Origins and Evolution of Language
Week 9: Gene-culture co-evolution

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Reminder: the human package

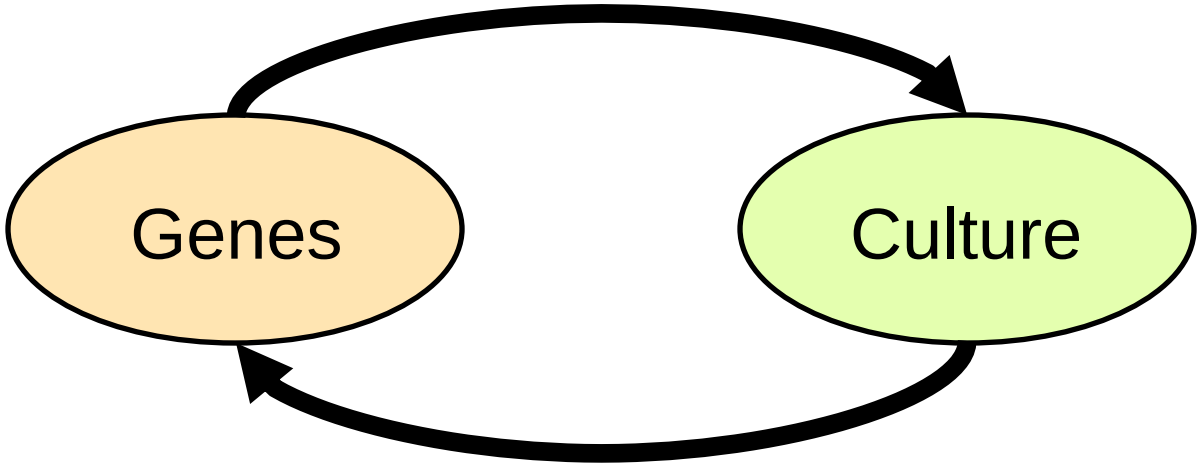
Somehow, we ended up with

- The ability to learn complex grammars
  - capacity for complex vocal imitation
  - ability to learn complex sequencing constraints
  - ability to learn compositional meaning-form mappings
- The ability and motivation to mindread and mindshare

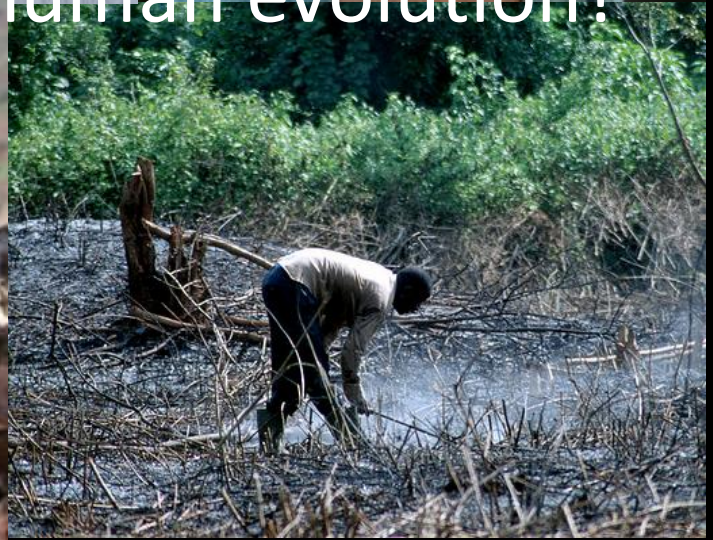
This sets up the preconditions for the **cultural transmission of learned, meaning-bearing communication**

- Once that's in place, exciting stuff happens

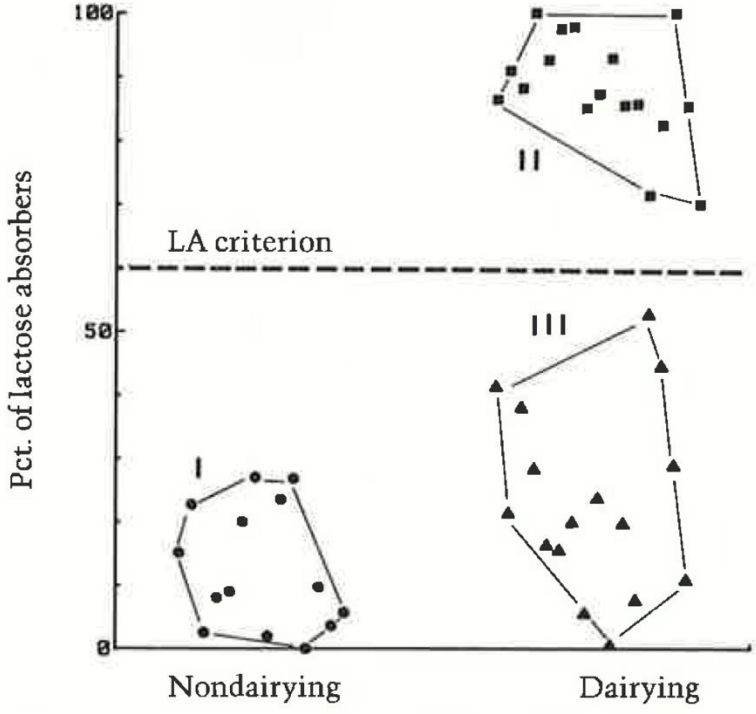
Gene-culture co-evolution



Has culture ended human evolution?

