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

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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

• Linguistic environment of evolutionary adaptation
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

![Graph showing the Baldwin effect in action]

Y-axis: Number of bits in genotype
X-axis: Generations

Red line: Initially Correct Bits
Blue line: Learnable Bits
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

![Graph showing the number of bits in the genotype over generations. The graph compares learnable bits and initially correct bits. The x-axis represents generations ranging from 0 to 2000, and the y-axis represents the number of bits ranging from 0 to 20. The learnable bits are depicted in blue, while the initially correct bits are in red.]
Language changes 10 times as fast

No Baldwin effect
No coevolution
“Learnable” genes win out
Genes cannot catch a linguistic “moving target”

3. Diverging human populations

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

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