What cultural evolution tells us about the innateness of language

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What's wrong with this picture?

What's wrong with this picture?

vs.

"The big language evolution debate"

Nativism and culture

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- Chomsky and Pinker:
  - are both nativists
  - neither appear to believe in a significant explanatory role for cultural evolution

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- Chomsky and Pinker:
  - are both nativists
  - neither appear to believe in a significant explanatory role for cultural evolution
- I want to argue that these two go together
- If you take cultural evolution seriously, it has surprising implications for nativism

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- Linguistic nativism:
  - strong, language-specific constraints

Why believe in linguistic nativism?

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- POVERTY OF THE STIMULUS
  - Given limited evidence, language acquisition would be impossible without significant innate knowledge

Cultural evolution

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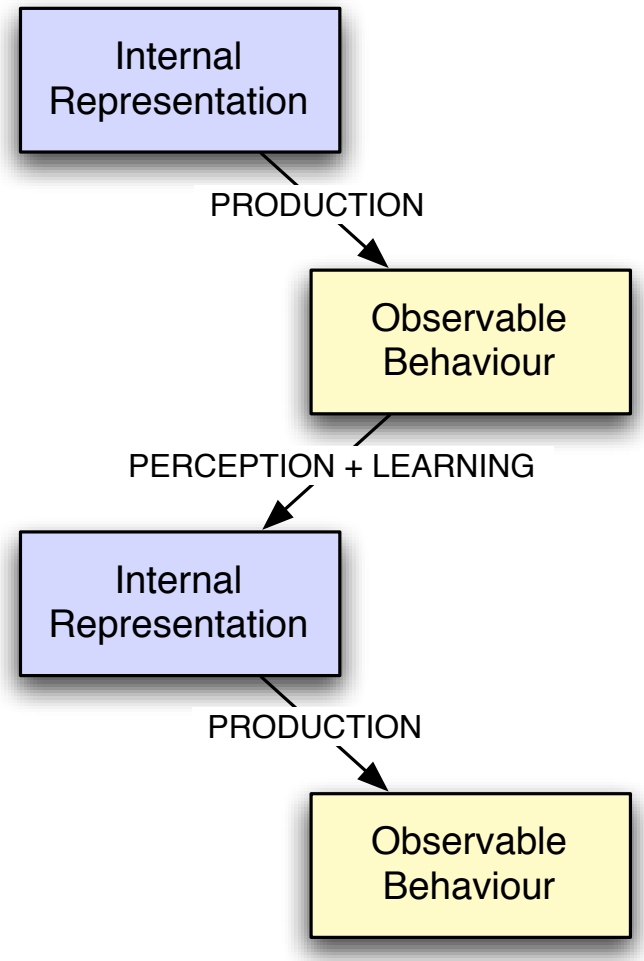
- Cultural evolution:
  - the analog of biological evolution in the domain of socially (rather than genetically) transmitted information
- Arguably, language is the best example in nature of a culturally transmitted system

Iterated Learning

- One mechanism for cultural evolution
- *Iterated Learning:*
  process whereby a behaviour is acquired through observation of another's behaviour, who acquired it in the same way



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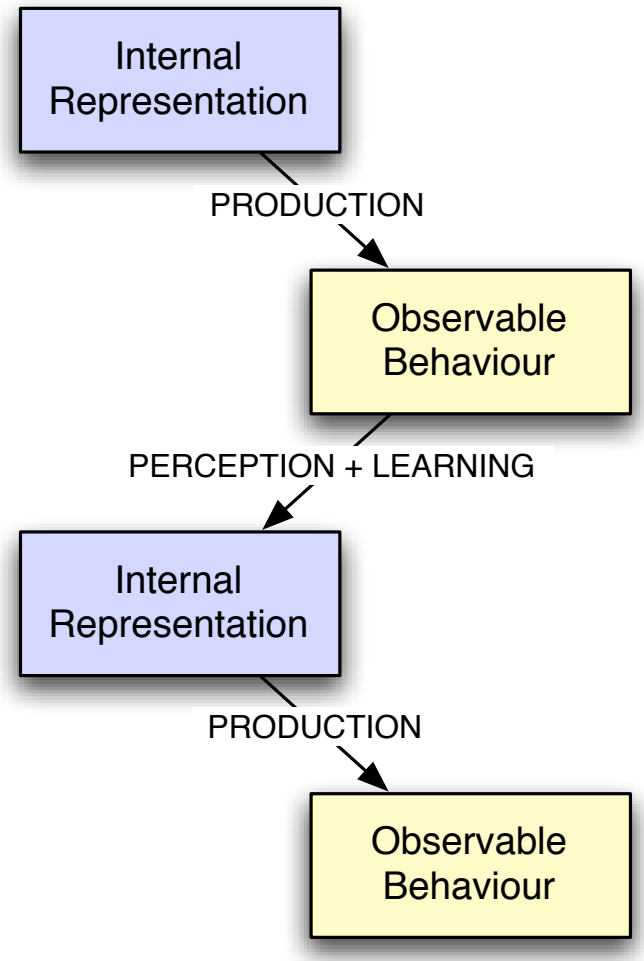

Iterated Learning

- Nothing particularly controversial about this
- Nevertheless, it has unexpected properties we are only beginning to appreciate
- How do we study it?
  - Formal models
  - Experimental models with human participants

A formal model of Iterated Learning

Kirby, Dowman & Griffiths (2007), *PNAS*

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- Need:
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  - and a way of telling what language universals this gives rise to.

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A formal model of Iterated Learning

- Is it right to assume that universals are transparently related to innate constraints?
- Need:
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- Use *bayesian* model of learning

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$$p(h|d) \propto p(d|h)p(h)$$

- Allows us to provide a model of innateness, *p(h)*, and predict what language (hypothesis), *h*, a learner will pick given a given set of data, *d*

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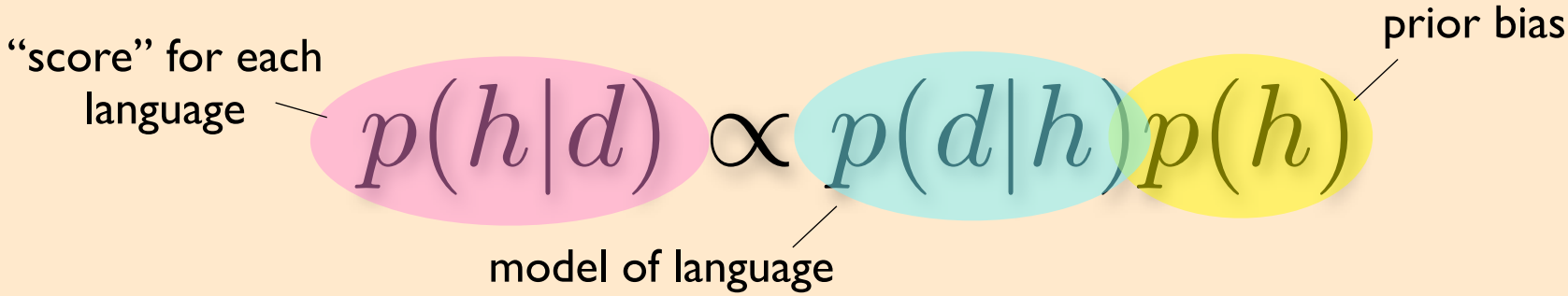

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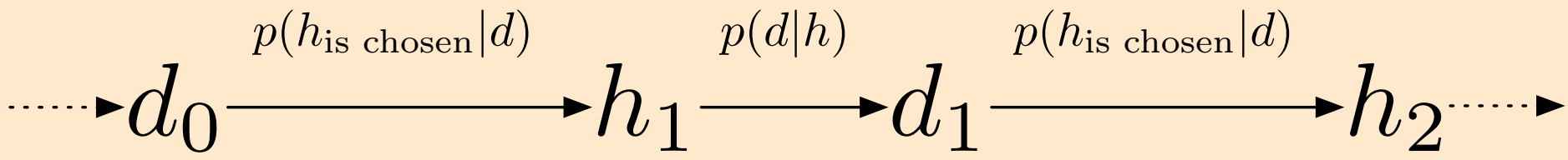