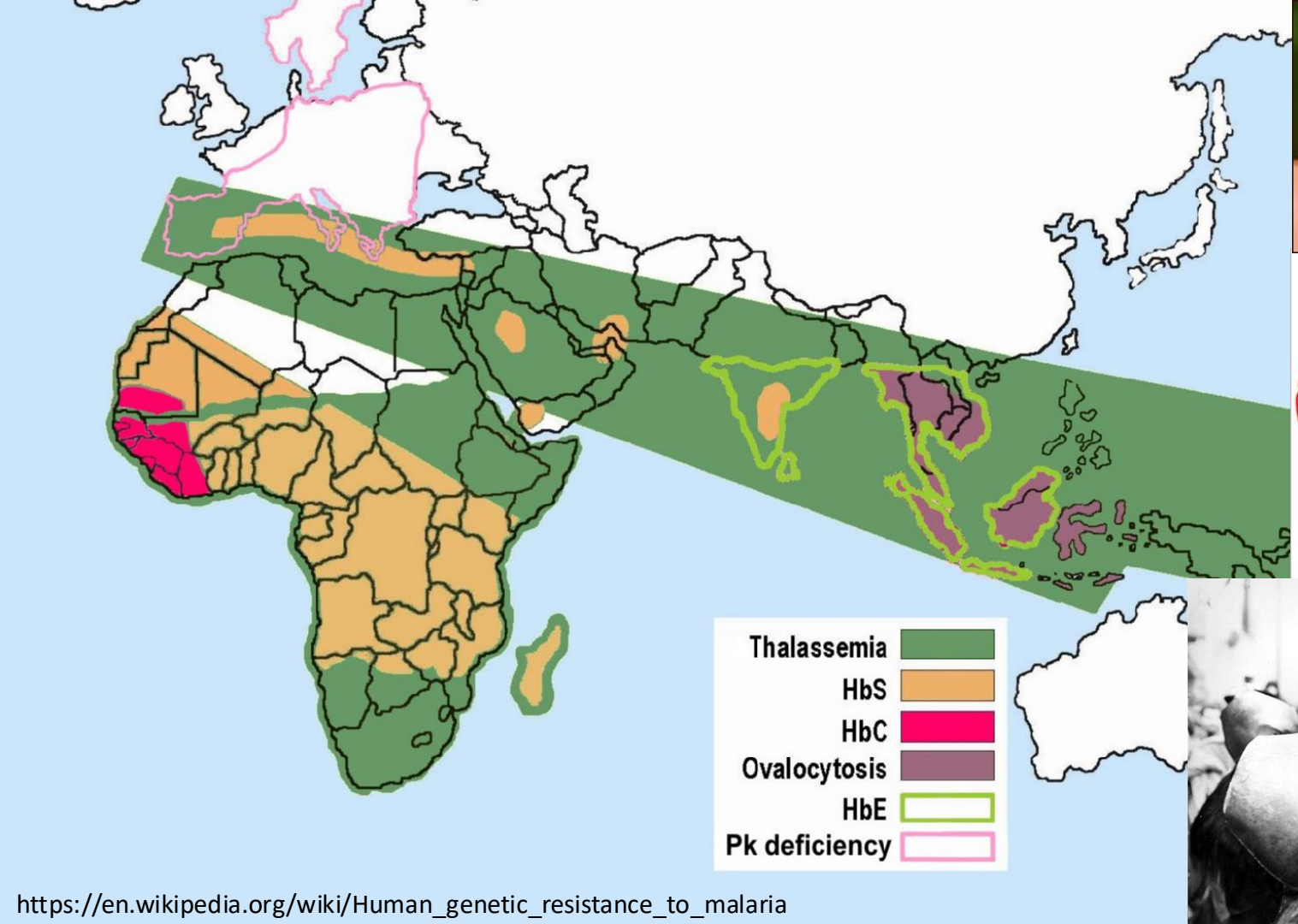


Dairying and lactase persistence



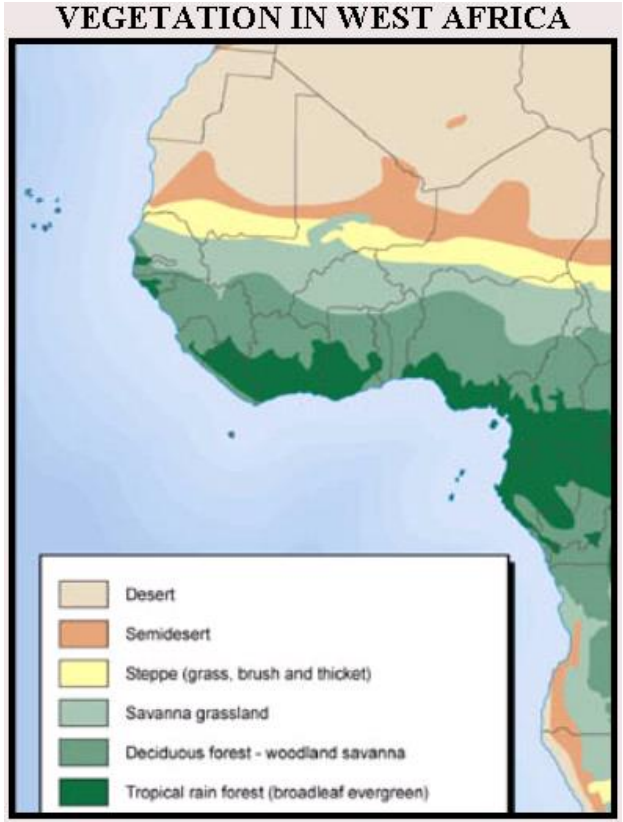
Gerbault, P., et al. (2011). Evolution of Lactase Persistence: an example of human niche construction. *Philosophical Transactions of the Royal Society of London B, 366,* 863-878.

Figure 5.4 from Durham, W. (1991). *Coevolution: Genes, Culture, and Human Diversity.* Stanford, CA: Stanford University Press.



