Evolution of Syntax Through Horizontal Social Interactions

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Human Language : Unique

1. Meaning-signal mappings has structural properties:

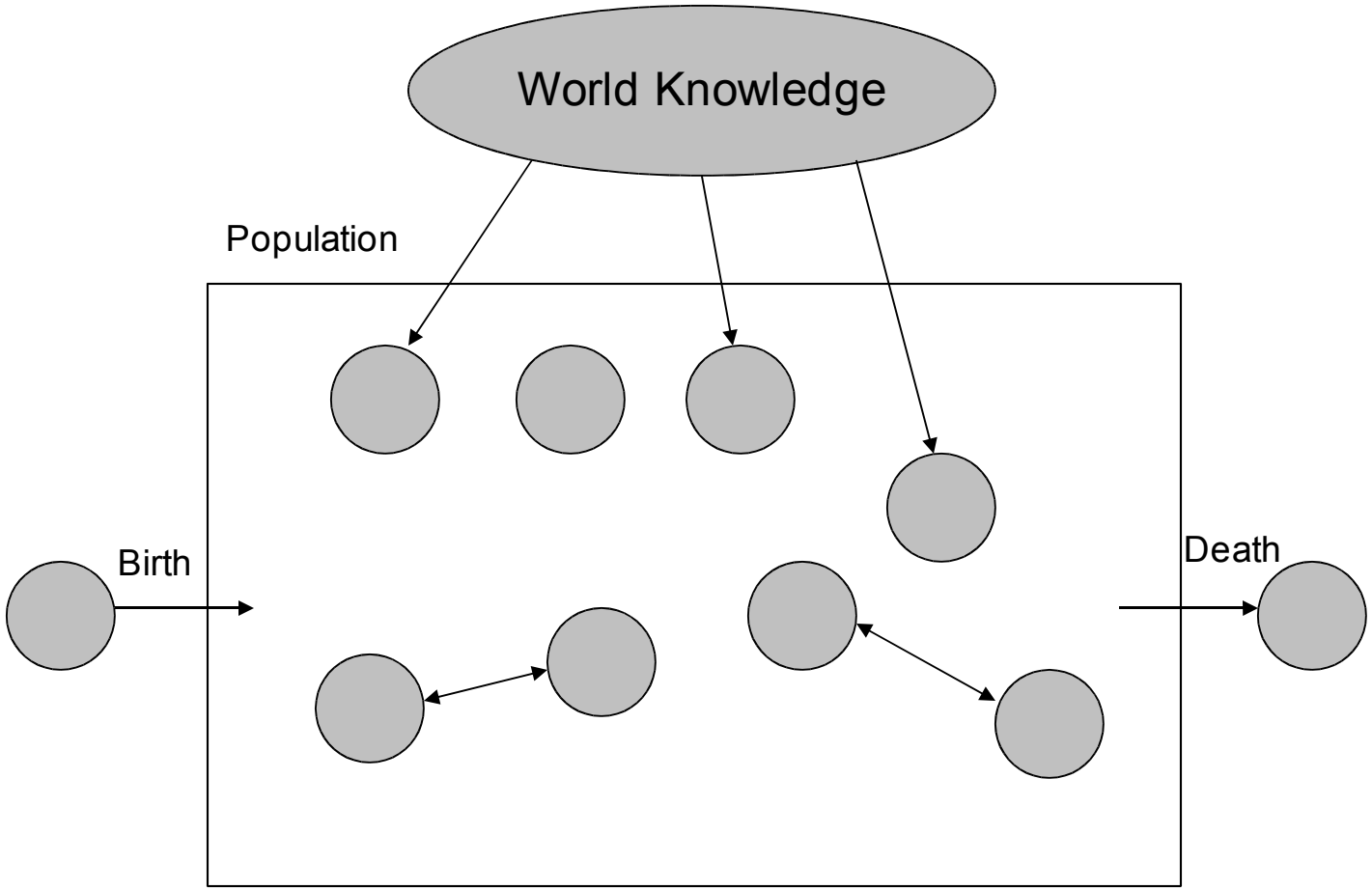
   Infinite range of expressions through compositionality and recursion of syntax

