Biological and cultural foundations of human language: Insights from computer simulations
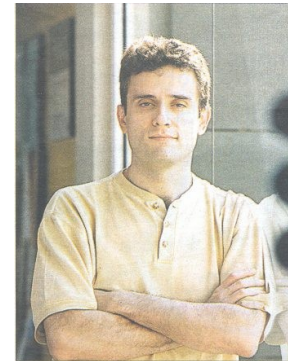
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Morten Christiansen

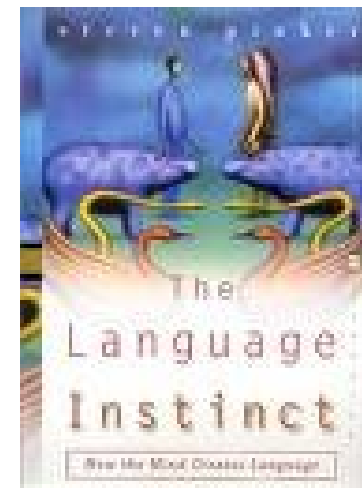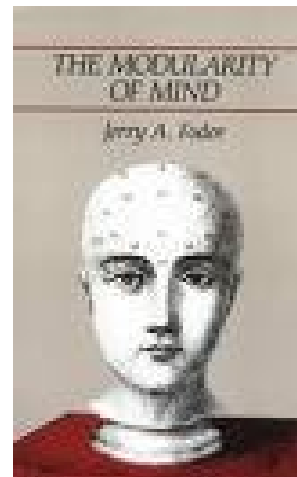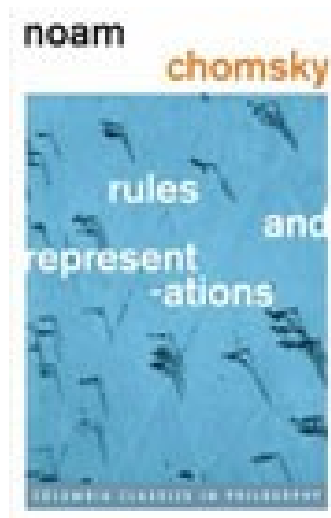Florencia Reali

Andrea Baronchelli

Romualdo Pastor-Satorras

Overview

- 1. A brain adapted for language?

- 2. Co-evolution of genes and language? Simulating the Baldwin effect

- 3. Diverging human populations

- 4. Functional features can become genetically embedded

- 5. Conclusions

1. A brain adapted for language?

Could brains be *adapted* for language?

- Language seems extremely *complex*

- And to have many highly specific and incredibly subtle properties

- How can children figure it out, while linguists can't?

- That is, how is language acquisition possible?

- Perhaps the triggering of a *genetically coded* language-specific faculty?
    - language instinct
    - language organ
    - language acquisition device
    - language module

A *language-specific* faculty implies the brain is *adapted* for language, just as it adapted for vision
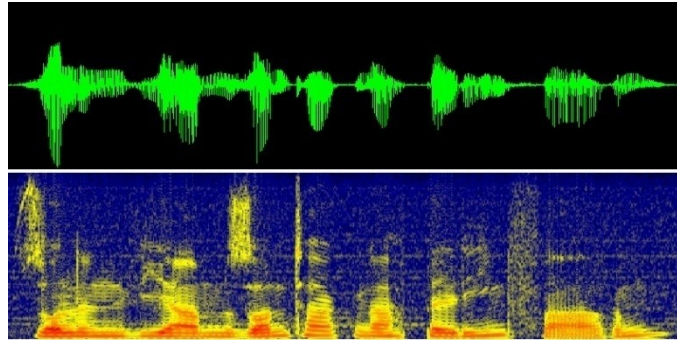
- The visual environment today

- Visual environment of evolutionary adaptation
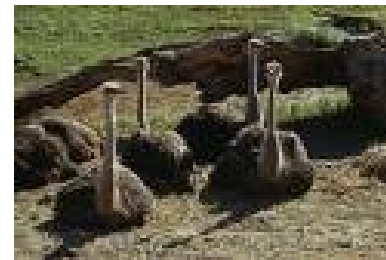

Strangely similar…

- The linguistic environment today

"…the cat sat on the mat…"

- Linguistic environment of evolutionary adaptation
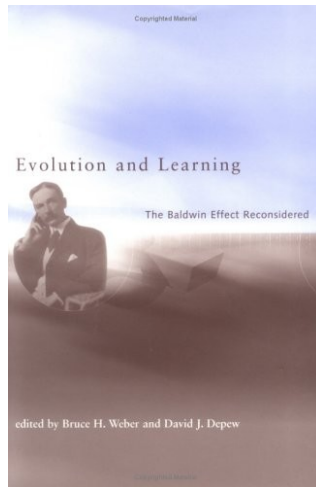

Roar!