https://en.wikipedia.org/wiki/Human_genetic_resistance_to_malaria

Construction of a malarial niche



Evidence of gene-culture co-evolution

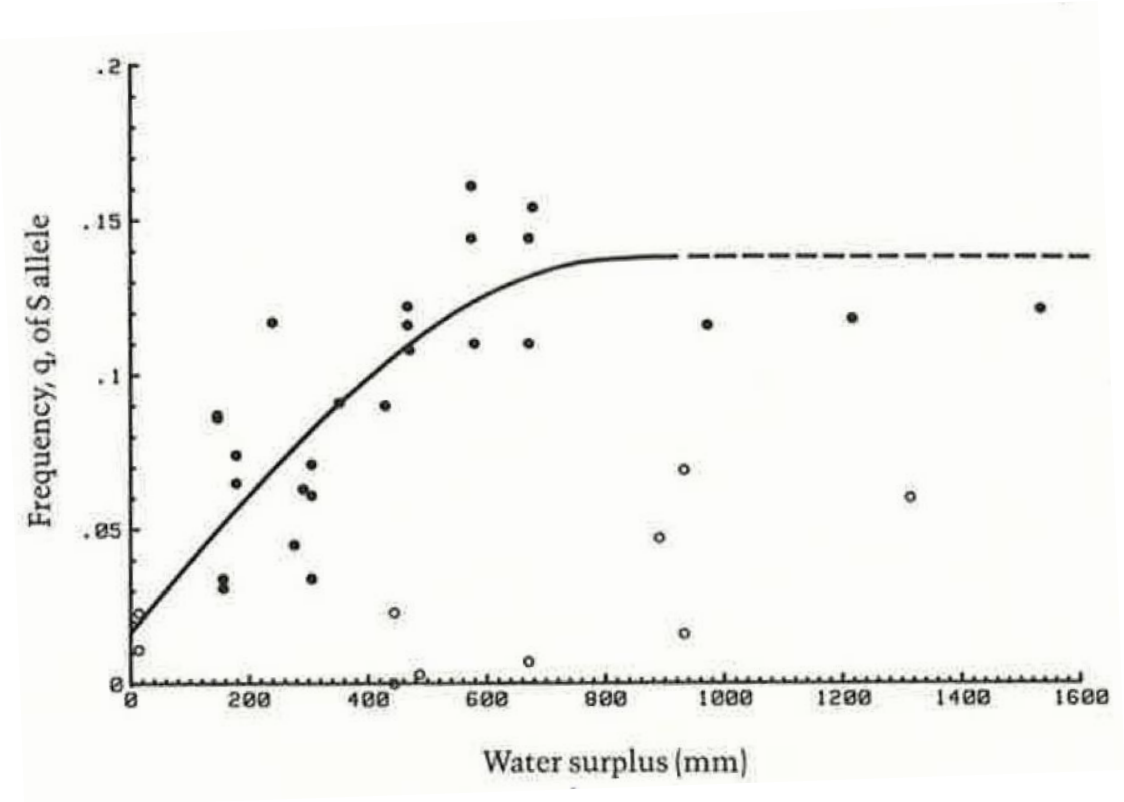


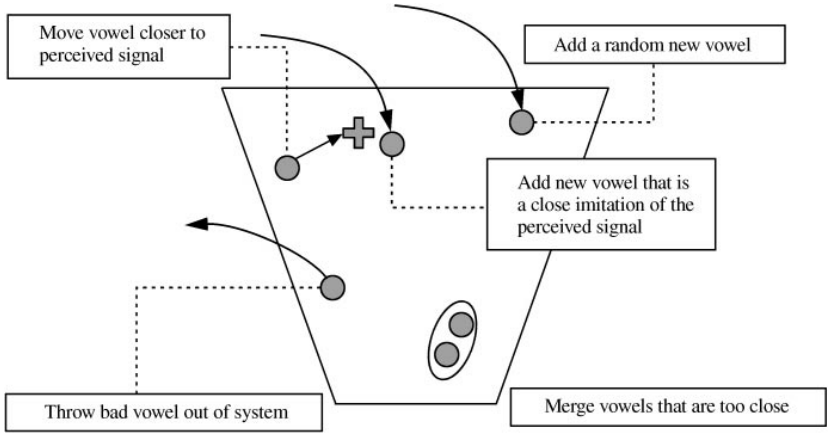
Figure 3.10 from Durham, W. (1991). *Coevolution: Genes, Culture, and Human Diversity.* Stanford, CA: Stanford University Press.

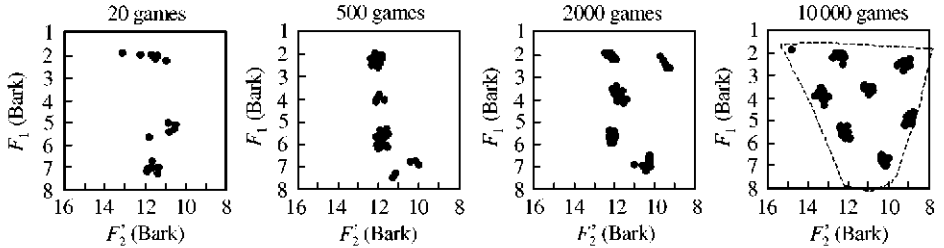
Two examples

- Niche construction in perceptual/articulatory capacity
- Moving targets and the evolution of innate constraints

(Reviewed in Smith, K. (2020). How Culture and Biology Interact to Shape Language and the Language Faculty. *Topics in Cognitive Science, 12,* 690–712.)

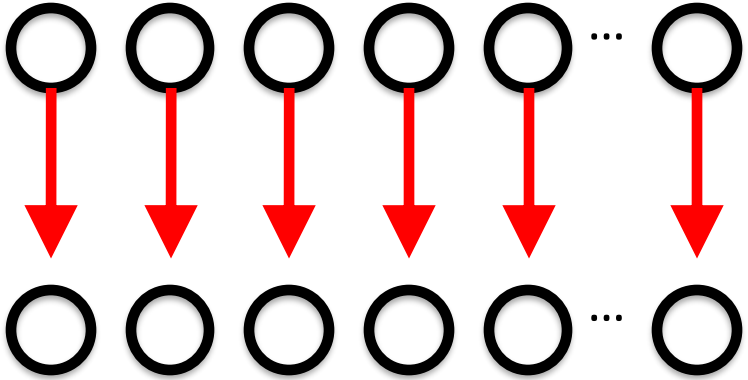
Example 1: could co-evolution produce increasingly sophisticated linguistic capacities?



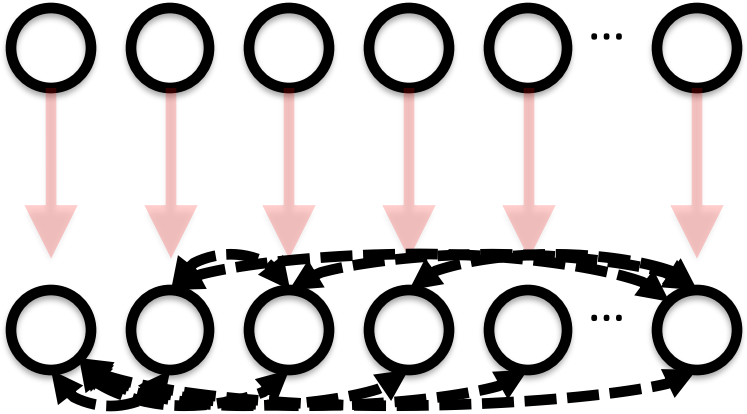


de Boer, B. (2000). Self-organization in vowel systems. *Journal of Phonetics*, *28*, 441–465.
de Boer, B. (2016). Modeling co-evolution of speech and biology. *Topics in Cognitive Science, 8,* 459–468.

