Language Evolution and the Shift from Kin-Only to Non-Kin Communication

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Essential Components of Human Language

Researchers have identified three essential components of language that theories of language evolution must account for (Fitch 2005; 2007):

- **Signal**: capacity for vocal learning, or the ability to imitate complex acoustic signals
- **Syntax**: the ability to generate an infinite number of sentences from a finite number of words, and an infinite number of words from a finite number of sounds
- **Semantics**: ability to encode unlimited propositional meanings, or communicate nearly any thought we can have

Types of Selection Underlying the Evolution of Language

Evolutionary theory distinguishes three types of selection, each of which has been argued to be a force driving the evolution of language:

- **Natural Selection**: Being able to acquire knowledge about the world through language, and potentially avoid dangerous situations, was advantageous to early humans (e.g. Pinker & Bloom 1990)
  - **Advantages**: Ability to acquire knowledge about the world
  - **Disadvantages**: Communication delays and risk of deception
- **Kin Selection**: Based on the concept of inclusive fitness - an individual's reproductive success PLUS the effects the individual has on the reproductive success of his/her kin. Those individuals with the greatest inclusive fitness will be those who help their relatives survive by sharing useful information with them. (Fitch 2004; 2007)
  - **Advantages**: Ability to communicate with relatives
  - **Disadvantages**: Communication delays and risk of deception
- **Sexual Selection**: Complex language was attractive to the opposite sex, allowing skilled language users to be more reproductively successful (e.g. Miller 2001)
  - **Advantages**: Ability to attract a mate
  - **Disadvantages**: Communication delays and risk of deception

A Puzzle for Kin Selection

If Kin Selection is the mechanism underlying the evolution of language, how can we explain communication between non-kin? (Fitch 2004) proposes Reciprocal Altruism:

"Once language capabilities had evolved, via kin selection, to the level where valuable information could be exchanged at low cost, (reciprocal altruism) provided the additional possibility for such exchange among unrelated individuals who spoke similar dialects" (Fitch 2004; 2007)

But how did this transition from kin-only to non-kin communication occur?

**Goal**: develop an agent-based model in NetLogo to understand the transition from kin-only to non-kin communication

References


Model

**Agents** have two heritable traits:

- **Tag**: indicator of relatedness (Axelrod et al. 2004), implemented as a value between 0 and 9
- **Relatedness range (RR)**: How closely related another agent must be in order to speak with them (e.g. if an agent's tag = 5 and RR = 1, that agent will speak with others with tags between 4 and 6)

**Advantages**: Ability to communicate with relatives

**Disadvantages**: Communication delays and risk of deception

**Iterations** of the model contain two stages:

- Communication: agents decide whether to speak with (and share information with) each of their neighbors based on whether the tag of the neighbor falls within their RR.
  - Communication: allows for communication between non-kin
- Reproduction: 18-35 yr old females choose a neighboring male over 18. If there is an empty neighboring cell, they produce one offspring who inherits the average values of the parents' tags and RR's.

Simulations & Conclusions

**Simulations**: Eight preliminary experiments were conducted, manipulating presence or absence of three features of the model

1. Movement: ability of agents to move to a neighboring cell at each iteration (viscosity of the population)
2. Tag-based mating: agents' willingness to reproduce with kin or non-kin (sexual selection for those with similar tags)
3. Experience-based trust: whether agents' RR's are affected by successful communication achieved throughout their lifetime (How it works: If agents' life expectancies after the communication stage has increased, then communication was generally beneficial, and their non-inherited RR is increased - they become more altruistic and "trusting" towards others. Otherwise, non-inherited RR is decreased, making them slightly less willing to trust dissimilar agents in the next iteration)

**Desired outcome**: Multiple kin groups and ability for agents to speak to any other agent in the population

**Results**: In every case, inherited RR's converged to a small value (around 1.0).

Only Simulation #8 produces the desired outcome - with no movement, tag-based mating, and experience-based trust

<table>
<thead>
<tr>
<th>Simulation</th>
<th>Movement</th>
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<th>Exp-based trust</th>
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**Simulations & Conclusions**

State of model at the end of Simulation #8

Agents from multiple kin groups (color of agents = tag)

**Future Directions**:

- One simplifying assumption of this model is that the costs and benefits of communication are constant. If the relative costs were varied, how could this affect the evolution of non-kin communication?
- This model also assumes that the language capacity is already fully acquired, but it could continue to evolve throughout the shift from kin to non-kin interactions. How could this shape the evolution of various features of language?