Strangely dissimilar…

But perhaps language and the language faculty
co-evolved via the Baldwin effect (Pinker & Bloom, 1990)

- Driving acquired traits into the genes--
  - It may work for ostrich calluses
  - perhaps it works for language

2. Co-evolution of genes and language? Simulating the Baldwin effect

The Baldwin effect: A very simple simulation

- "Language" is a string of features

- Genes can express bias or neutrality on each feature:
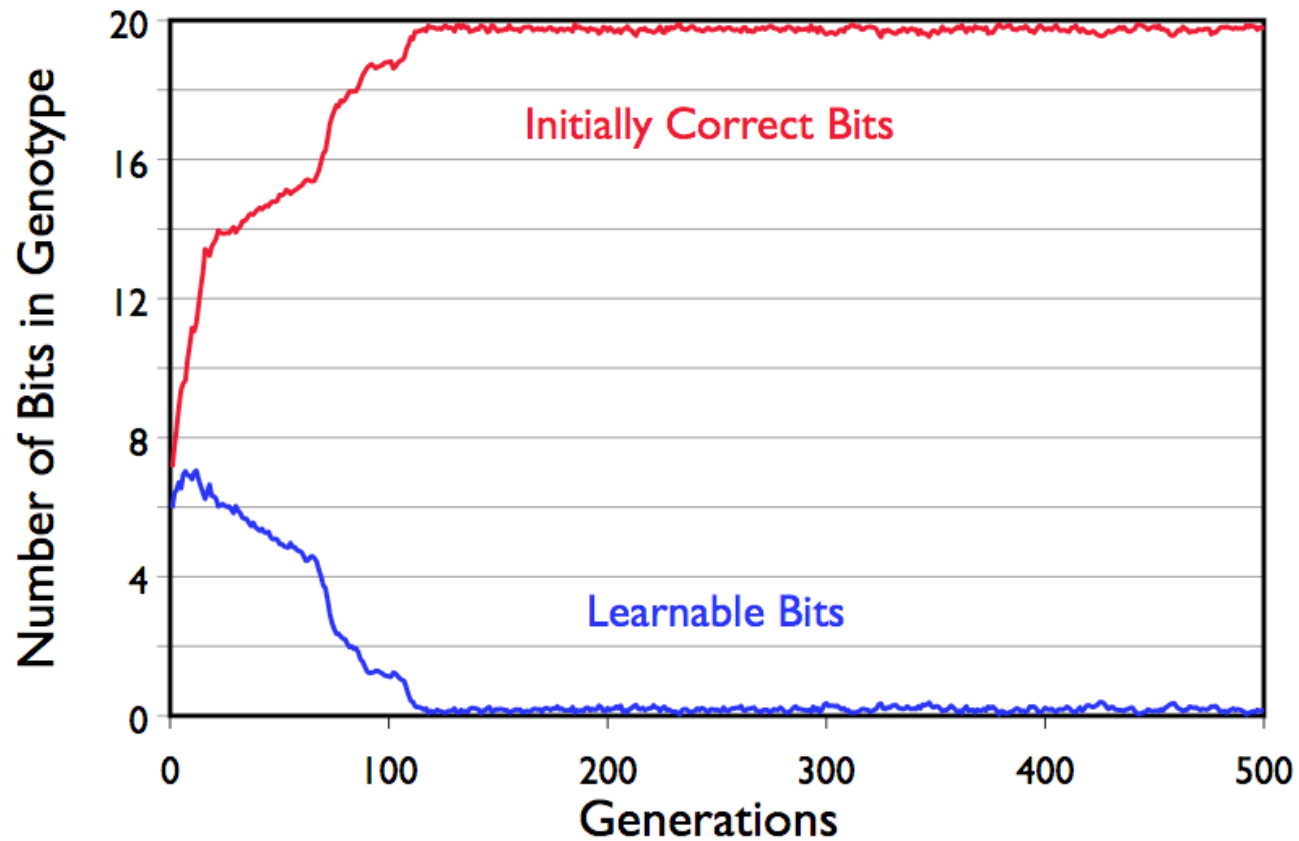 - "fixed" .95 bias to red:
  - "fixed" .95 bias to blue:
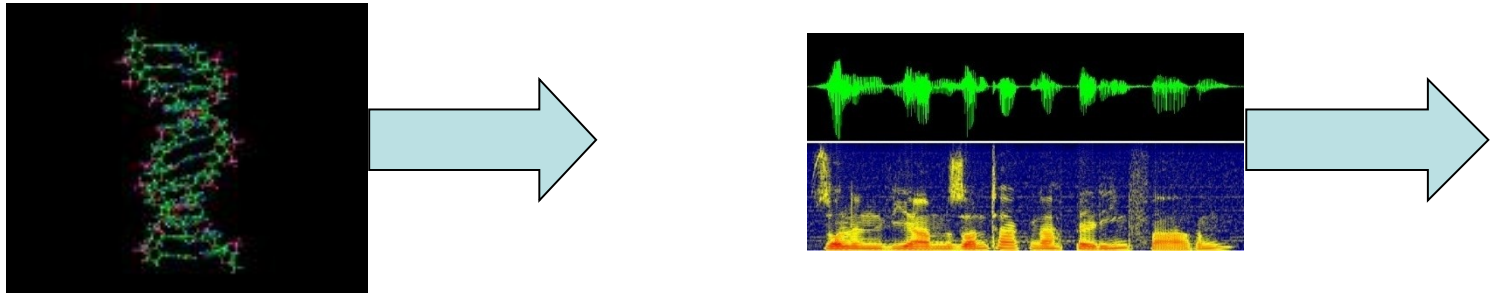 - "learnable": unbiased

- "Genome":

- Trial and error learning

- Only the fastest learners "reproduce"