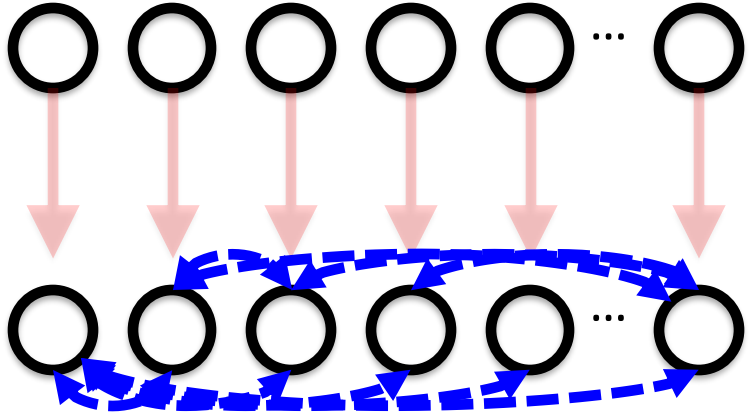
TRANSMISSION



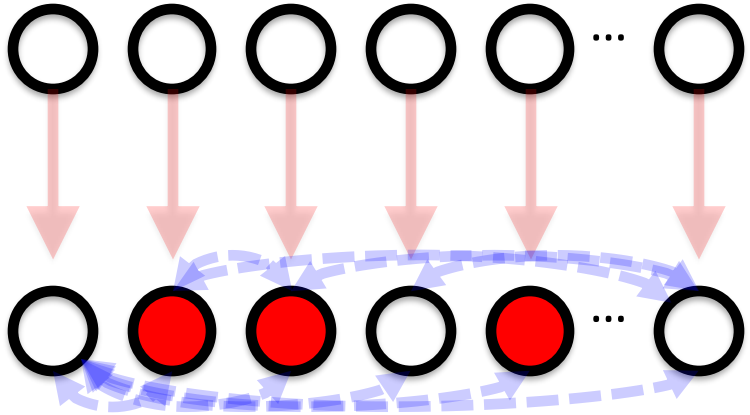
ADAPTATION IN COMMUNICATION



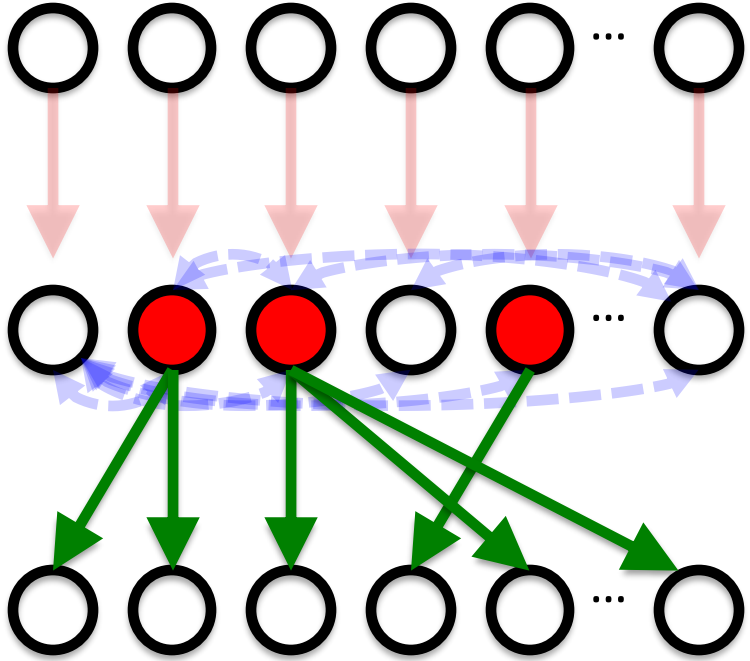
FITNESS
ASSESSMENT



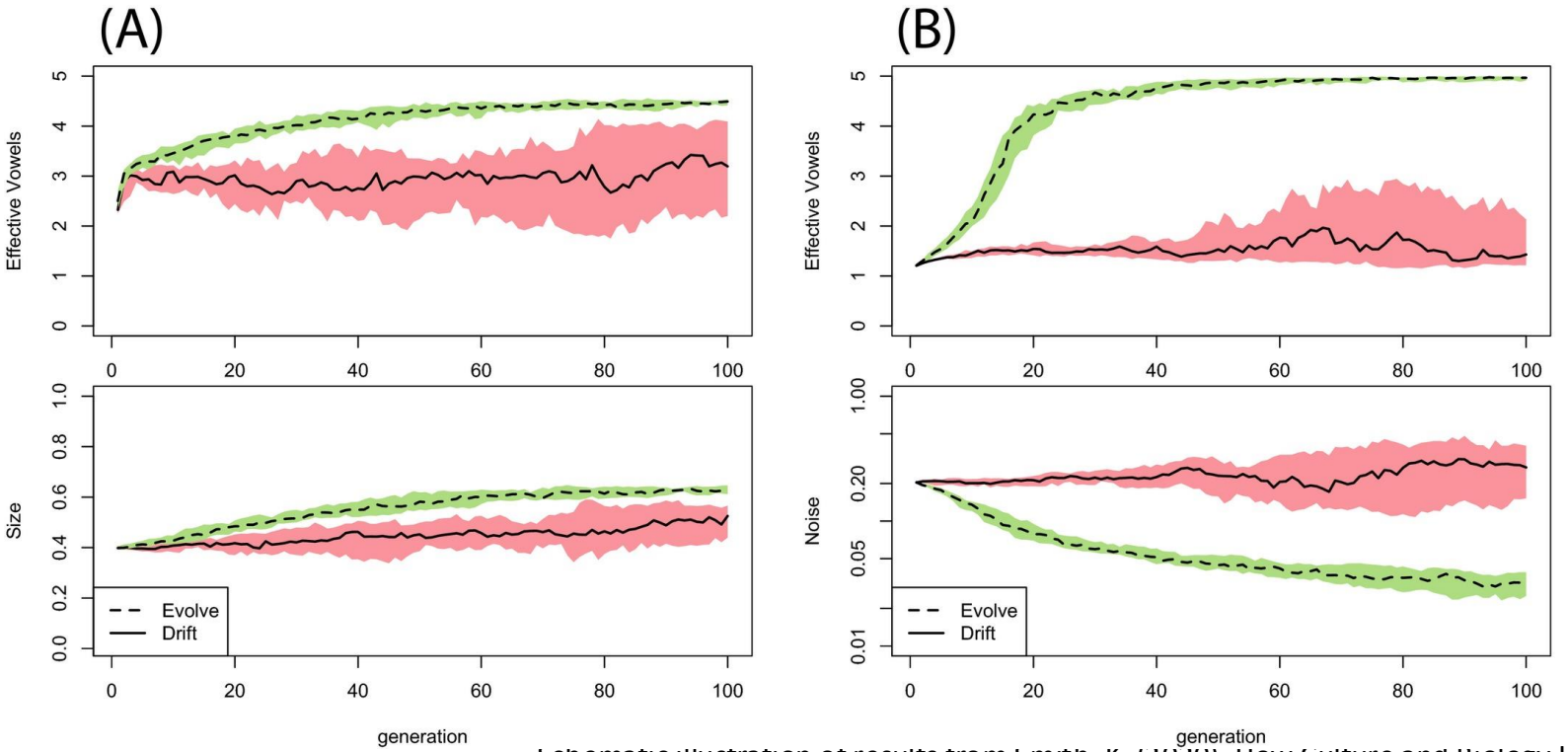
SELECTION



REPRODUCTION
+ MUTATION