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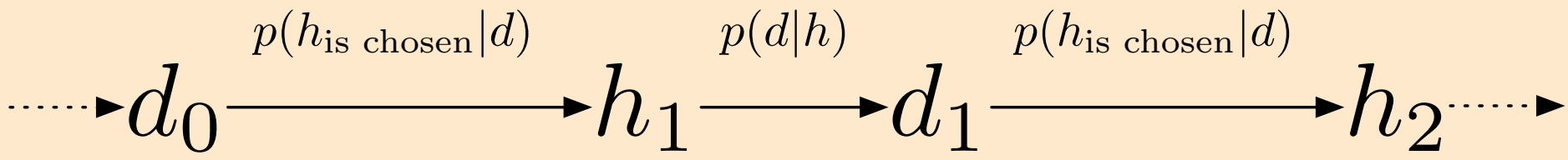
- Imagine a chain of these learners, each one's output the next one's learning data:



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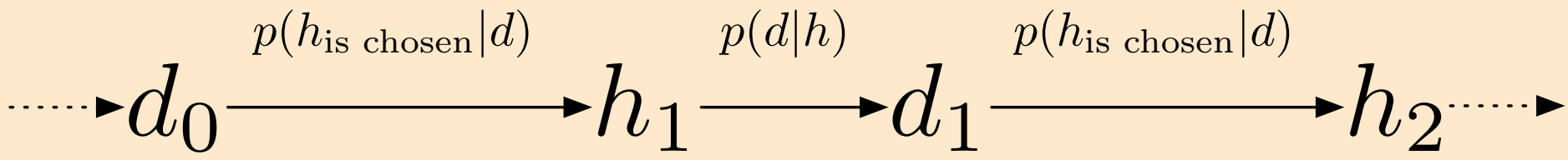
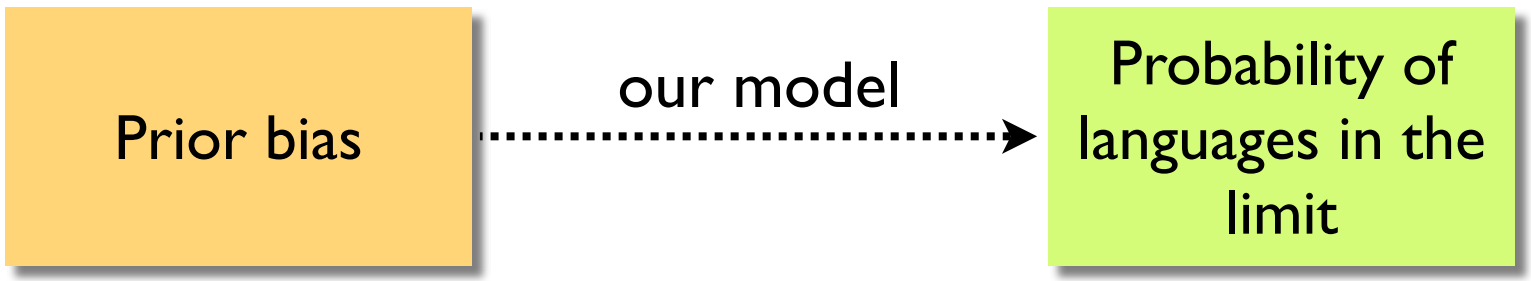


- There's a neat mathematical trick that lets us work out what will happen here to the probability of different languages in the limit

From innateness to universals

- To recap:
  - If we think of innateness in terms of *prior bias*
  - then we can work out what languages will emerge from iterated learning



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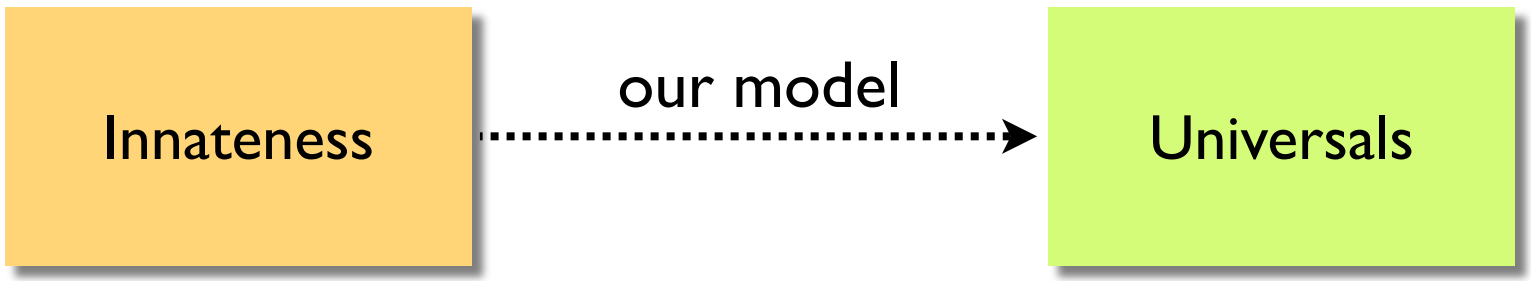

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A simple example: regularity