- And create the next generation by sexual recombination and mutation

- Do the genes begin to adapt to the language???
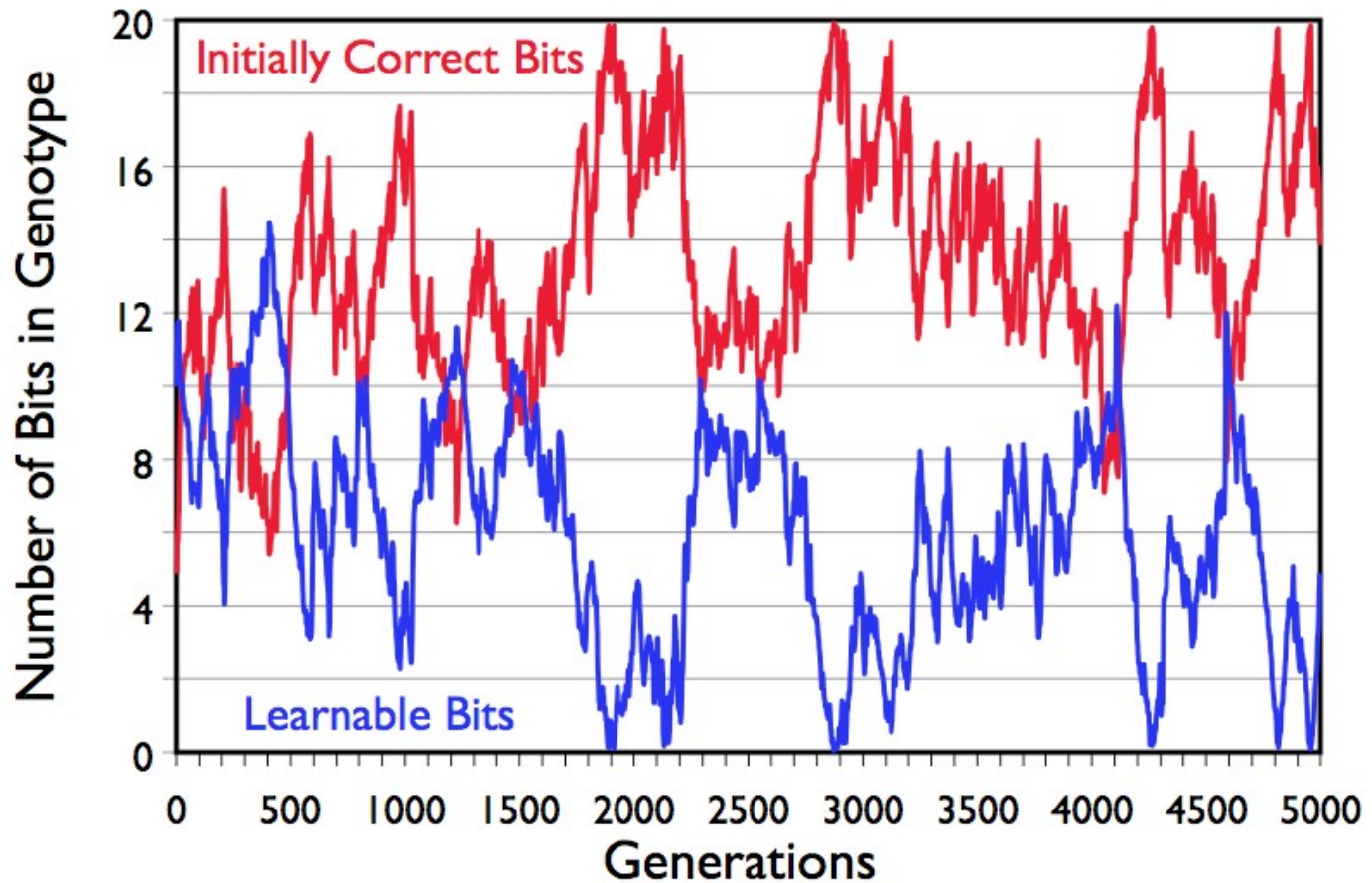
The Baldwin effect in action

But co-evolution requires genetic adaptation to a *varying* language
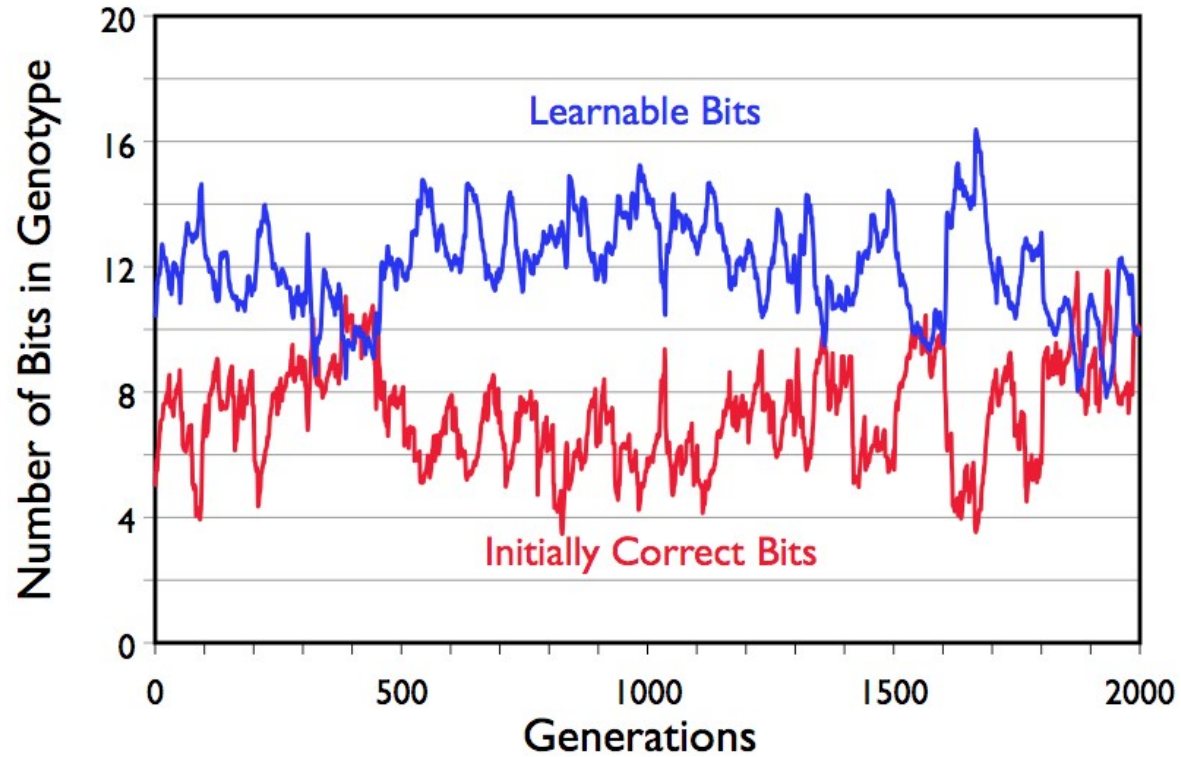
- Can language change *lead* language genes?