Result: niche construction leads to increasingly complex vowel systems

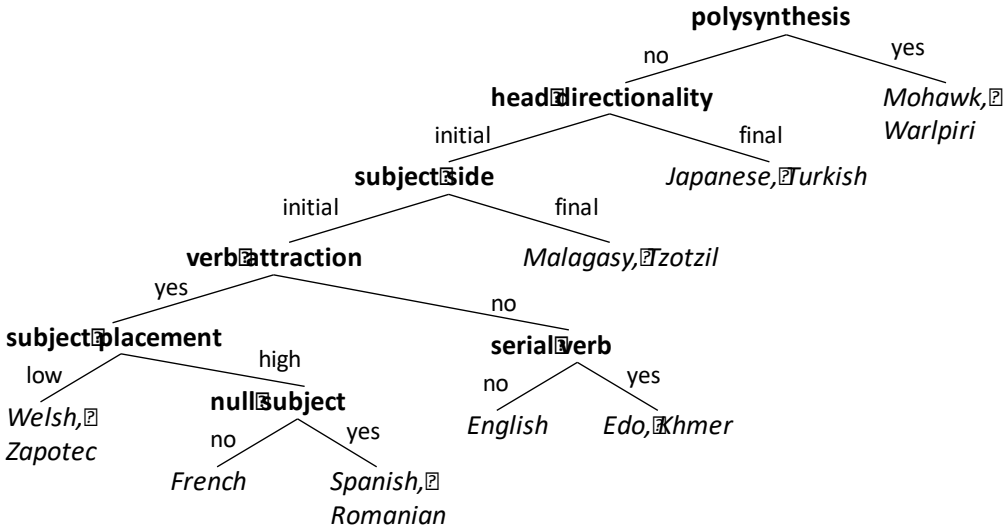


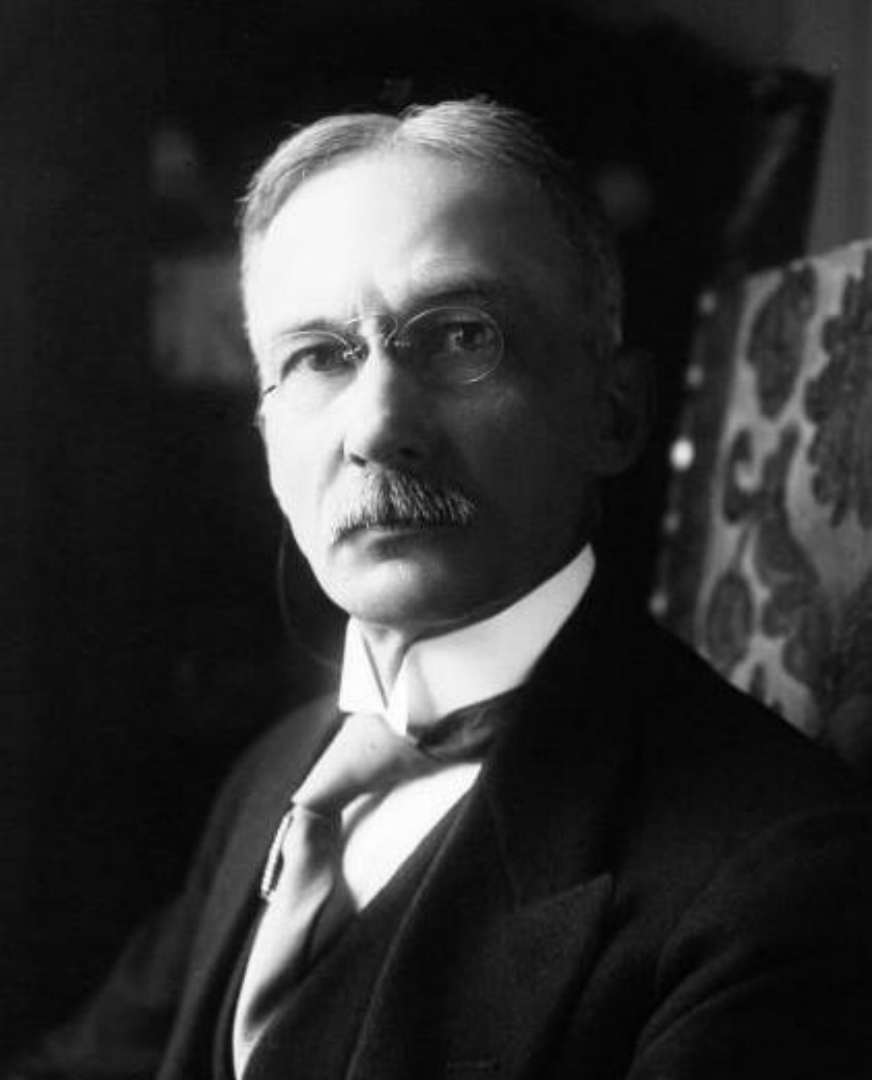
Schematic illustration of results from Smith, K. (2020). How Culture and Biology Interact to Shape Language and the Language Faculty. *Topics in Cognitive Science, 12,* 690–712.