2. Learning through observation of other's use of language

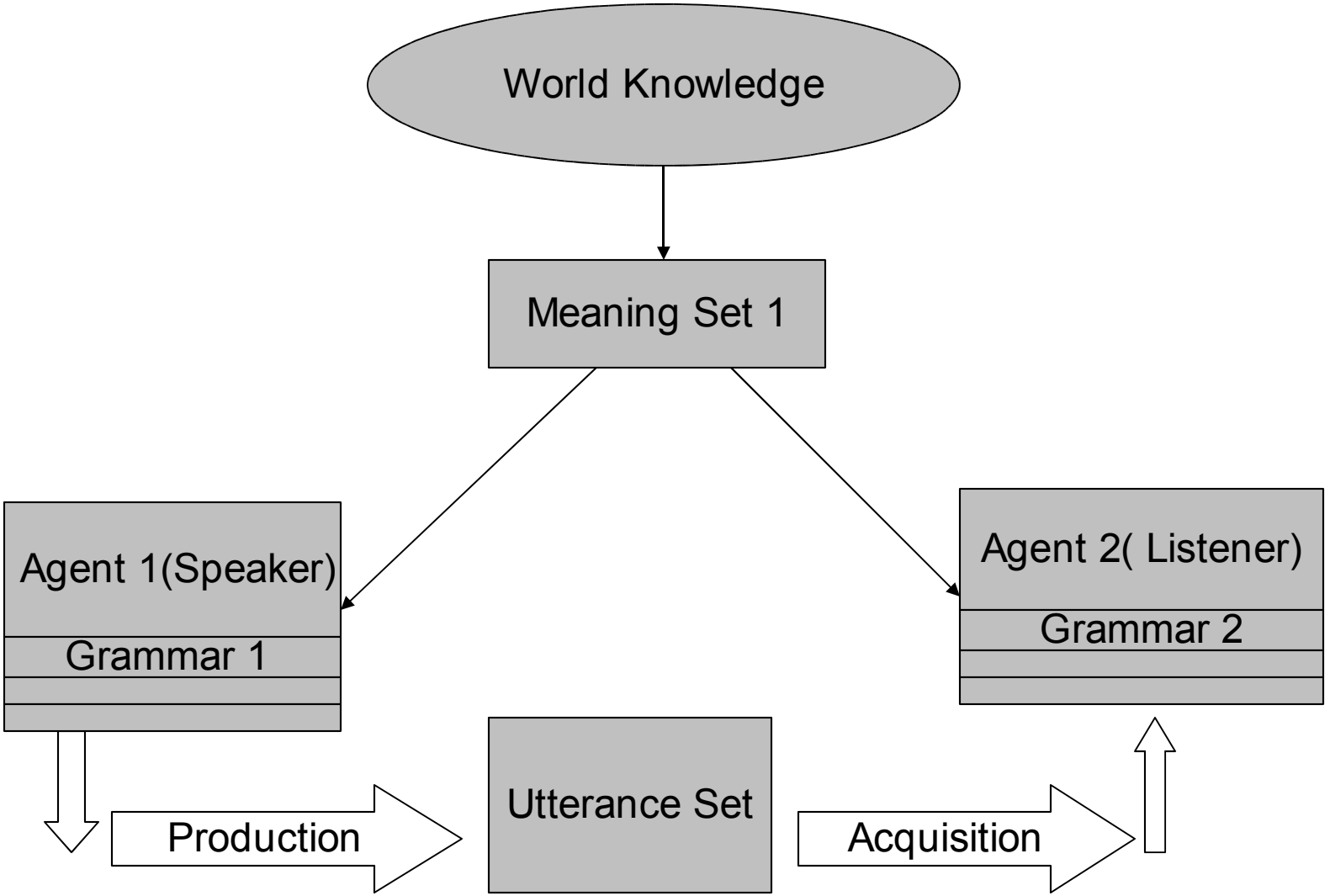
Our Aim

- To demonstrate that compositionality properties of syntax inevitably emerge over time through a dynamical process of social transmission within the same generation.
- We also wish to explore the influence of poverty of stimulus on the evolution of compositionality.

Computational Model



Computational Model (contd…)



Interaction Between Agents:

1. Speaker produces a string for a random meaning in a predefined set, using existing grammar or by invention (rule is induced).
2. Listener parses the string and tries to find a rule which could have produced it. If not, string meaning pair used for induction.