- Potential problem:
  - Language changes very fast, in relation to genetic change

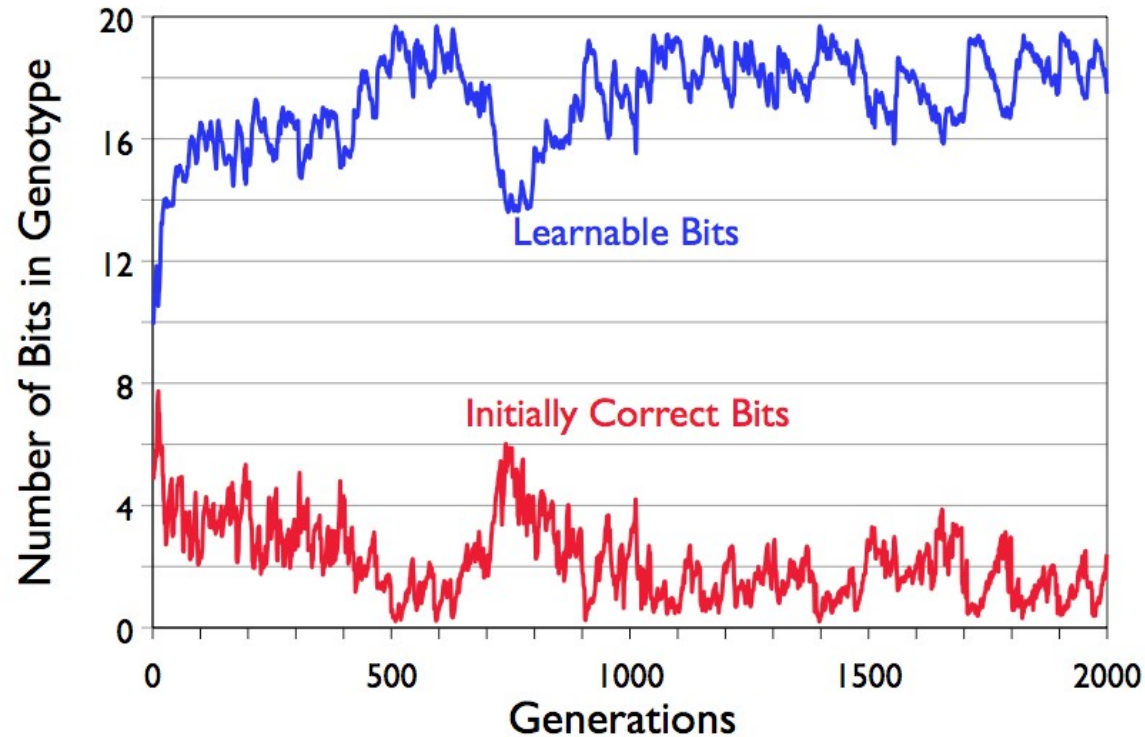- So what happens when language and genes can *both* change?