Example 2: could co-evolution produce arbitrary constraints on learning?

Central idea in many linguistic theories: **arbitrary innate constraints** on learning

- e.g. Principles and Parameters





A candidate mechanism: the Baldwin effect (aka genetic assimilation)

- Behaviour is initially learned
- Learning has some cost (time, **error**)
- Individuals whose genes reduce amount of learning required (e.g. by building in some aspects of the solution) are selected
- Eventually, learning minimized / nativised away

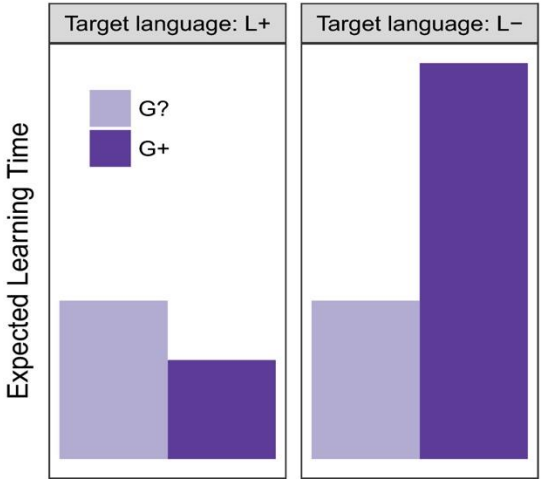
A very simple model of genetically-constrained learning

Language
(series of parameter settings)

L+ L- L+ L+ L- L- L-

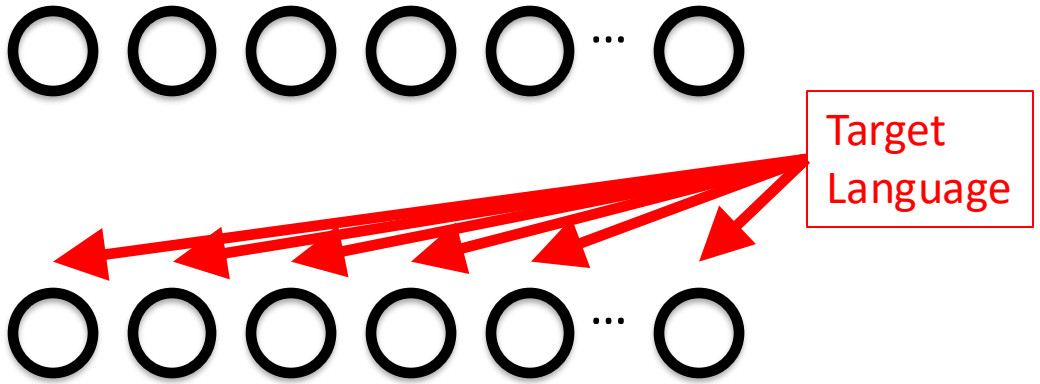
Genes

G+ ? G+ ? G- G- ?

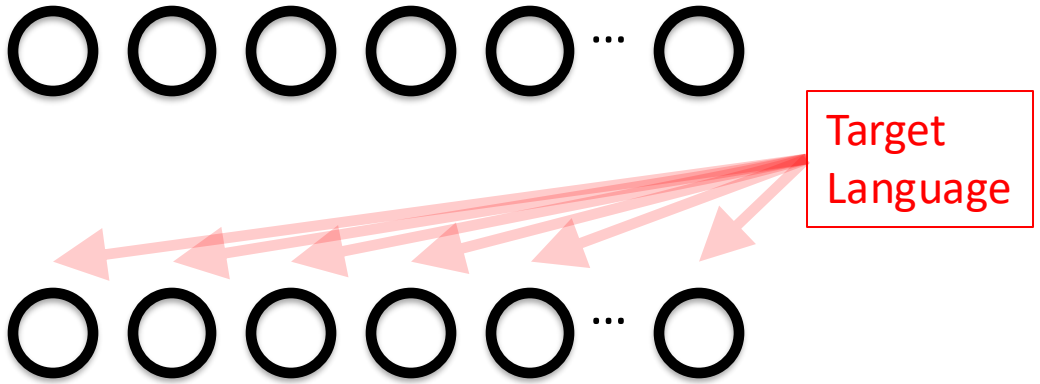


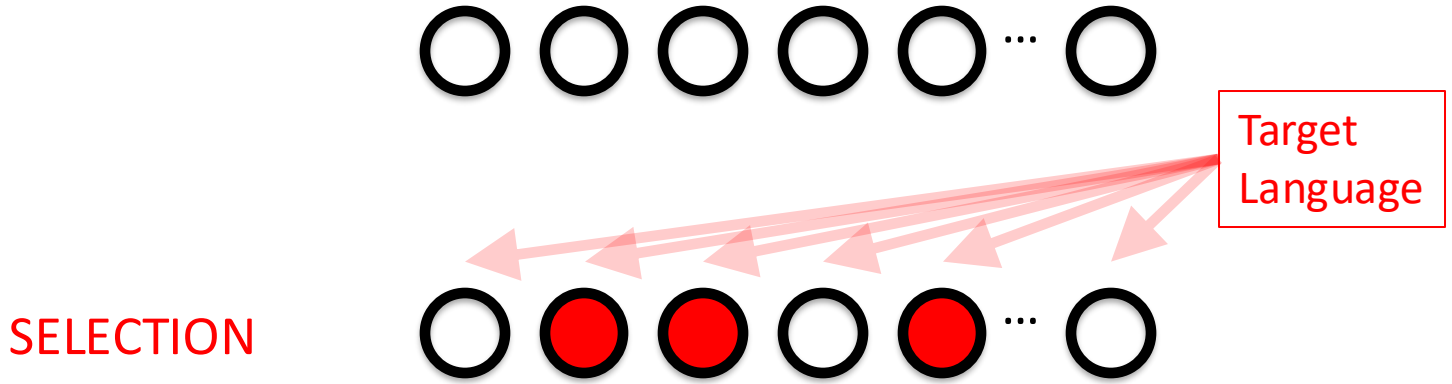
Chater, N., Reali, F., & Christiansen, M. H. (2009). Restrictions on biological adaptation in language evolution. *Proceedings of the National Academy of Sciences, USA, 106,* 1015-1020