Simulation Details

- World made of predefined concepts:

  john, tiger, eats,fears

- Concepts into predicate-argument combinations:

  eats(john,mary)

- Utterance is meaning-signal pair: (in Eng):

  <johneatsmary,eats(john,mary)>

Details of Grammar:

- Context free grammar (i.e. restricted DCG)
- 2 possible grammars. E.g.:

1. S/eats(tiger,john) → tigereatsjohn

2. S/p(x,y)→N/x V/p N/y
   V/eats→eats
   N/tiger→tiger
   N/john→john

Rule Subsumption

- Deleting duplicate rules in grammar: incorporation and rule deletion

S/eats(tiger,sausages)→tigeeatssausages
S/eats(john,sausages)→johneatssausages

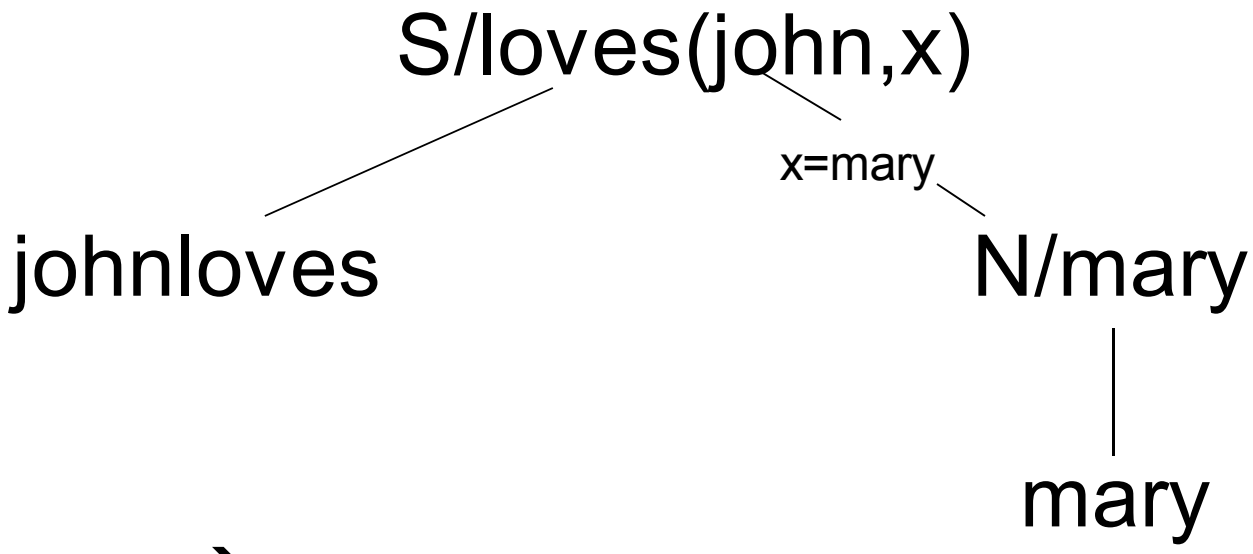
S/eats(x,sausages)→N/x eatssausages
N/tiger→tiger, N/john→john

Invention

- Speaker doen’t have a way to generate string for some meaning – grammar is absent
- Speaker finds closest meaning for which grammar available – a parse tree for the meaning created
- At wrong part string replaced with random sequence