- Model language as a set of meanings
- Meanings can be expressed regularly, or irregularly
- Start with the assumption that there is a slight innate bias in favour of regularity
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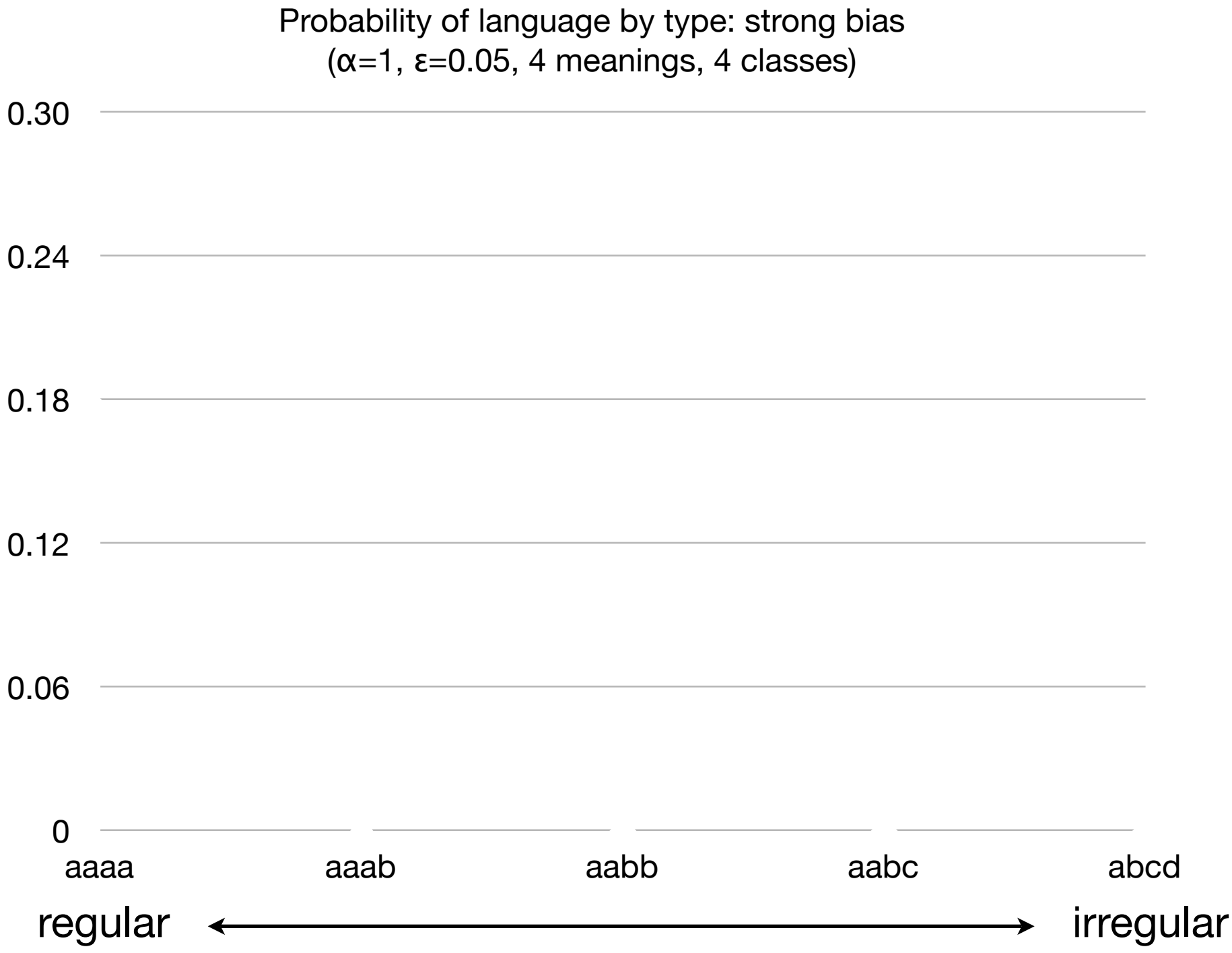
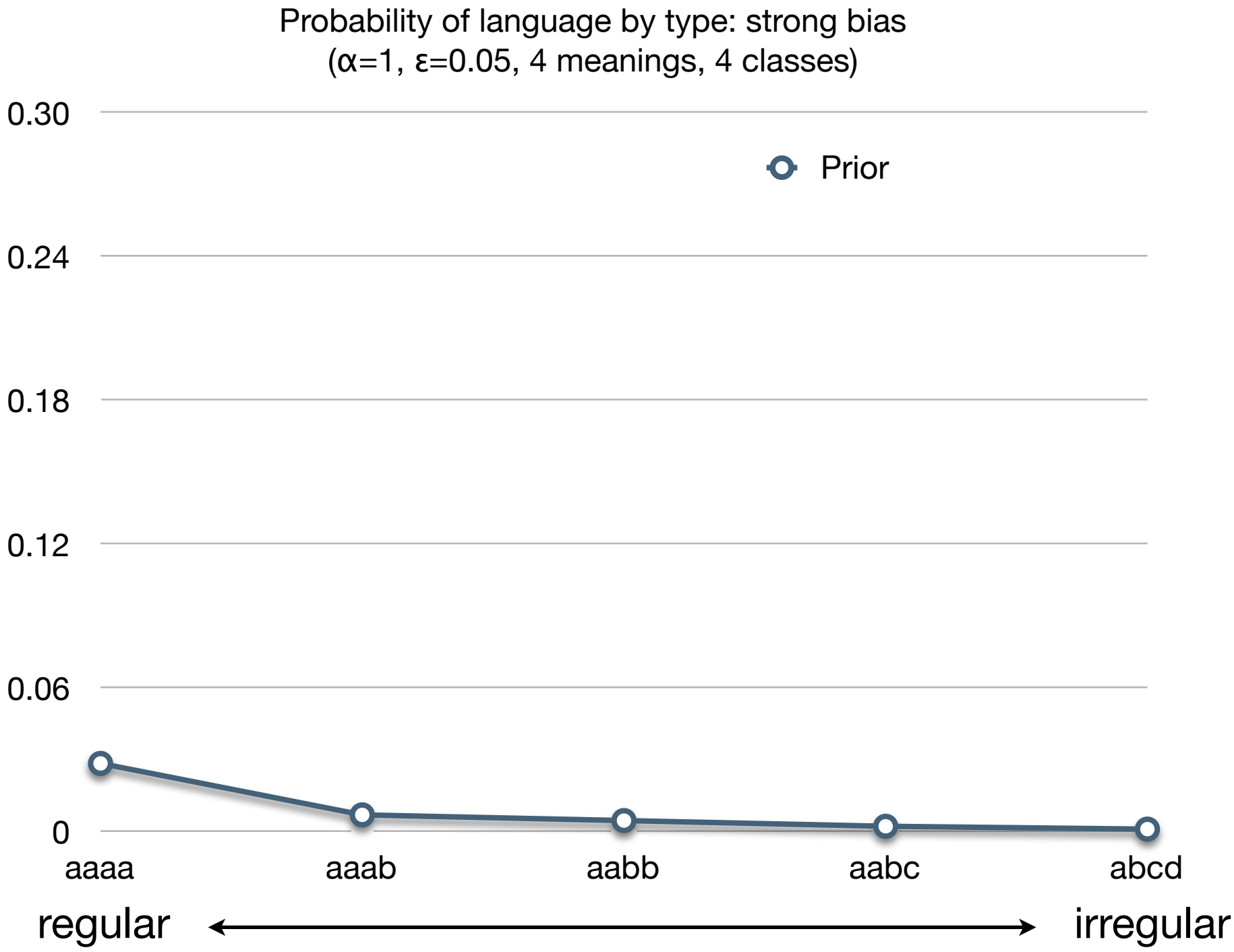
- What happens?


