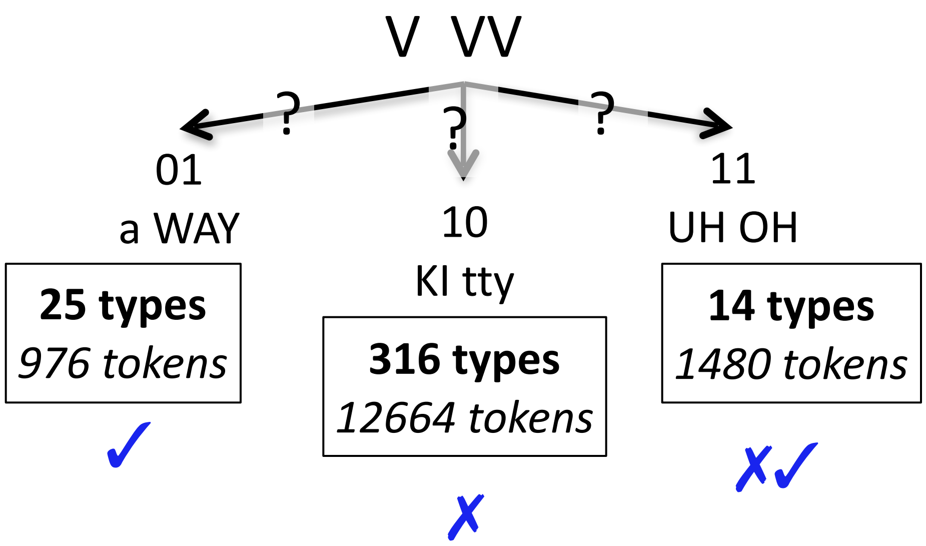
These items are good for a few English grammars (5/26).

Regular data filter in action

Constraint-based: OT, with inflectional knowledge

406 syllable word forms

8 syllable distinctions



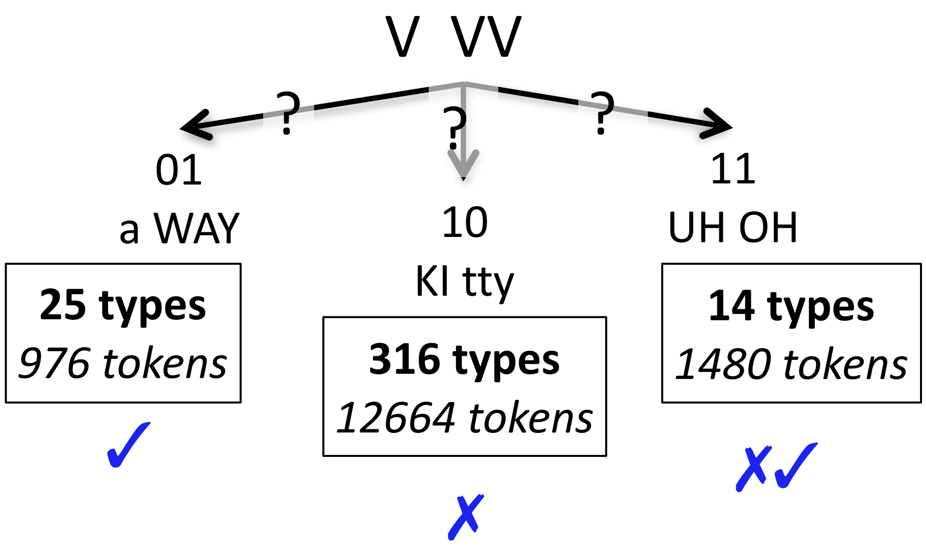
How many items should the stress “rule” apply to? N = 25 + 316 + 14 = 355