Invention

- S/loves(john,x)→ johnloves N/x
  N/mary→ mary



N/anna→anna

Our Argument

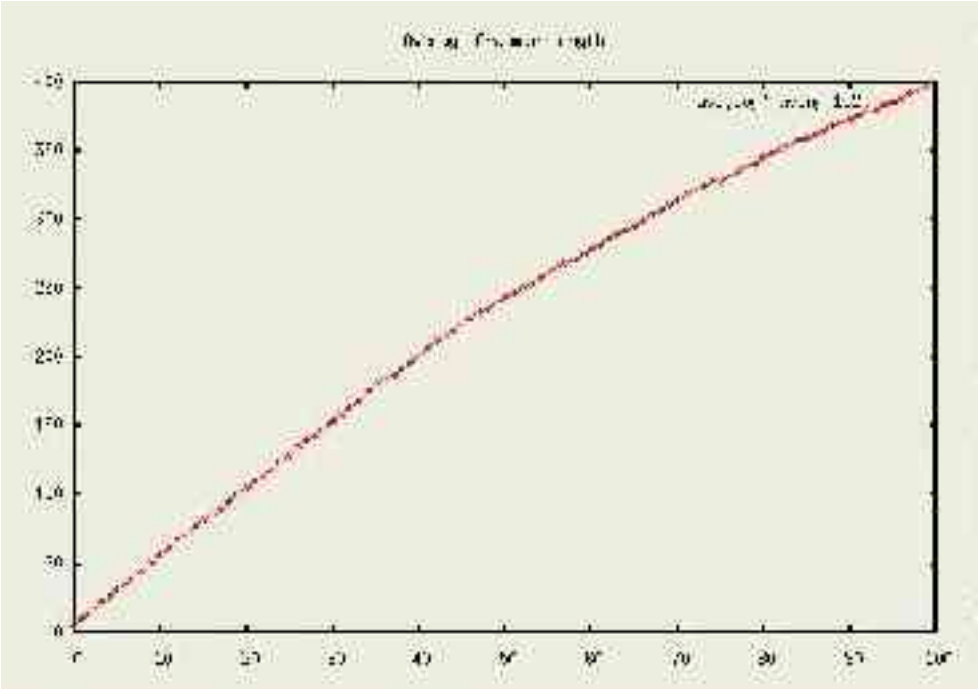
- Compositionality emerges due to subsumption assumption.
- Extent of influence of Poverty of Stimulus on compositionality?
- Do high-frequency utterances escape compositionality and become holistic?
- We aim to compare horizontal and vertical models with varying parameters.

Summary of Simulation Cycle

- Initialize a population with no internal language.
- Repeat ‘n’ times:
  - Pick 2 agents randomly from the population. One speaker, other listener
  - Perform ‘m’ interactions.
  - Kill a random agent with some probability

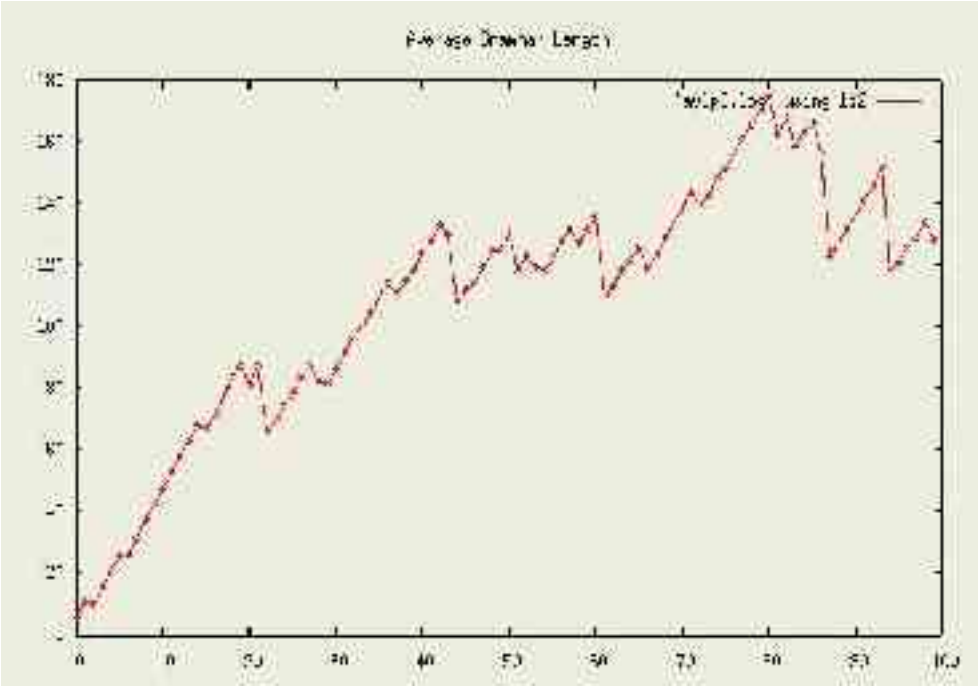
Results

- Parameters:
  - Probability of Death = 0.0
  - Number of Individuals = 10
  - Number of Interactions = 50, Iterations = 100