Probability of language by type: strong bias
(α=1, ε=0.05, 4 meanings, 4 classes)
0.30
0.24
0.18
0.12
0.06
0
aaaa
aaab
aabb
aabc
abcd
regular
irregular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Prior
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aabb
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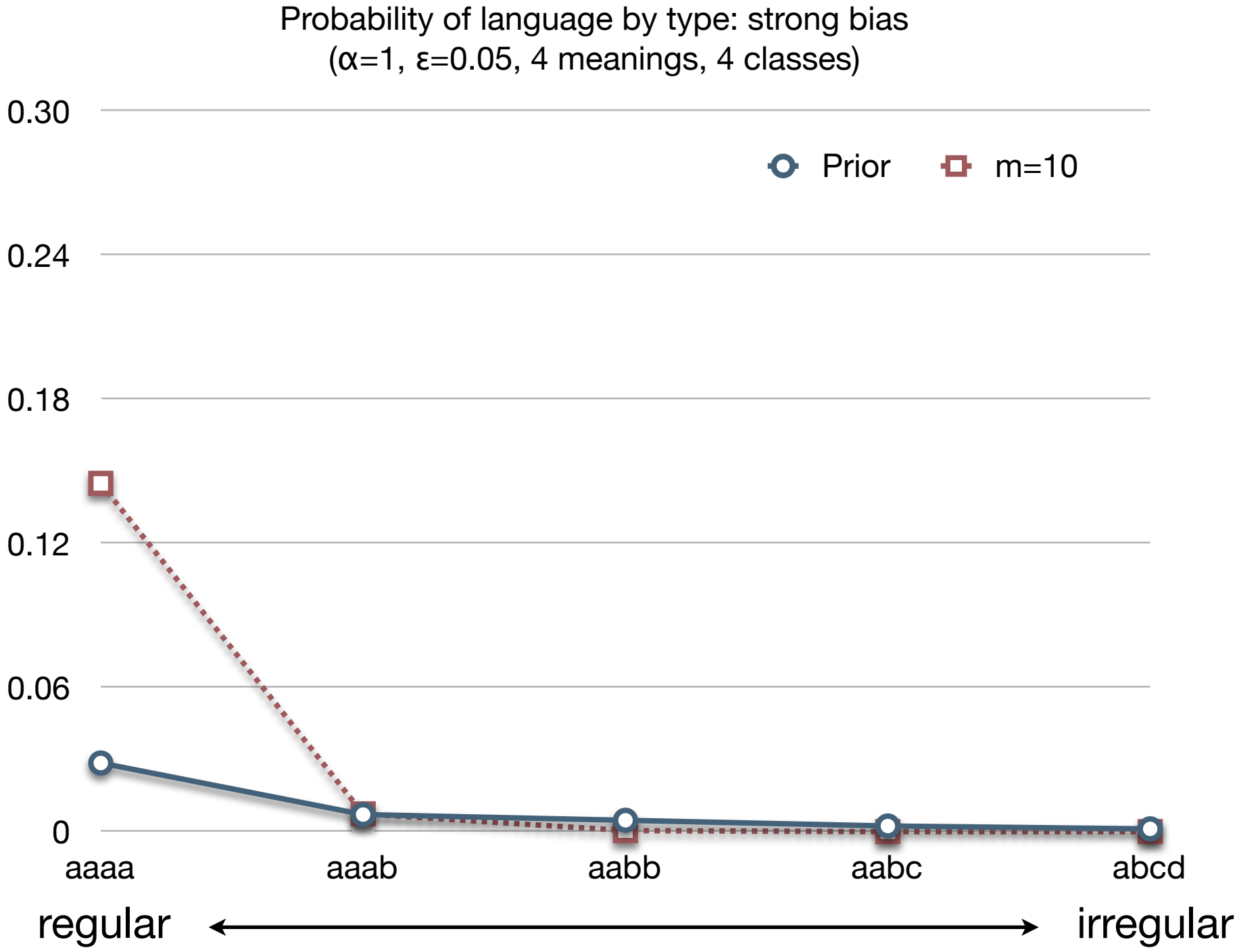
abcd
regular
irregular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0.12
0.06
0
Prior
m=10
aaaa
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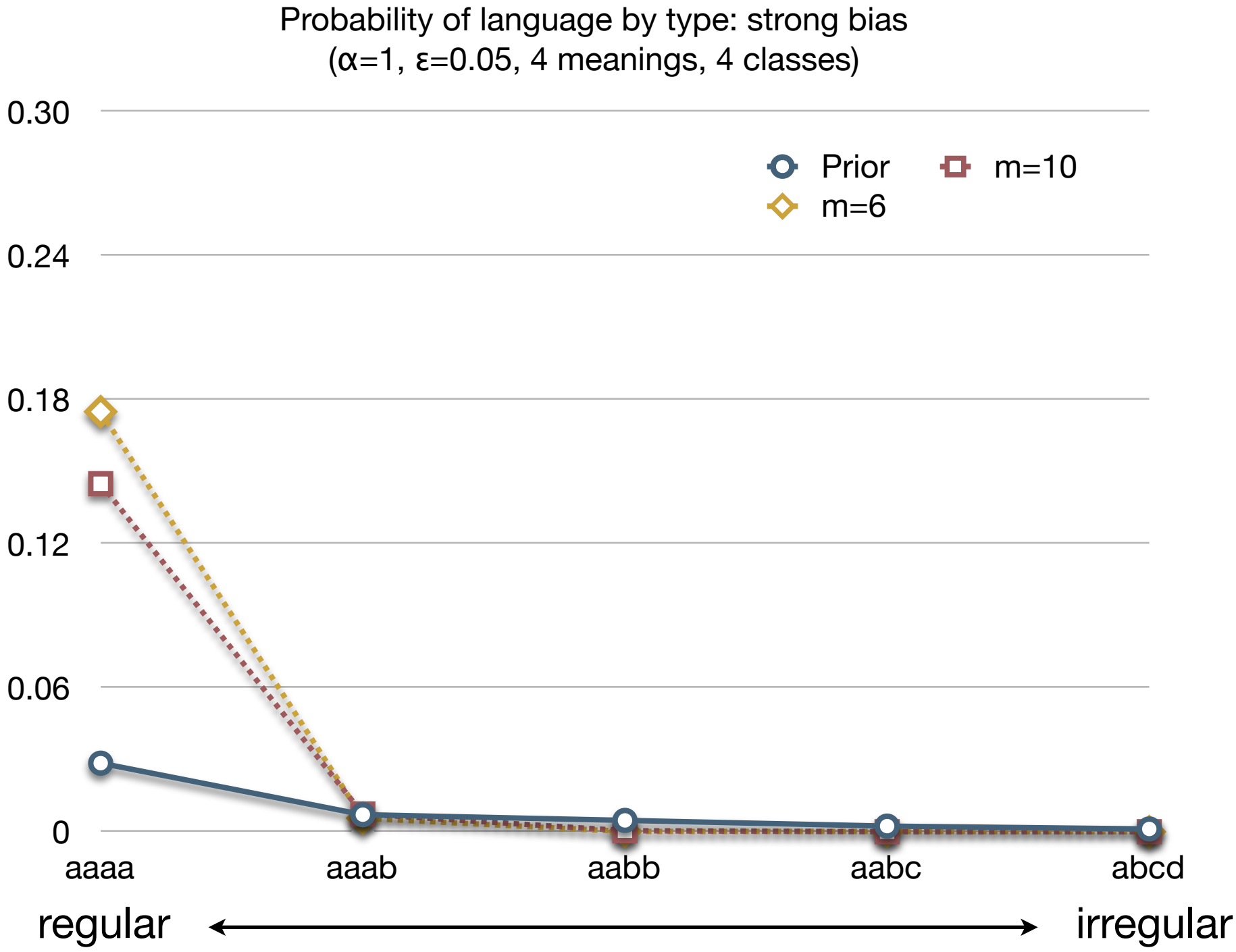
abcd
regular
irregular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m=6
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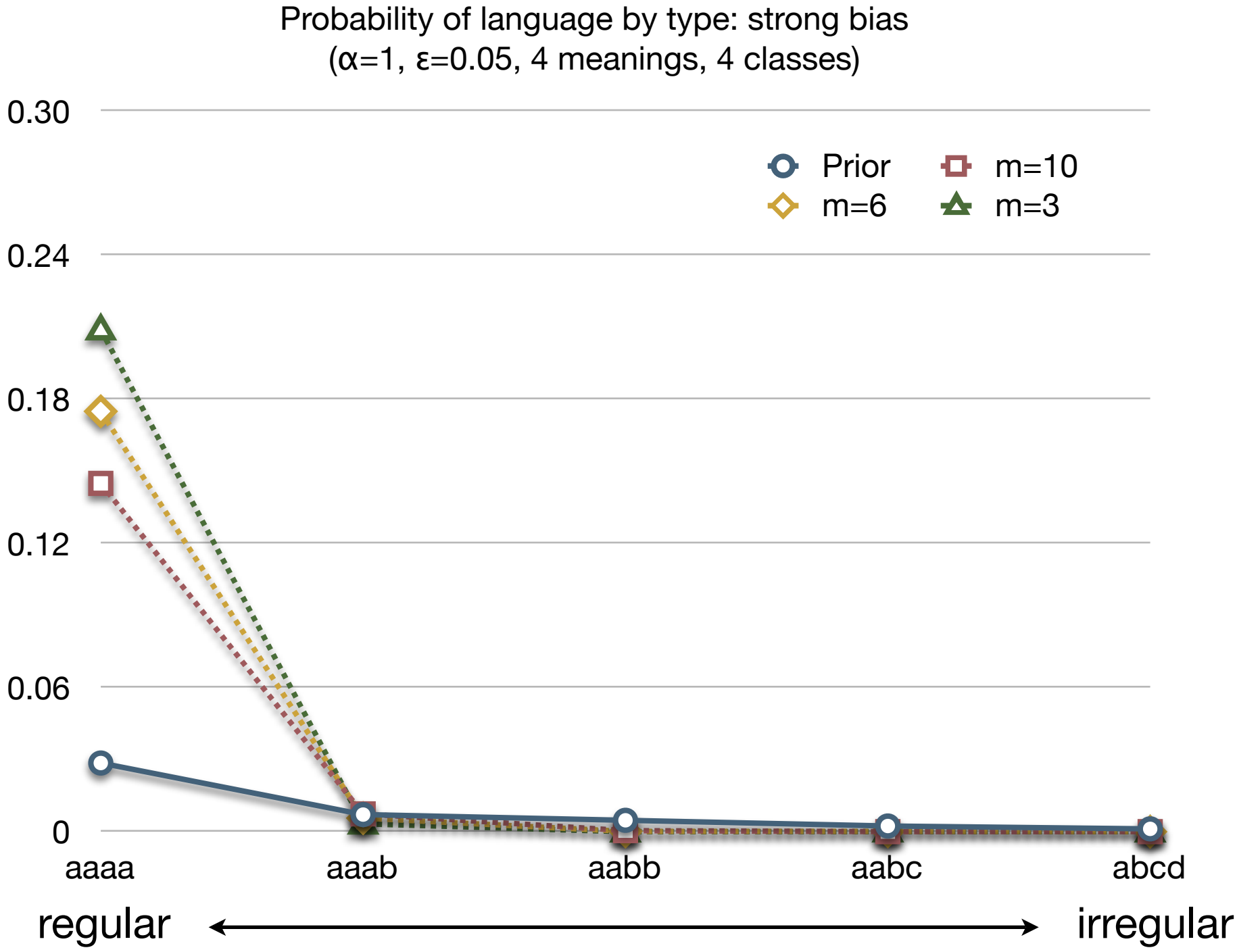
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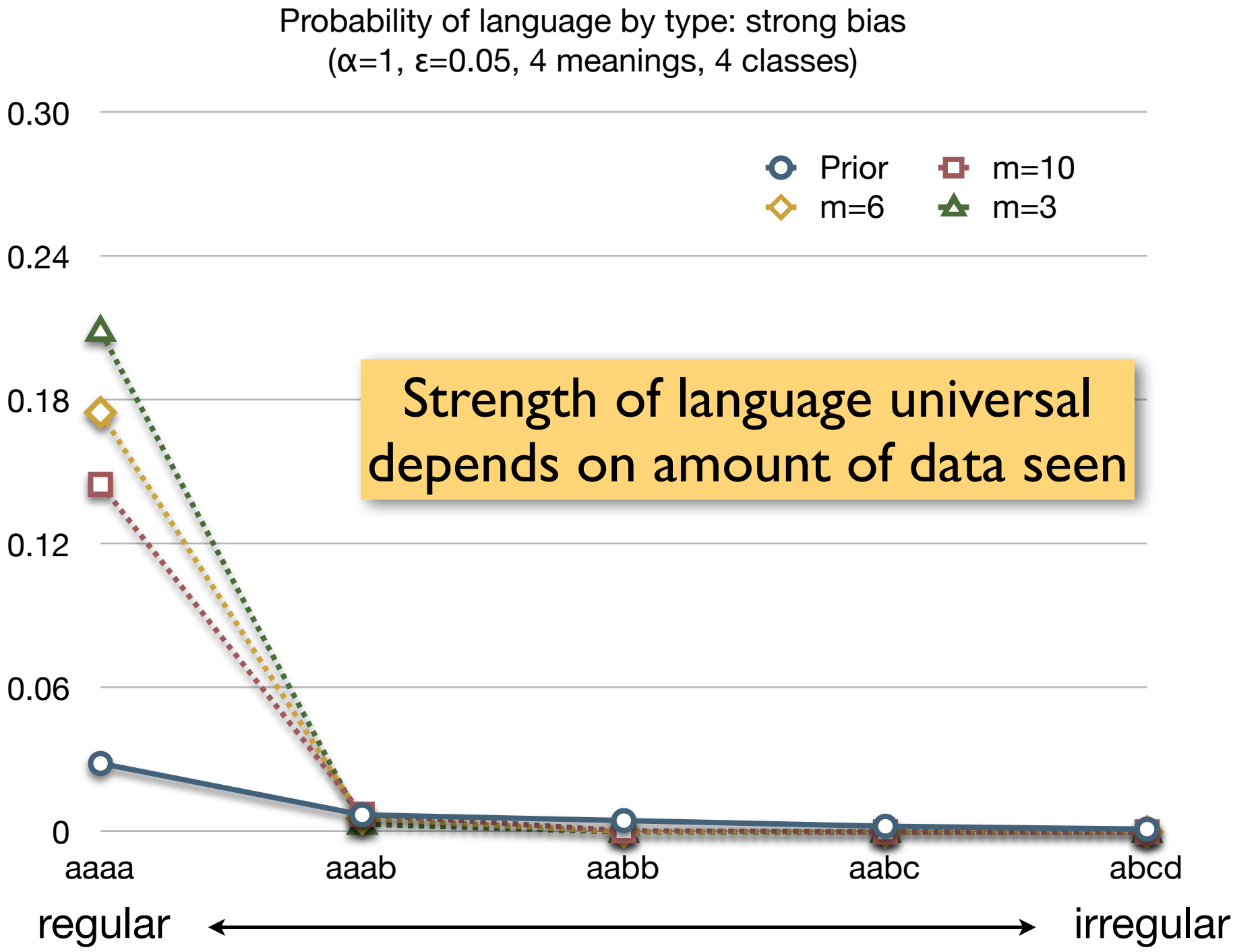
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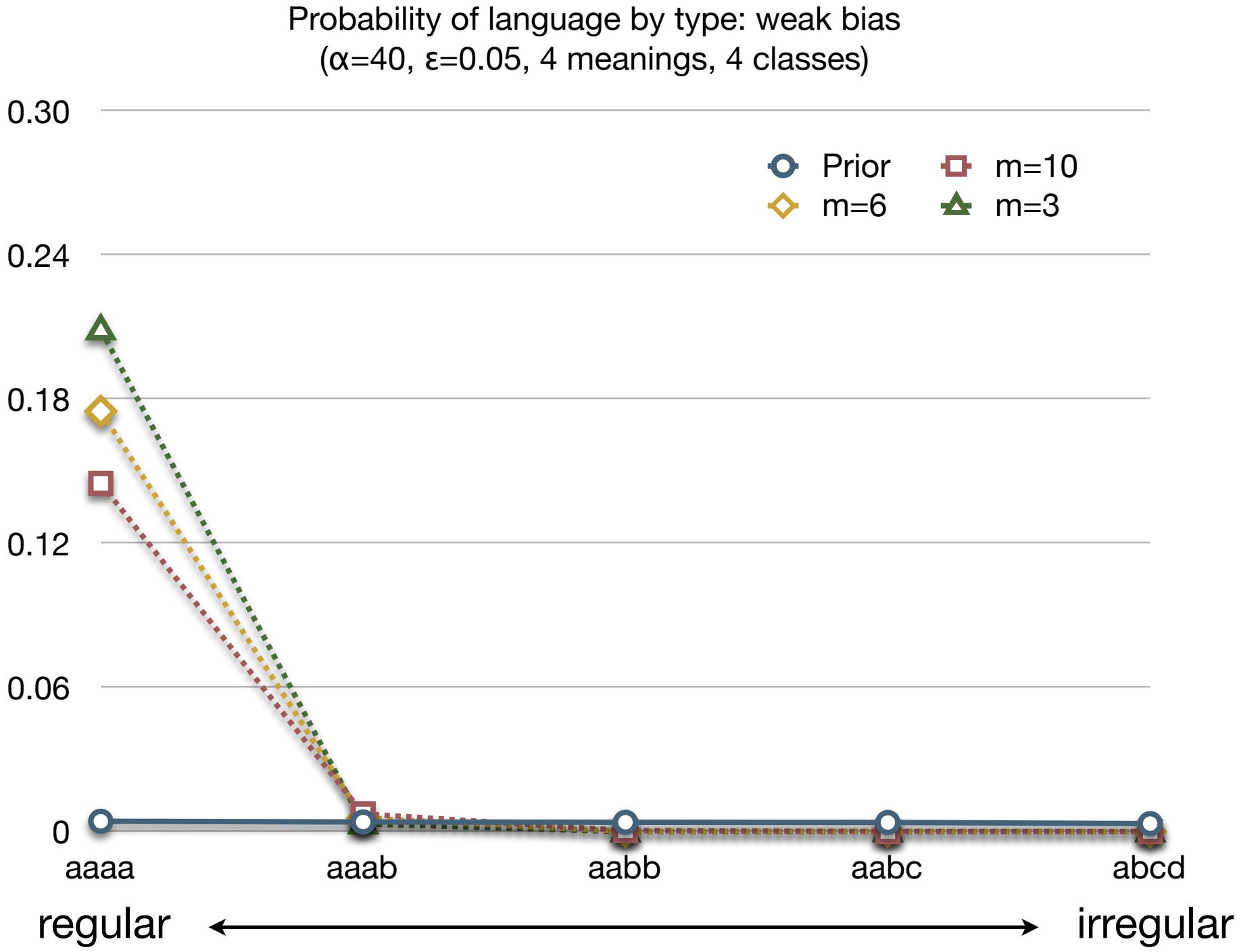
Prior
m=10
m=6
m=3
Strength of language universal depends on amount of data seen
aaaa
aaab
aabb
aabc
abcd
regular
irregular