LEARNING

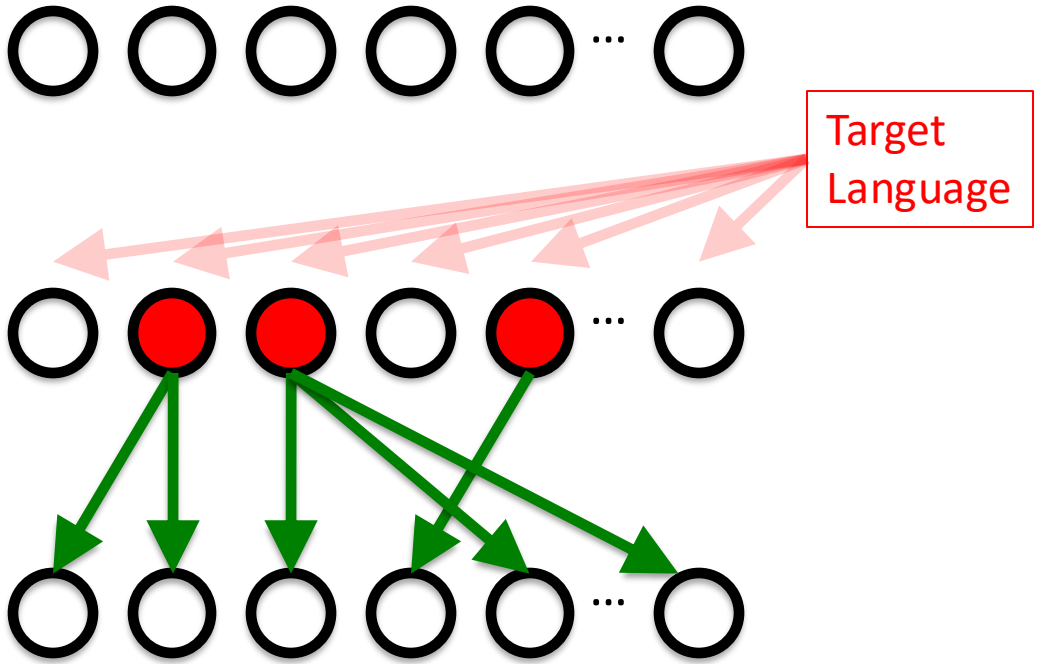


FITNESS
ASSESSMENT
(learning time)