Same speed for language and genetic mutation rate

Languages changes twice as fast

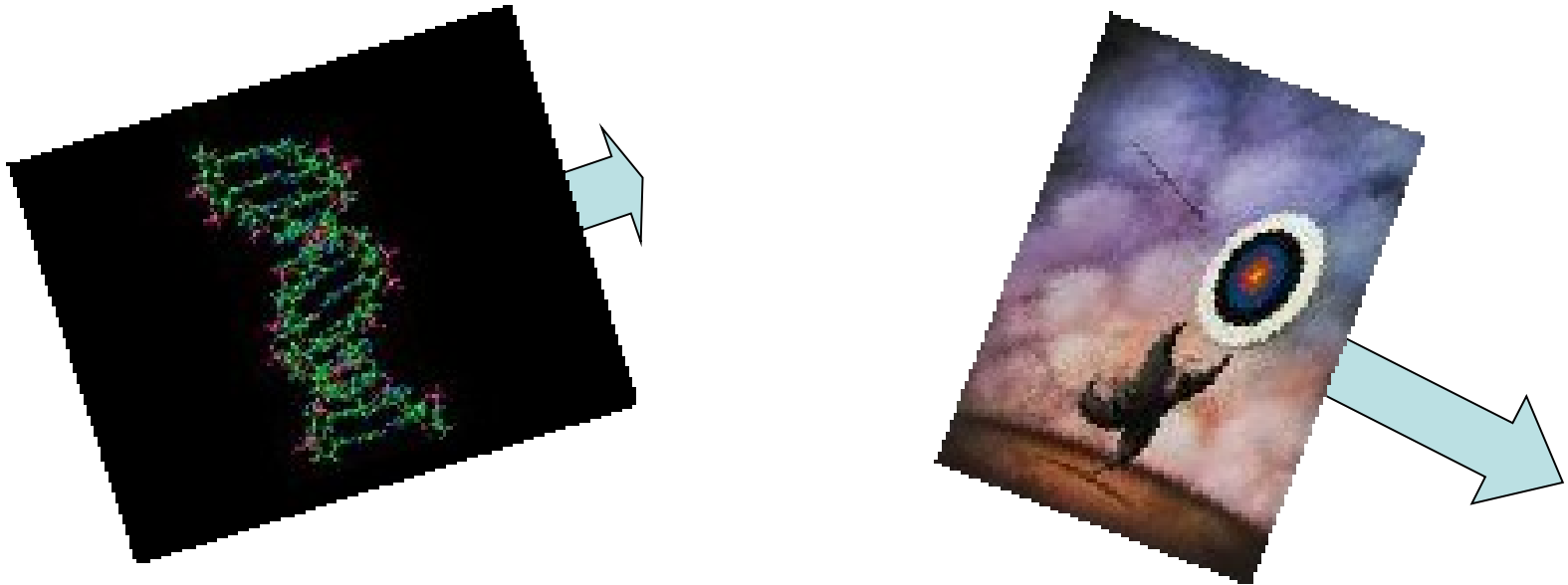# Language changes 10 times as fast

No Baldwin effect

No coevolution

"Learnable" genes win out

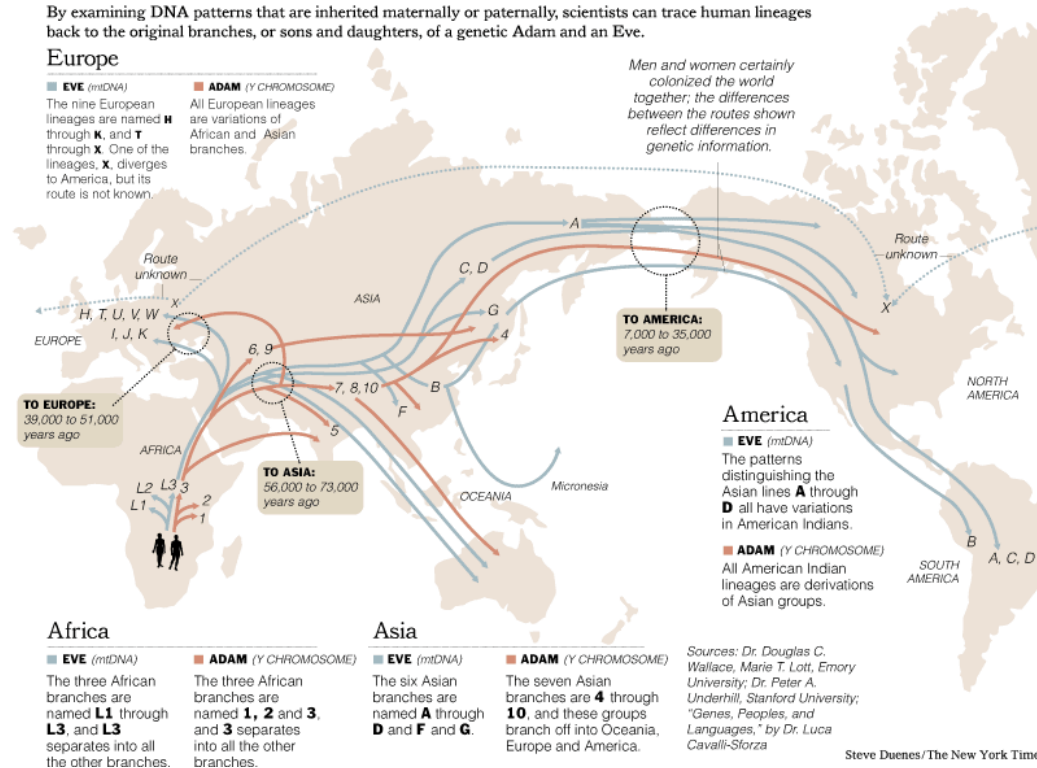# Genes cannot catch a linguistic "moving target"

Chater, N., Reali, F. & Christiansen, M.H. (2009). Restrictions on biological adaptation in language evolution. *PNAS, 106,* 1015-1020.

3. Diverging human populations

Joint work with Andrea Baronchelli, Romualdo Pastor-Satorras, Morten Christiansen, in prepartion

Once populations are split, co-evolution will be specific to the local linguistic environment

If language-gene coevolution occurred, it had better stop, once populations diverge

But wide geographical separation occurred early, w.r.t., to presumed time-scale for language

(And even geographically nearby groups show very fast linguistic change)

Test with population splitting simulations...