Probability of language by type: weak bias
(α=40, ε=0.05, 4 meanings, 4 classes)
0.30
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Prior
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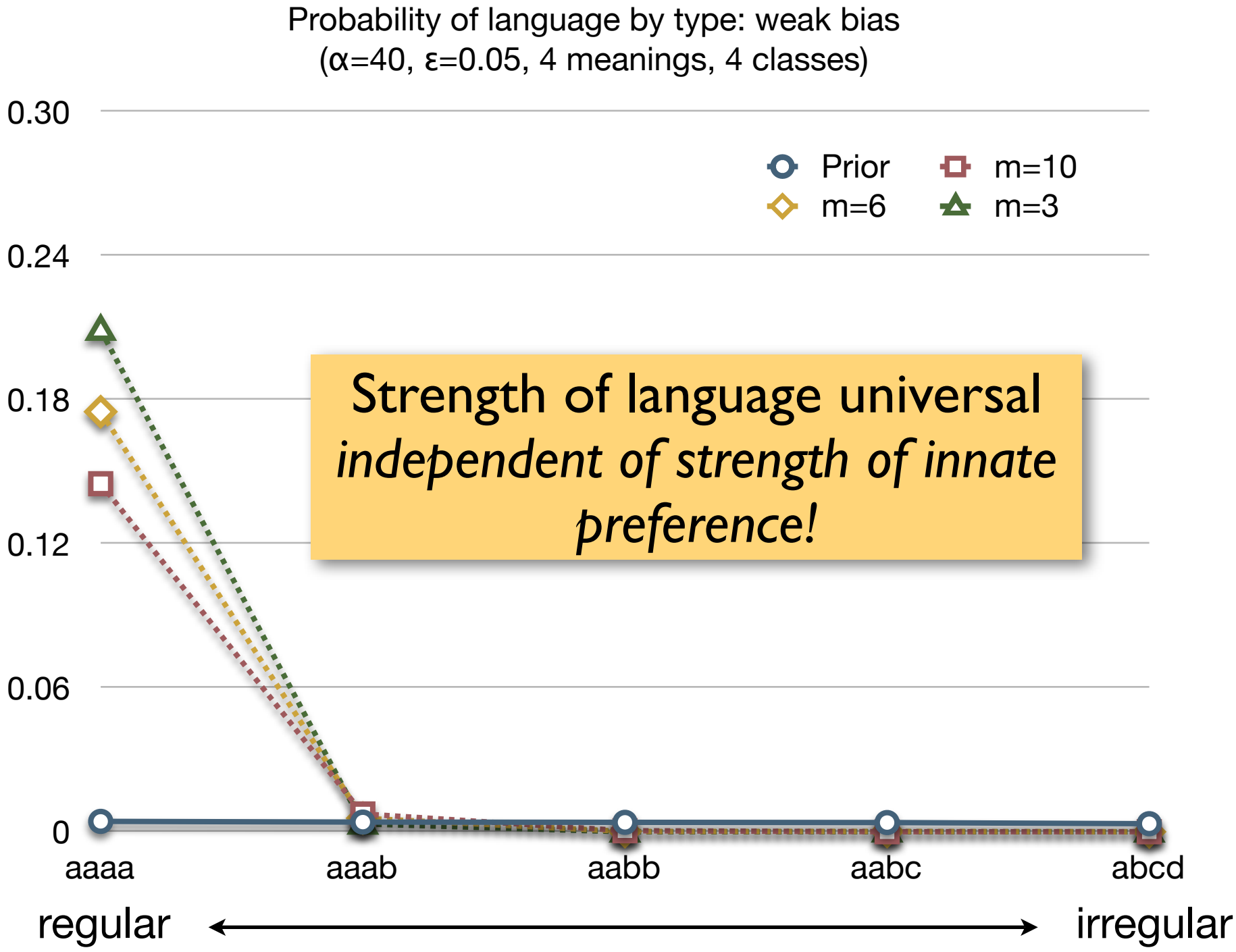
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Strength of language universal
independent of strength of innate preference!
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What does this mean?

