Language, Culture and Biology: does language evolve to be passed on by us, and did humans evolve to let that happen?

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Why is language interesting as a natural phenomenon?
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• It’s a complex dynamical system on three timescales:
  1. individual learning
  2. social coordination/cultural transmission
  3. biological evolution
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• But does this matter?
  • Do we need to take this into account to explain why language is the way it is?
Evolutionary linguistics orthodoxy: learning & evolution matter

- One answer (e.g. Pinker & Bloom 1990):
  - explaining language structure means thinking about biological evolution of constraints on learning
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- Genetically determined Language Faculty shapes what languages we can learn, and this has fitness impact
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• To explain adaptive structure in language, look to natural selection of learning constraints
Human nature determines human behaviour, i.e. innate learning mechanism determines language structure.
Evolutionary linguistics orthodoxy: learning & evolution matter

- Biological evolution explains adaptive behaviour, i.e. communicatively functional language
So what about the third timescale?

• Where does socio/cultural stuff fit in?
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- Dual inheritance:
  - biological inheritance of language faculty, cultural inheritance of languages
How this fits in with our previous picture

• Our genes affect our learning biases/constraints, which somehow influence the socio/cultural process to give us the structural properties of language, which go on to affect our fitness
Our genes affect our learning biases/constraints, which *somehow* influence the socio/cultural process to give us the structural properties of language, which go on to affect our fitness.
Does this matter?
Can’t we just ignore this difficult stuff?

• Can simply ignore cultural transmission when making evolutionary arguments?
• Does it add anything substantial?
Does this matter?
Can’t we just ignore this difficult stuff?

• Can simply ignore cultural transmission when making evolutionary arguments?
  • Does it add anything substantial?

• Research programme initiated by Hurford in the early 90s to try and answer this
Methodology: how to study the influence of cultural transmission

- Intuitions about interacting dynamical systems are poor
  - *Models* allow us to study the mechanisms in an idealised setting.
- Apply understanding gained to real systems later.
Methodology: how to study the influence of cultural transmission

- Three broad types of models:
  - **Computational/robotic**
    Castello; Damper; de Beule; Bleys; Briscoe; Dowman; Gasser; Gong; Hawkey; Hoefler; **Hurford**; Kirby; Lakkaraju; Laskowski; Mehler; Schulz; A. Smith; K. Smith; **Steels**; Swarrup; Uno; Wang; Wellens; Worgan; Yamauchi; Zuidema...
  - **Mathematical**
    Baronchelli; Dowman; **Griffiths; Kalish**; Kirby; Nakamura; K. Smith...
  - **Experimental**
    Beqa; **Cornish**; Dowman; Feher; Flaherty; Kirby; Roberts; Scott-Phillips; A. Smith; K. Smith; Tamariz...
A broad framework:
The Iterated Learning Model
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2. Individuals learn by observing instances of behaviour
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*The Iterated Learning Model*

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2. Individuals *learn* by observing instances of behaviour

3. Individuals also *produce* behaviour that is the input to others’ learning
A broad framework: The Iterated Learning Model

- Models vary in a number of ways:
A broad framework: *The Iterated Learning Model*

- Models vary in a number of ways:
  - How is learning modelled?
    - e.g., is it the same for all individuals, or does it evolve biologically? How domain-specific is it? How constrained?
A broad framework: 
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• Models vary in a number of ways:
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    e.g., is it the same for all individuals, or does it evolve biologically? How domain-specific is it? How constrained?
  • What is being learned?
    e.g., Learning to produce signals for meanings with varying degrees of explicitness about what those meanings are; learning to solve a task that requires communication.
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  - What is being learned?
    e.g., Learning to produce signals for meanings with varying degrees of explicitness about what those meanings are; learning to solve a task that requires communication.
  - What is the population structure?
    e.g., size; population turnover; spatial structure; social networks; horizontal vs. vertical transmission.
What have we learned from this modelling work?
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• Socio/cultural transmission is an *adaptive system*
  
  • Language can exhibit appearance of design *without* either natural selection or intentional design
  
  • It is adapting to ensure it’s *own* survival
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- Clear imperative on culturally transmitted language *(Deacon, Christiansen)*:
  - To be transmitted with fidelity it must be learnable despite constraints placed on that transmission
  - Languages adapt to the nature of the transmission *bottleneck*
Structure as a hallmark of cultural adaptation
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  • If we know some meaning-signal pairs, we can accurately predict others
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• This is a cultural rather than biological adaptation
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- **Experimental models** (e.g. Cornish):
  - Give us direct evidence in the lab
Cultural evolution in the lab

(Kirby, Cornish, Smith forthcoming)
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- Participants exposed to artificial language made up of picture/string pairs (initially random)
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- Try and learn this
- Tested on full set of “meanings”
- Sample of output on test used as input language for next participant
## Example initial language

<table>
<thead>
<tr>
<th>umonamo</th>
<th>kinahune</th>
<th>lahupine</th>
</tr>
</thead>
<tbody>
<tr>
<td>nelu</td>
<td>kanehu</td>
<td>namopihu</td>
</tr>
<tr>
<td>kapihu</td>
<td>humo</td>
<td>laupiki</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>moki</th>
<th>luneki</th>
<th>lanepi</th>
</tr>
</thead>
<tbody>
<tr>
<td>kalu</td>
<td>mola</td>
<td>pihukimo</td>
</tr>
<tr>
<td>nane</td>
<td>kalakihu</td>
<td>mokihuna</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>kilamo</th>
<th>kahuki</th>
<th>neluka</th>
</tr>
</thead>
<tbody>
<tr>
<td>pilu</td>
<td>neki</td>
<td>pinemohu</td>
</tr>
<tr>
<td>luki</td>
<td>namola</td>
<td>lumoka</td>
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Example final language
(10 “generations” later)

- Confirms computational results: structure emerges that optimises *learnability* and *expressivity*
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- Only weak innate biases required and may be weakened by co-evolution (Smith & Kirby)
- Fits observations about genes and tone languages (Dediu & Ladd)
So where does this leave biology?
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- Models build a lot in:
So where does this leave biology?

- Models build a lot in:
  - Learning complex signals
So where does this leave biology?

• Models build a lot in:
  • Learning complex signals
  • Inferring meanings
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• The real evolutionary story?
  • Not: natural selection of innate constraints that determine language structure
  • Instead: pre-adaptations that enable iterated learning
Preadaptations
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- A number of other species produce learned complex sequential signals (e.g. birds)
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• Transmitted by iterated learning, but do not carry semantics
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- Transmitted by iterated learning, but do not carry semantics
- Evolves for other reasons
  - Complex learned song is fitness indicator (e.g. Ritchie, Kirby & Hawkey; Okanoya)
Preadaptations
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• Inferring complex meanings is probably beyond birds
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  • Although no other primate can learn complex sequential signals

• Intentional inference plausibly evolves for reasons other than communication
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- Substrate for later externalising of meaning (cf. Fitch; Mithen)
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  - What biases do we have?
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• Once this is in place, linguistic structure is delivered by adaptation through iterated learning
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• Still much work to be done, but multiple modelling strategies represent the best approach.