Tracing Human History Through Genetic Mutations

By examining DNA patterns that are inherited maternally or paternally, scientists can trace human lineages back to the original branches, or sons and daughters, of a genetic Adam and an Eve.
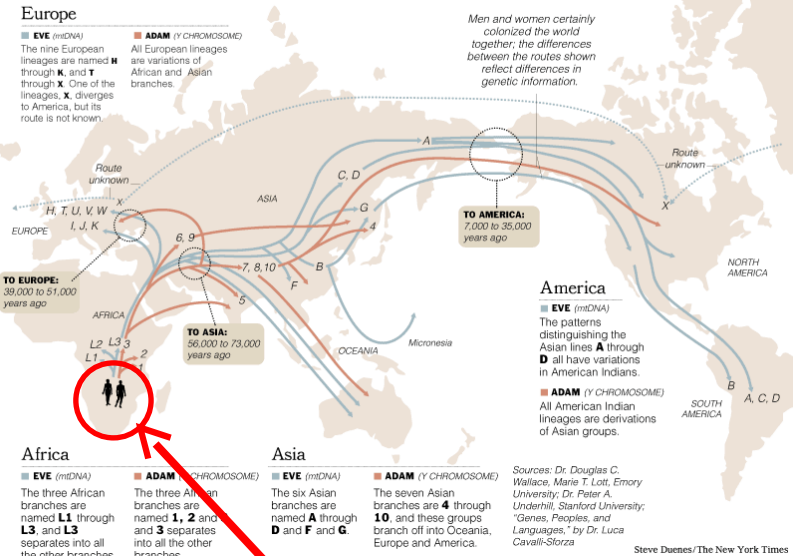
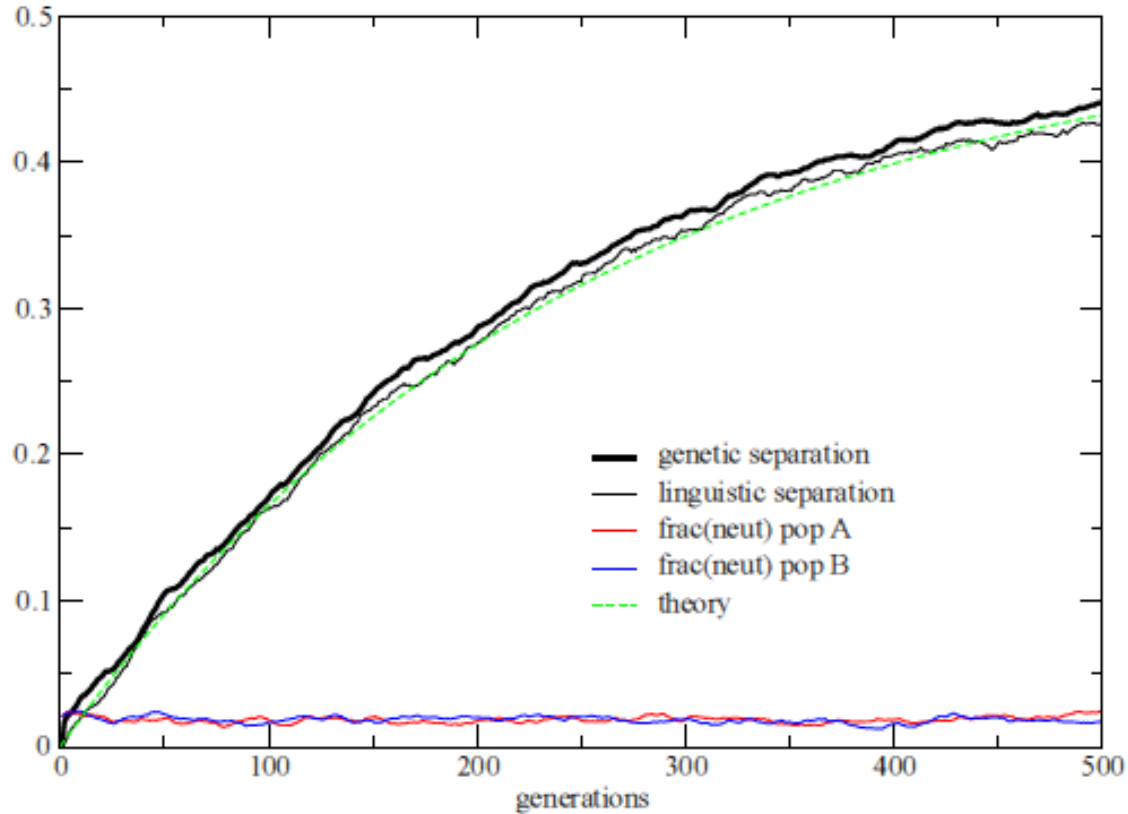No co-evolution beyond this point!