- What's innate matters, but you can't predict language universals from innateness
- Equally, you can't infer innateness from universals.
- Strong universals do not imply strong innate constraints
- Neatly predicts Dediu & Ladd's (2007) genes/tone correlation

Linguistic adaptation

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- Language is *adapting* culturally
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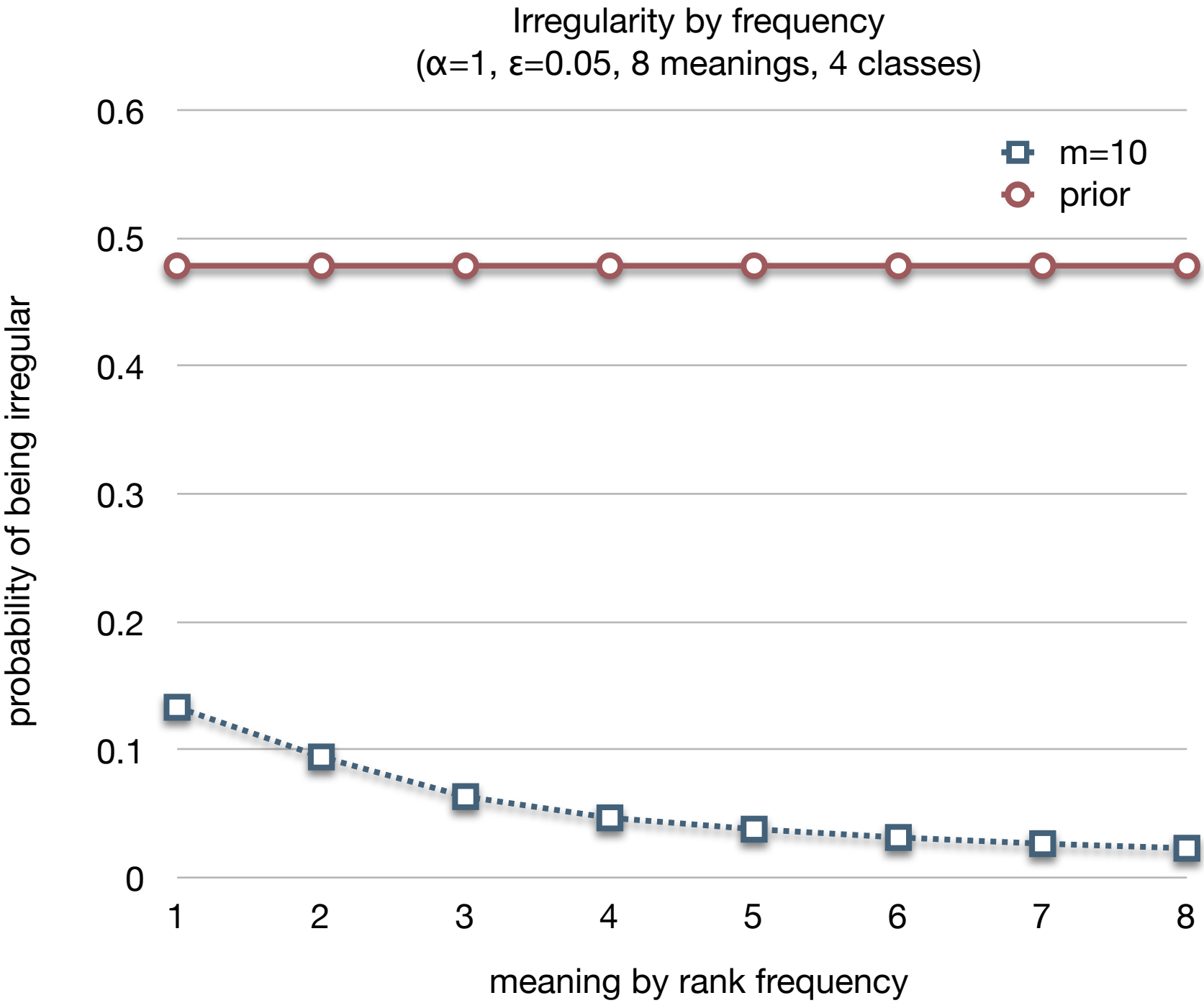
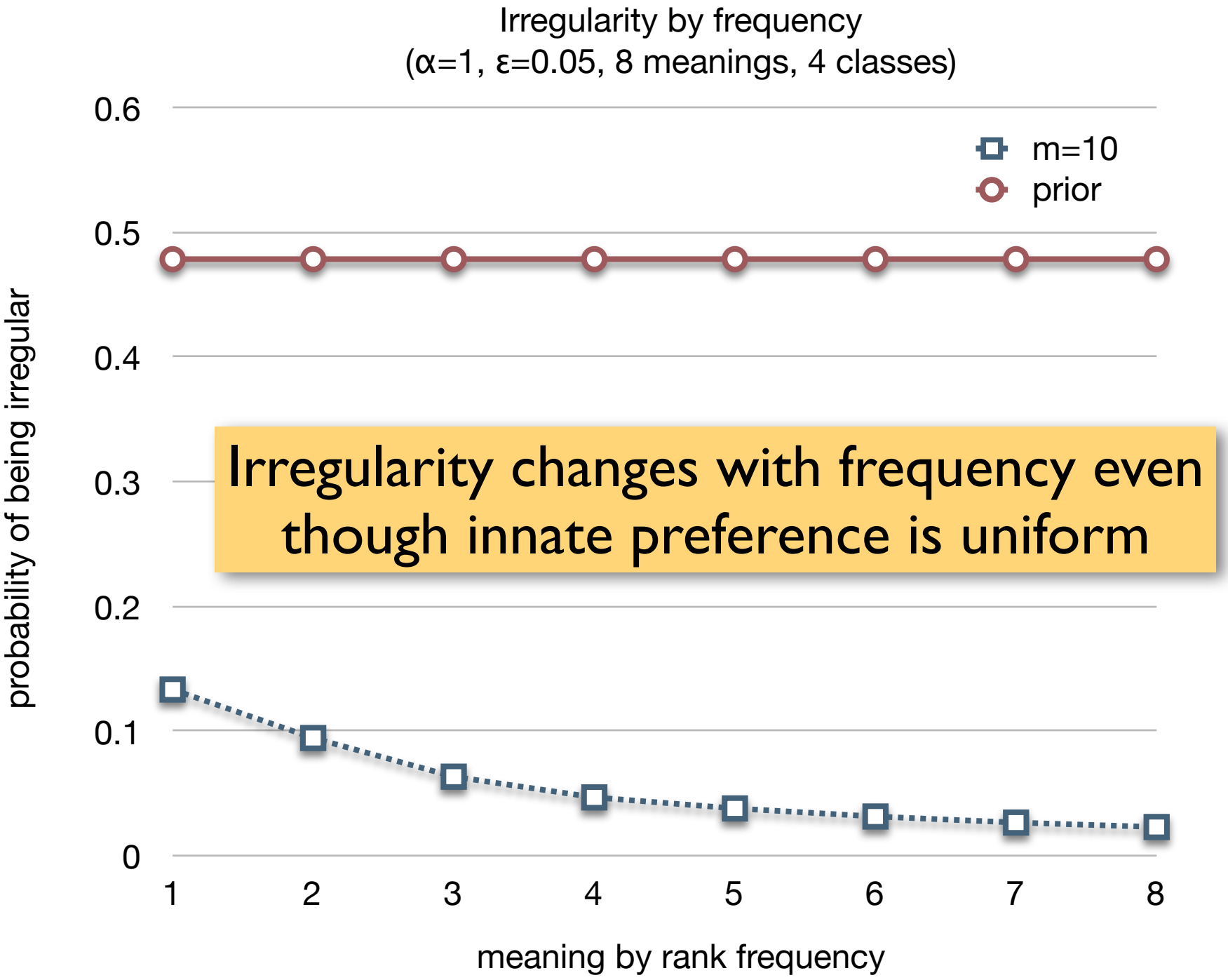
- The languages we see are the ones optimised for transmission
  - No need for natural selection
- The tougher the transmission "bottleneck", the more pressure there is to adapt
  - Turns the poverty of the stimulus problem on its head
  - Explains the frequency/irregularity correlation in morphology