Regular data filter in action

Constraint-based: OT, with inflectional knowledge

406 syllable word forms

8 syllable distinctions



How many exceptions are allowed? 355 / ln(355) = **60**

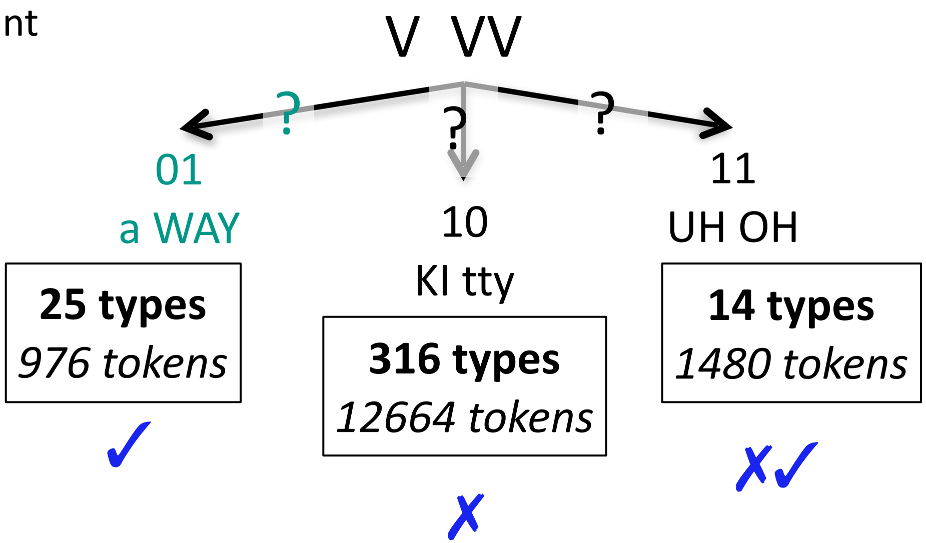
Regular data filter in action

Constraint-based: OT, with inflectional knowledge

406 syllable word forms

8 syllable distinctions

If this is the dominant pattern, too many exceptions:
316 + 14 > 60



How many exceptions are allowed? 355 / ln(355) = **60**

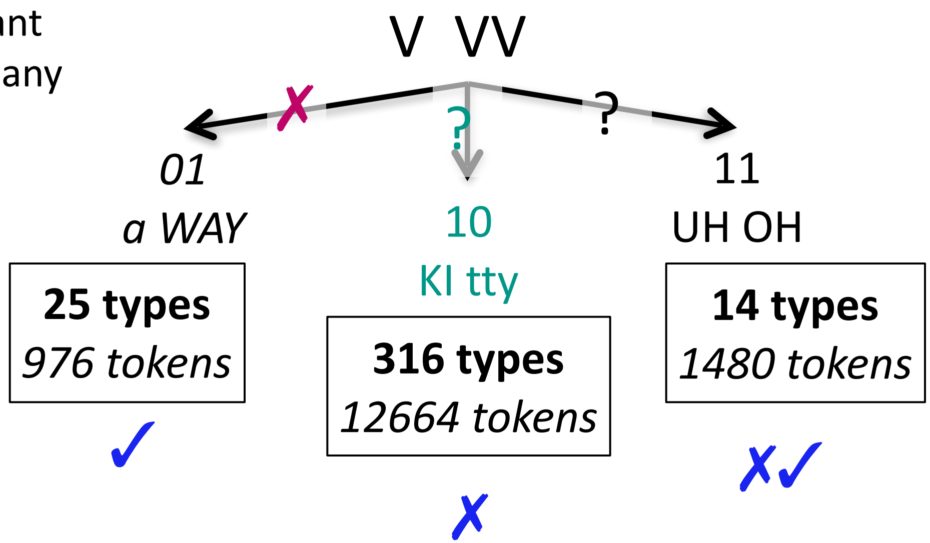
Regular data filter in action

Constraint-based: OT, with inflectional knowledge

406 syllable word forms

8 syllable distinctions

If this is the dominant pattern, NOT too many exceptions:
25 + 14 < 60



How many exceptions are allowed? 355 / ln(355) = **60**

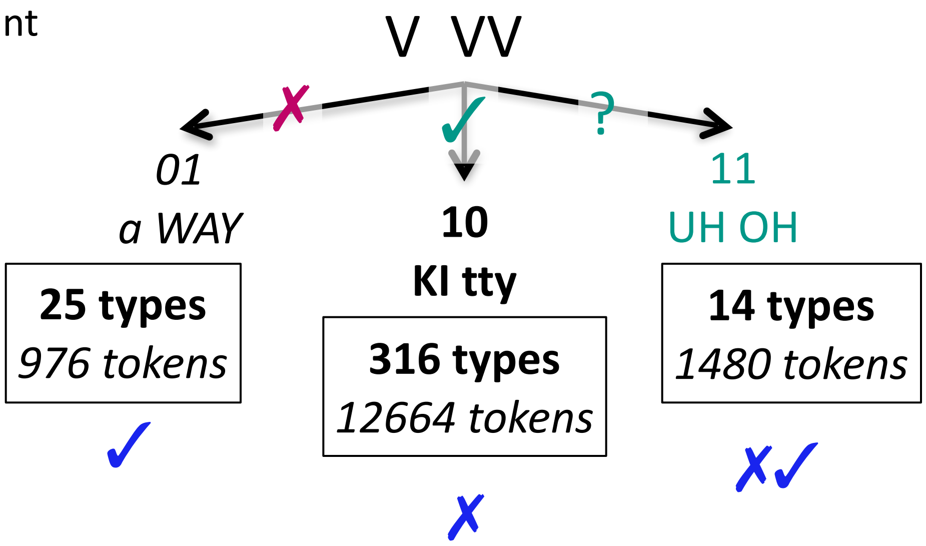
Regular data filter in action

Constraint-based: OT, with inflectional knowledge