Joint work with Andrea Baronchelli, Romualdo Pastor-Satorras, Morten Christiansen (in prep)
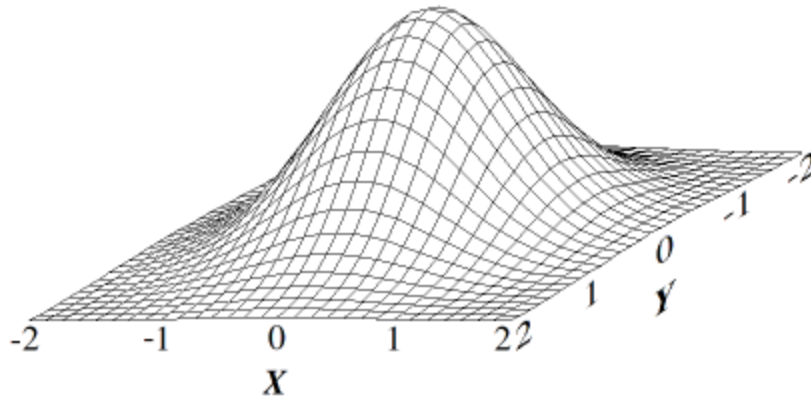
Case 1: Language change is fast
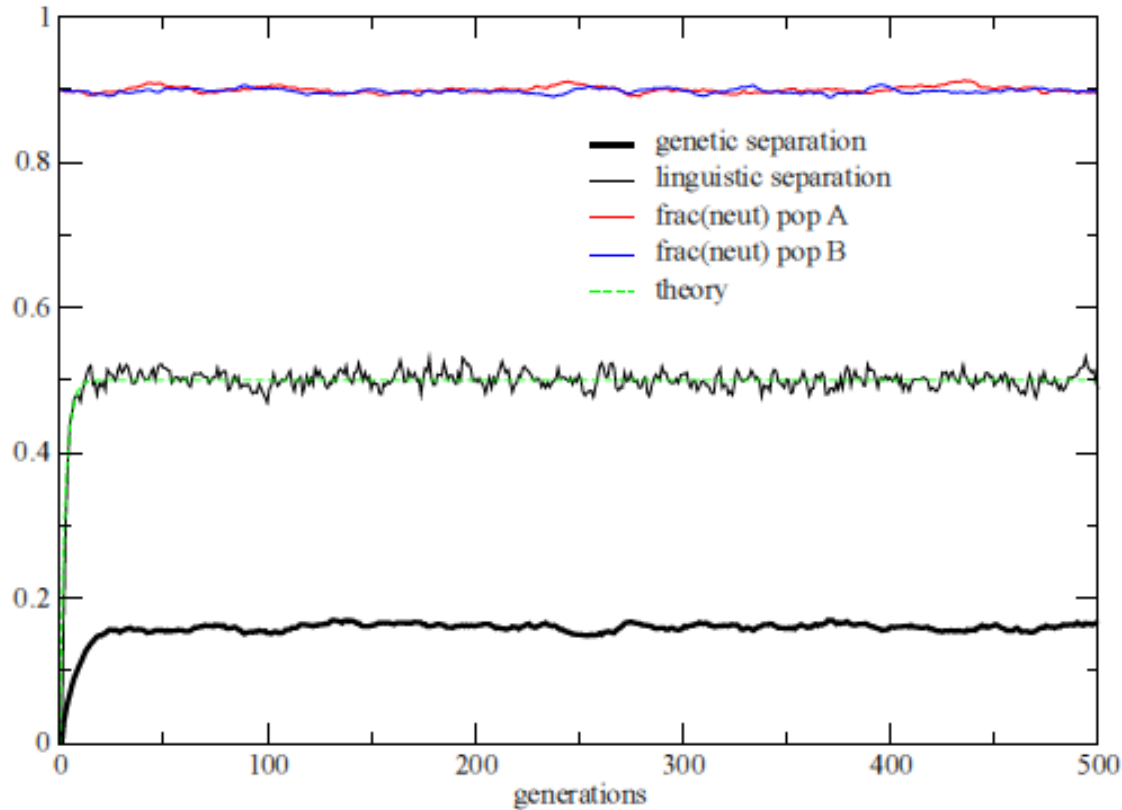
- No coevolution
- Neutral "genes" dominate
- No UG

Case 2: Language change is slow

- Lots of local coevolution; few neutral genes
- Genetic divergence precisely *mirrors* linguistic divergence;
- No UG

4. Functional features can become genetically embedded

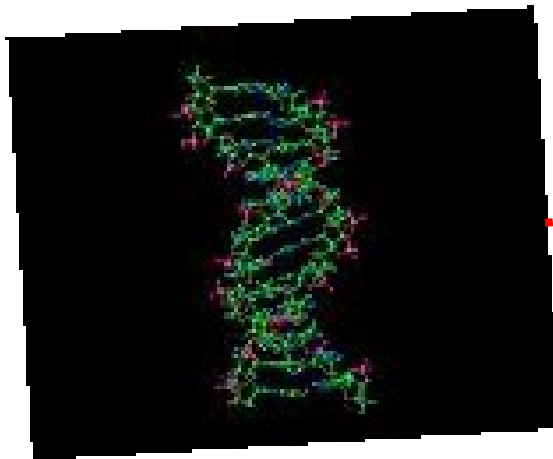# But non-arbitrary features of language may become genetically assimilated

- Because non-arbitrary features will be stable under cultural evolution
  - Compositionality
  - Large vocabulary
  - Layers of both phonology and syntax

- And hence may provide a viable target for biological evolution...