Irregularity by frequency
(α=1, ε=0.05, 8 meanings, 4 classes)
0.6
0.5
0.4
0.3
0.2
0.1
0
probability of being irregular
m=10
prior
1
2
3
4
5
6
7
8
meaning by rank frequency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0.4
0.3
0.2
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probability of being irregular
m=10
prior
Irregularity changes with frequency even though innate preference is uniform
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2
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Beyond formal models

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- Can we replicate the modelling results in the lab?

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- Is our model of learning reasonable?
- Can this kind of evolution happen in a reasonable time-scale?
- Can cultural adaptation happen without human intention?

An experimental paradigm

Cornish, K. Smith, Tamariz, A. Smith, Flaherty, Beqa

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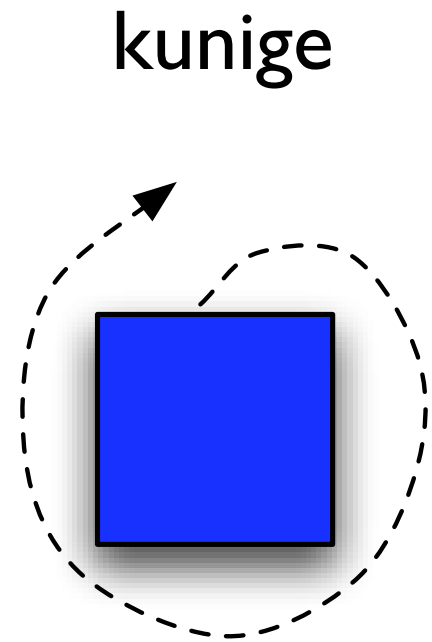
- Participants exposed to artificial language made up of picture/ string pairs (typically initially random)



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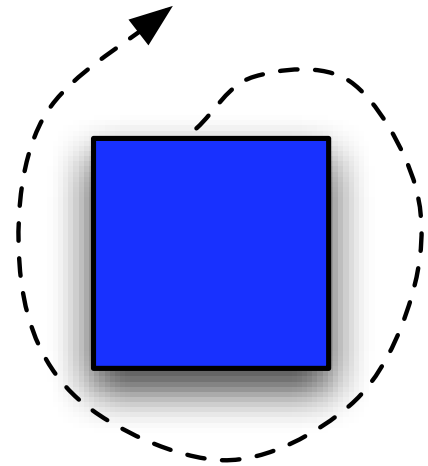
kunige



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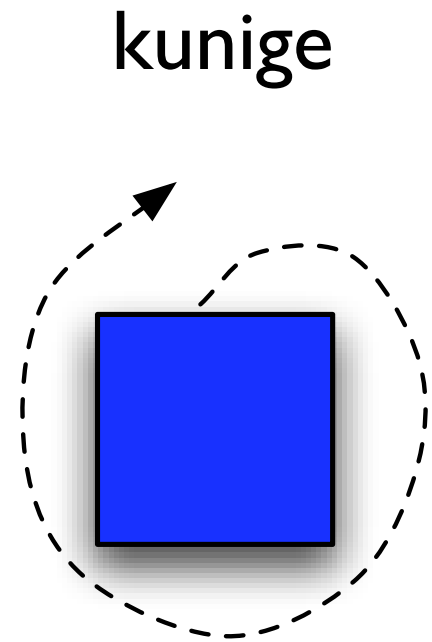

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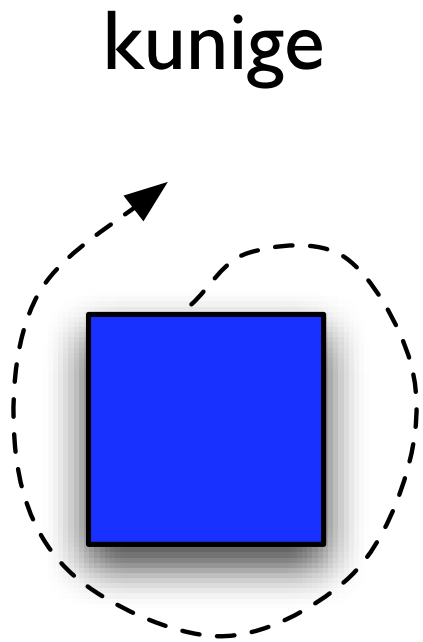
- Output on test used as input language for next participant



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  - Frequency of meanings
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Emergence of structure

Cornish (2006); Kirby, Cornish & Smith (forthcoming)

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- Meanings are moving coloured shapes
  - 3 x 3 x 3 meaning space
- Initial language completely random (and hard to learn!)