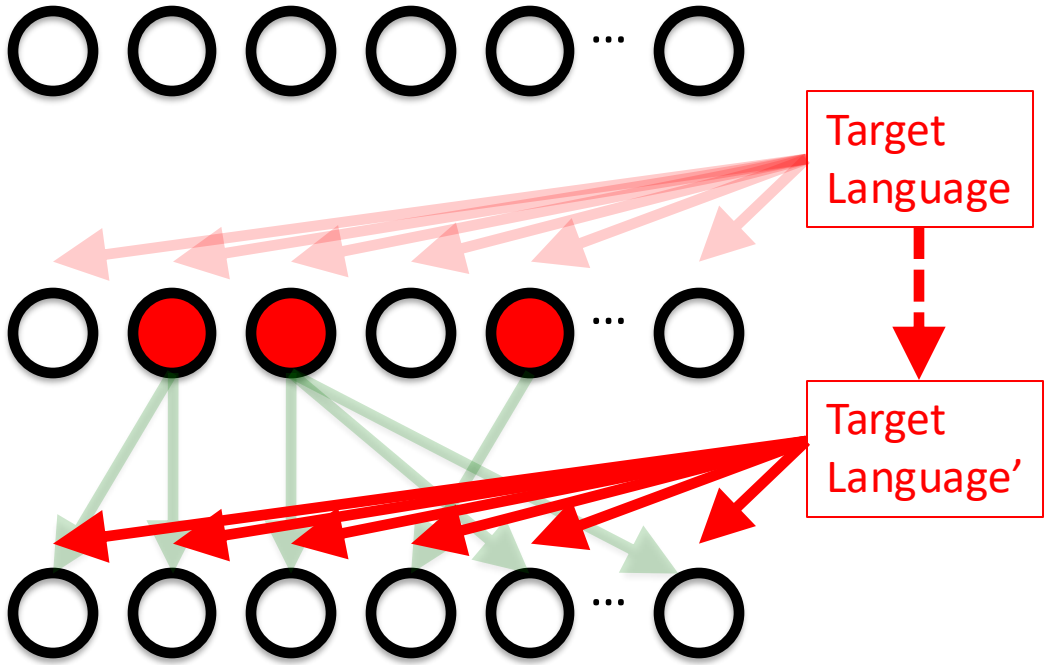


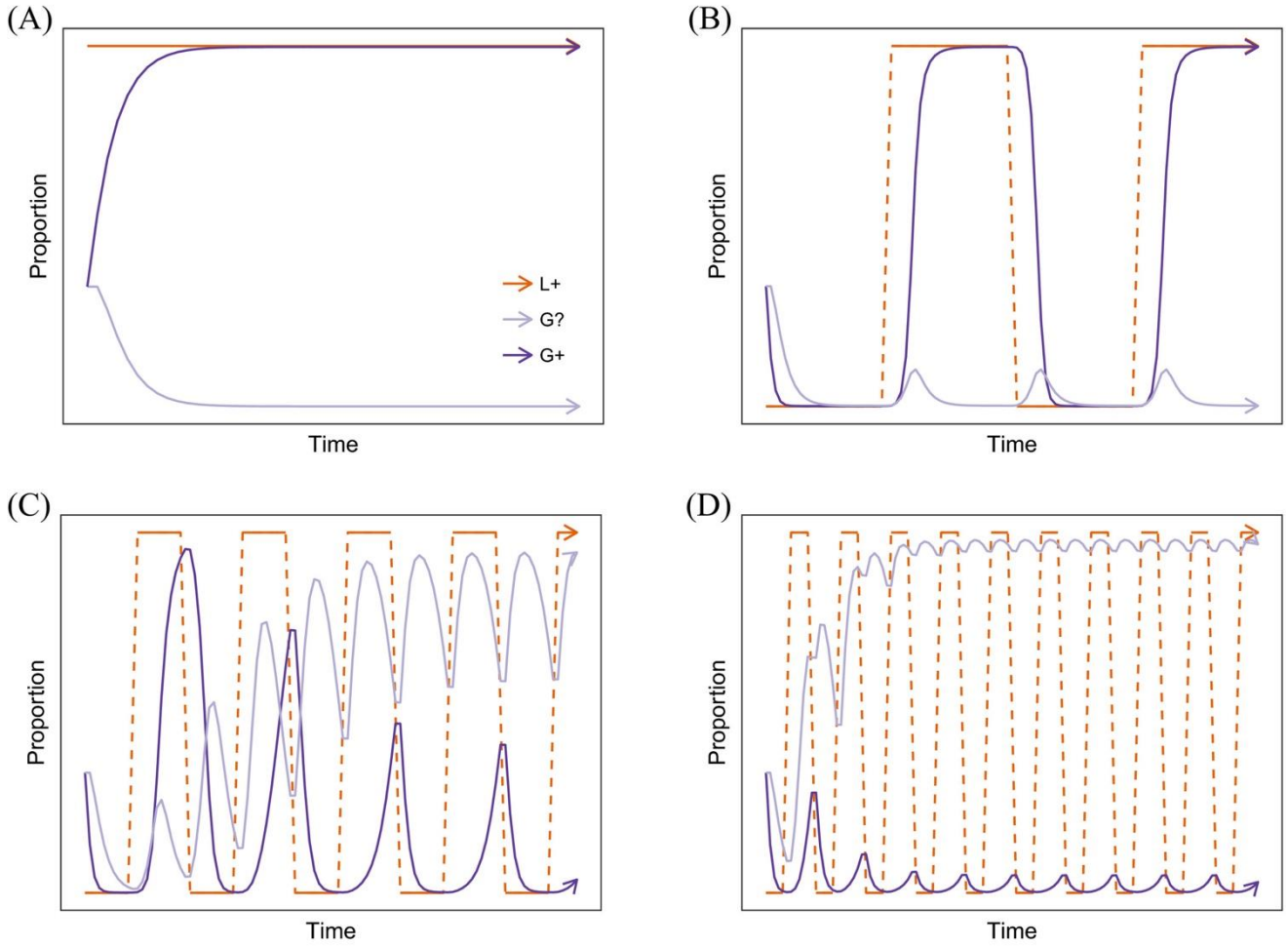

Target
Language
SELECTION

REPRODUCTION
+ MUTATION



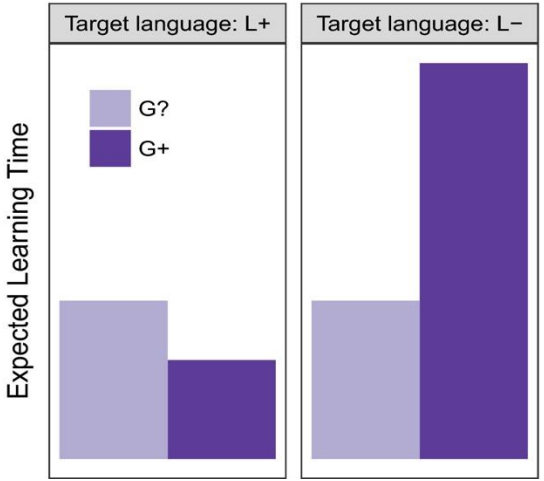
LEARNING




(A)
Proportion
Time
L+
G?
G+
(B)
Proportion
Time
(C)
Proportion
Time
(D)
Proportion
Time

Critique: it's complicated!

- They don't model different strengths of innate bias
- Their learning model disfavours nativisation
- They model language change as a separate process
  - Language changes independent from learner biases
  - No **amplification** of biases by culture



Thompson, B., Kirby, S., & Smith, K. (2016). Culture shapes the evolution of cognition. *Proceedings of the National Academy of Sciences, USA, 113*, 4530-4535

de Boer, B., & Thompson, B. (2018). Biology-culture co-evolution in finite populations. *Scientific Reports, 8,* 1209

Critique: it's complicated!

Two key factors

- What is the link between biological constraints and cultural change?
  - Chater et al. (2009): if the language changes completely independently, biology has a hard time tracking culture
  - If culture amplifies genetic biases, biology can have a rapid effect on culture
- How transparent is the link between genes and behaviour to selection?
  - Can selection identify "good" genes?
  - Chater et al. (2009): yes, through learning cost for "wrong" biases
  - Thompson et al. (2016): often not, because learning **masks** genetic biases

Gene-culture co-evolution: summary

- Humans are constructing environments which create new selection pressures and shape the evolution of our genes
- Language likely to be involved in the same process
- Should expect suite of genes underpinning learning and use of language to be under selection
- In some (most?) cases, can lead to cycles of niche construction producing increasingly sophisticated linguistic capacities
- Evolution of Universal Grammar (strong domain-specific constraints on language learning) more complicated

Course outline in retrospect

Week	Topic
1	Introduction
2	Natural selection, adaptation and language
3	Intention and structure in animal communication
4	Social learning and cumulative culture
5	Evolution of vocal learning and grammar learning
6	Evolution of social cognition
7	Cultural evolution of language
8	Sign language and language origins
9	Gene-culture co-evolution

Produces adaptations

Some but not much?

Human social / technological niche

Important cognitive innovations: vocal learning, sequence learning, compositional grammar learning

Important cognitive innovation: mindreading

How transmission produces linguistic structure

How natural selection responds

Recent review articles

Smith, K. (2022). How language learning and language use create linguistic structure. *Current Directions in Psychological Science, 31,* 177-186.

Smith, K. (2020). How Culture and Biology Interact to Shape Language and the Language Faculty. *Topics in Cognitive Science, 12,* 690–712.

Kirby, S. (2017). Culture and biology in the origins of linguistic structure. *Psychonomic Bulletin & Review, 24,* 118–137.

Tamariz, M. (2017). Experimental studies on the cultural evolution of language. *Annual Review of Linguistics, 3,* 389–407.

Finishing up

- Final tutorial
  - Self-domestication in humans (as related to niche construction?)

- Assignment 2 due 12th December
  - Marks and feedback on assignment 1 due 14th/15th November
  - Cover sheet for assignment 2: *"In response to the feedback I received on essay 1, I took the following actions: ..."*
  - Postgrads only: deadline for question proposals, Wednesday 4th December
  - Final deadline for assignment-related questions: Monday 9th December