Non-arbitrary features of language can become genetically assimilated
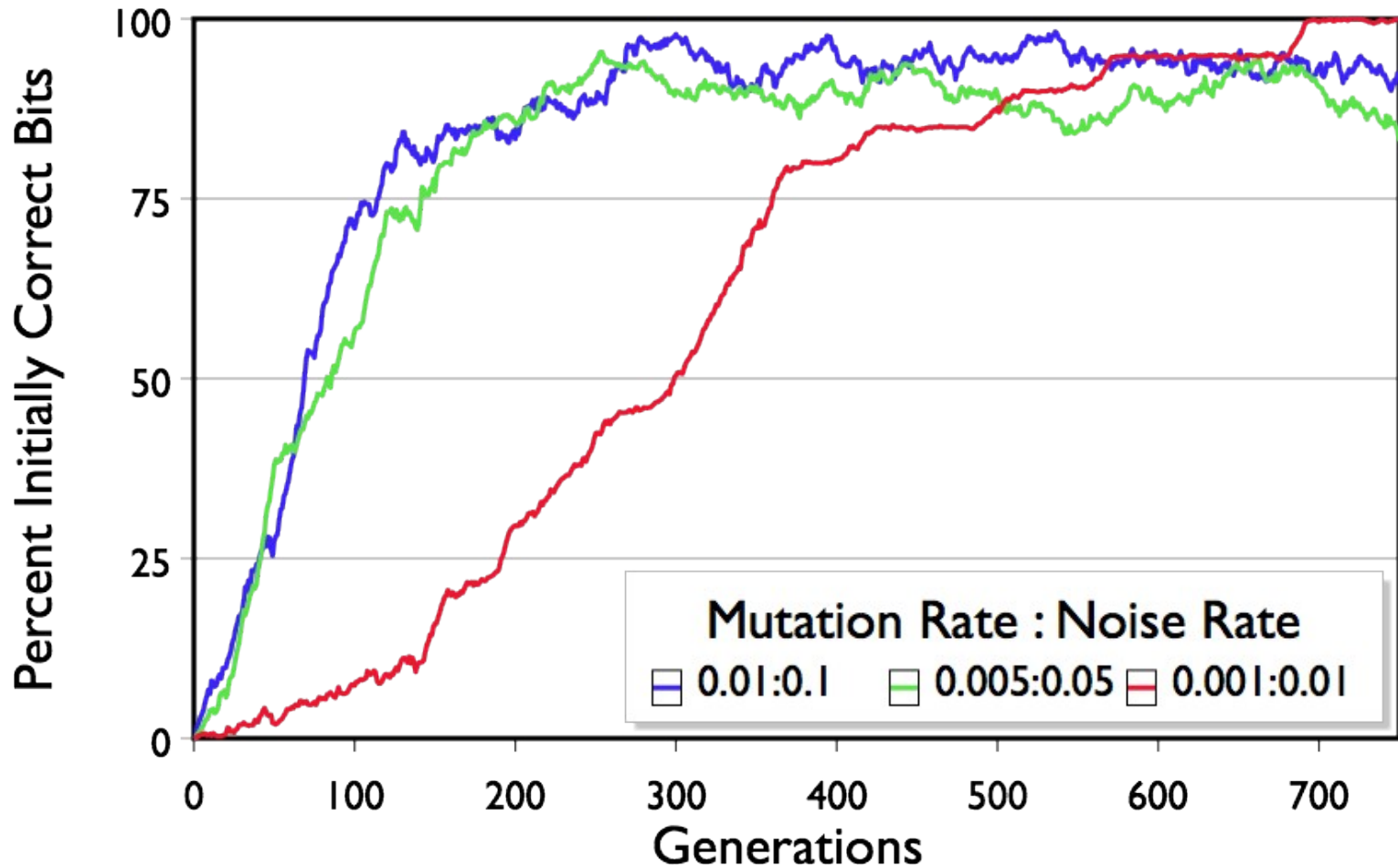
Genes cannot catch a linguistic "moving target"
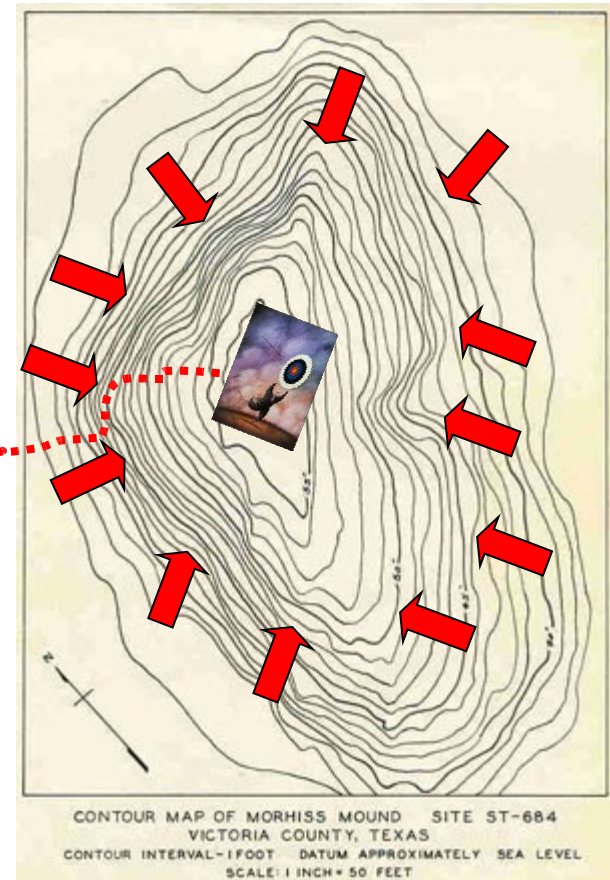
Christiansen, Reali & Chater (submitted)

5. Conclusions

- No co-evolution of genes for arbitrary features of language
  - Incompatible with classical UG in linguistics (but there is not *necessarily* a clash with minimalism metatheory)

- Co-evolution of functional features of language might occur (but not required to explain functional universals)

- Language evolution is primarily cultural evolution: language evolves to be easy to learn and process

Language is shaped by the brain