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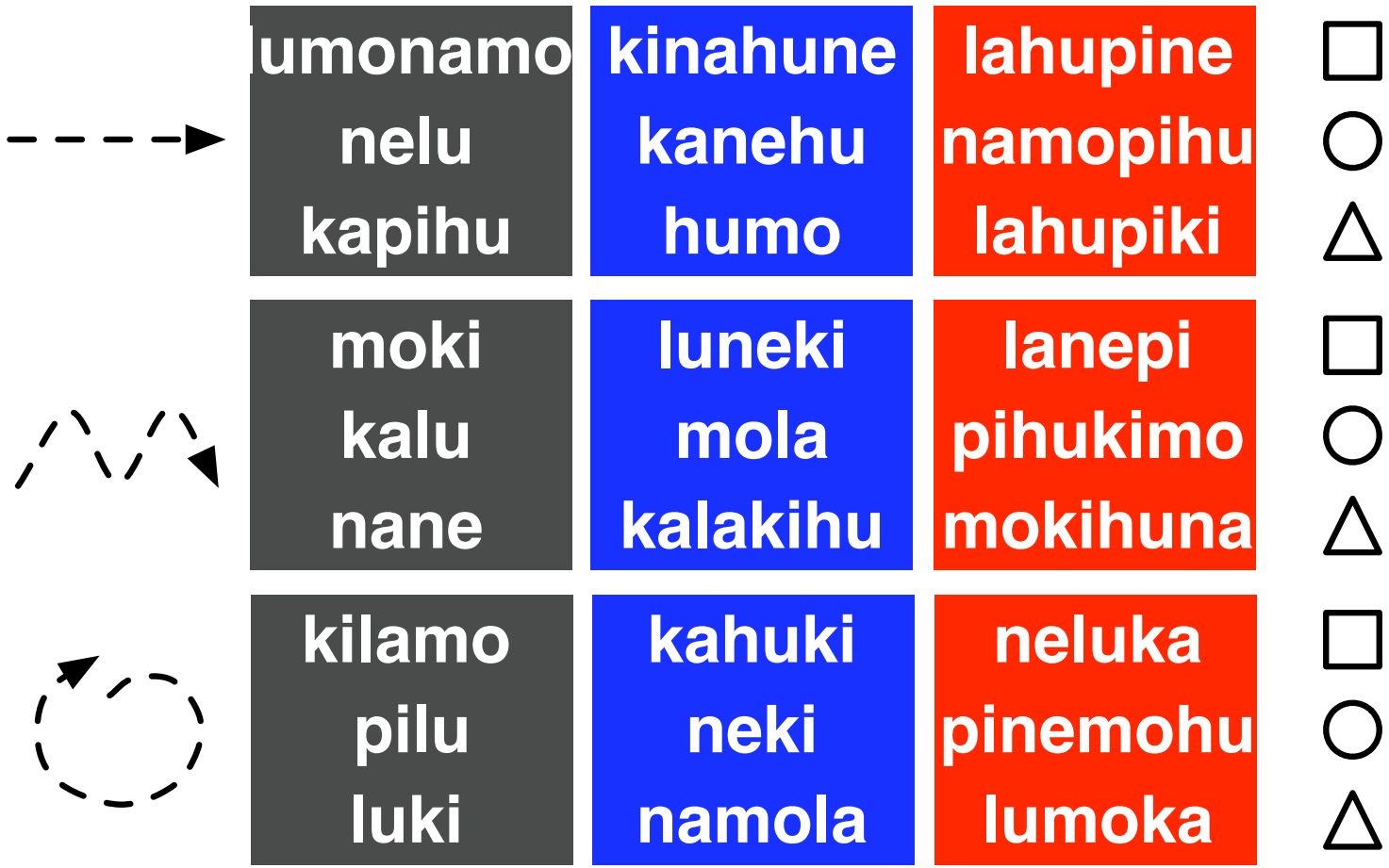
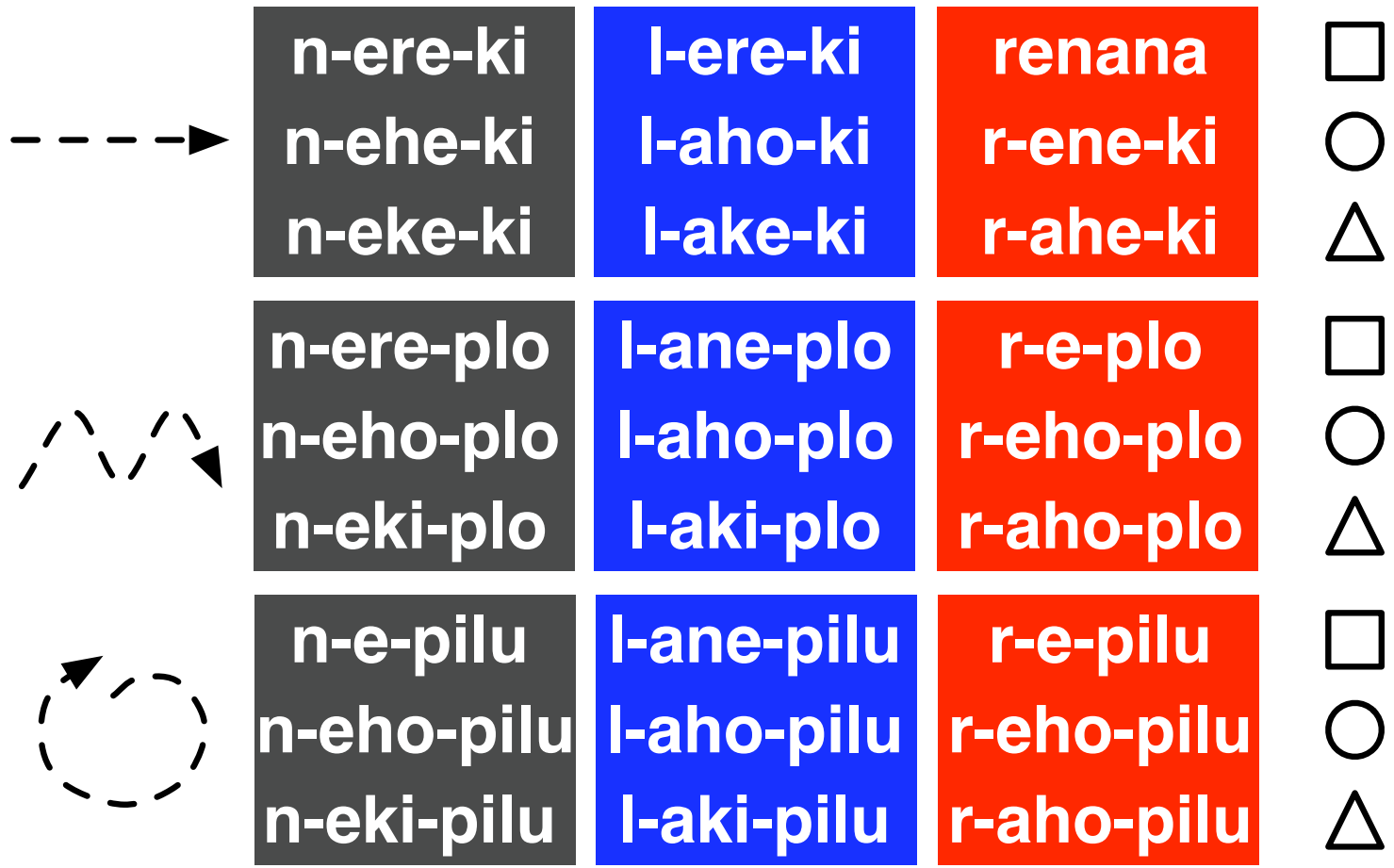
Example initial language



Example final language
(10 "generations" later)



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- Over generations:
  - language becomes easier to learn
  - *infrequent* irregulars regularise

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Frequency/irregularity

Frequent	vipirir / vipirar	→	rivipir / rivipar
	tada / sinefu	→	*tada / senoufe*
	ridetir / ridetar	→	ravipir / ravipar
Infrequent	*gidu / riwe*	→	riwa / riwe
	livove / domipu	→	rimipir / rimipar

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tada / sinefu → *tada / senoufe*

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- Reduces three different sources of support for linguistic nativism:
  - strong universals do not imply strong constraints
  - appearance of design does not imply natural selection
  - stimulus poverty actually drives cultural adaptation, reducing the problem innate knowledge is presumed to solve

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- I am not denying innateness
  - It's just not necessarily strongly constraining or language specific
- I am not denying a role for biological evolution
  - The real question is revealed:
    How did humans end up being the only species able to transmit a symbolic system culturally?