406 syllable word forms

8 syllable distinctions

If this is the dominant pattern, too many exceptions:
25 + 316 > 60



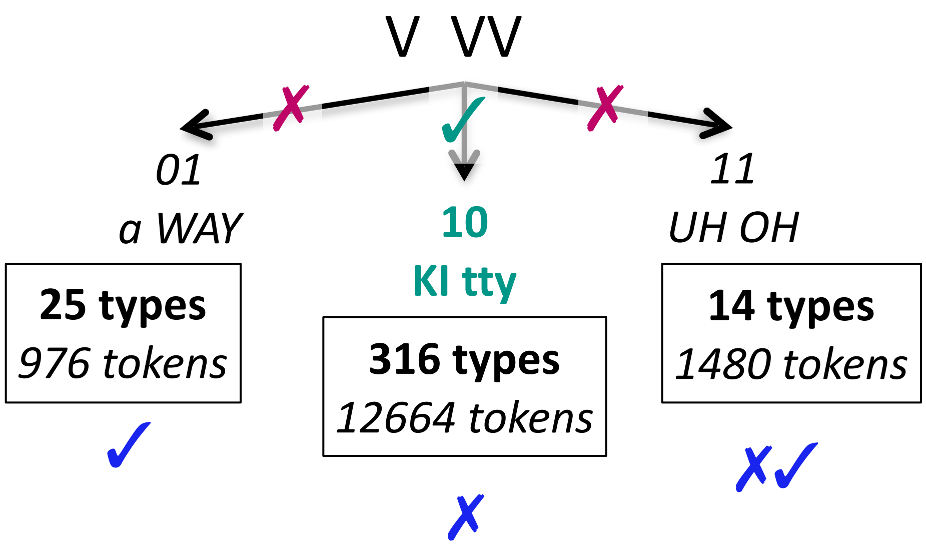
How many exceptions are allowed? 355 / ln(355) = **60**

Regular data filter in action

Constraint-based: OT, with inflectional knowledge

406 syllable word forms

8 syllable distinctions



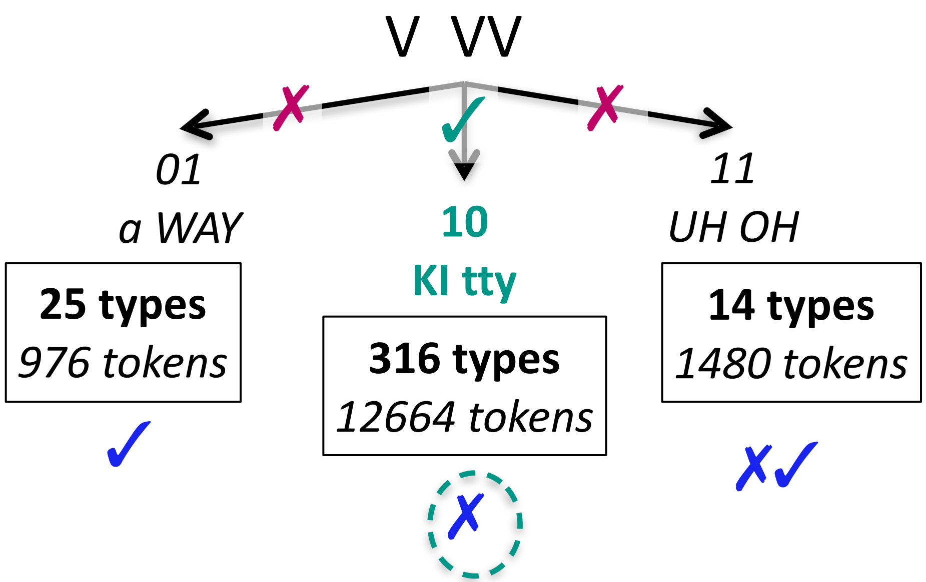
Under the OT syllable representation, there is a dominant stress pattern for this word form. Therefore, this pattern should be accounted for by the underlying generative system.

Regular data filter in action

Constraint-based: OT, with inflectional knowledge

406 syllable word forms

8 syllable distinctions



Unfortunately, this is the only pattern the English grammars cannot account for….this means a learner using the regularity filter would have even more trouble learning the English OT grammar constraints.