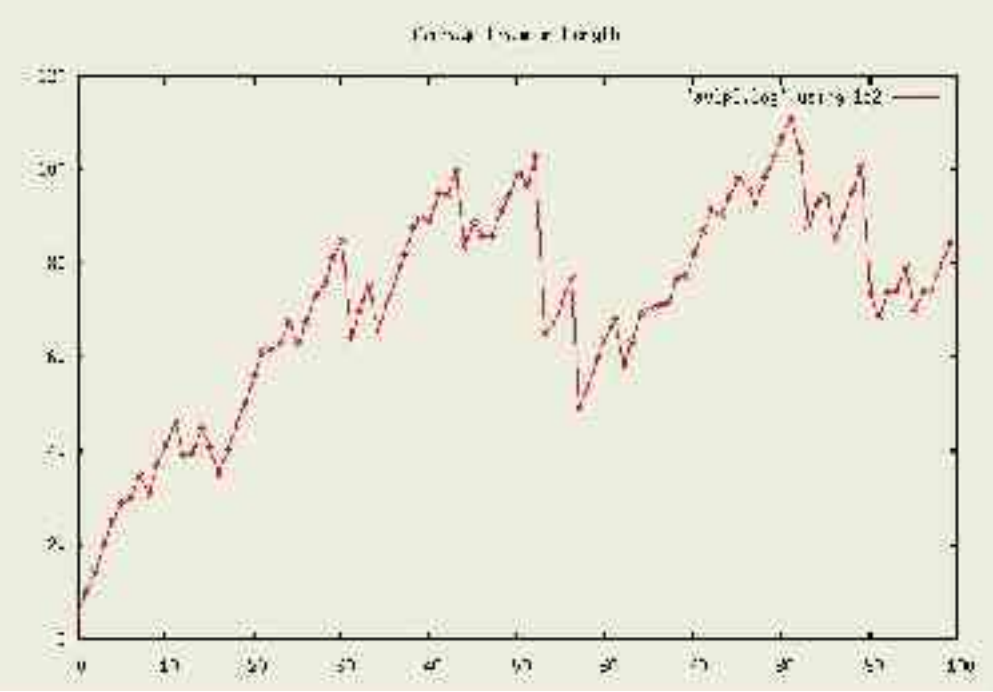
Results

- Parameters:
  - Probability of Death = 0.3
  - Number of Individuals = 10
  - Number of Interactions = 50 , Iterations = 100



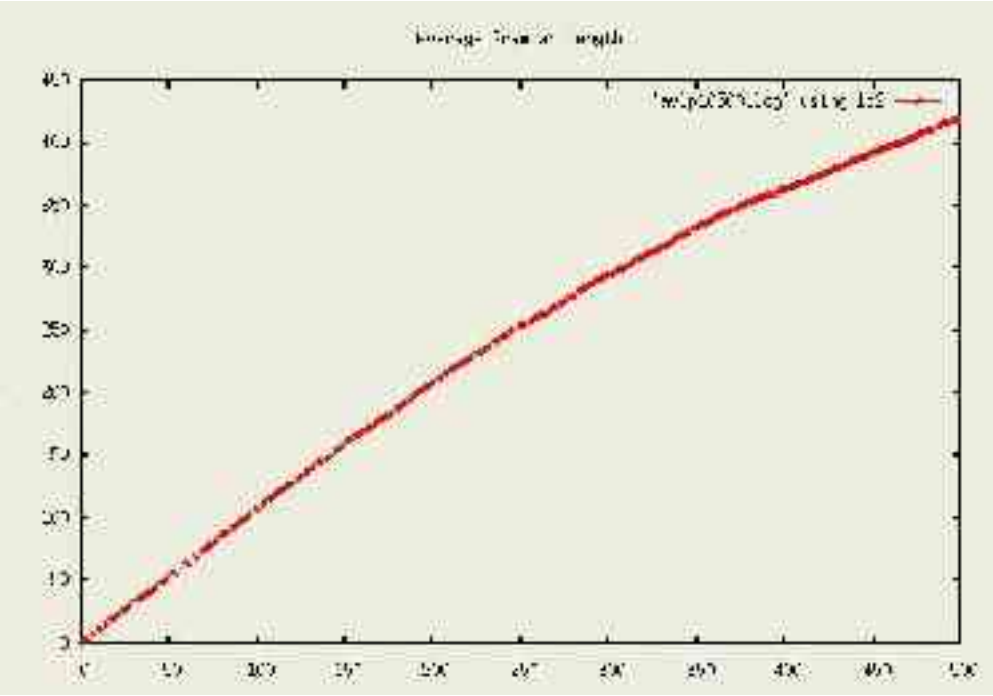
Results

- Parameters:
  - Probability of Death = 0.6
  - Number of Individuals = 10
  - Number of Interactions = 50 , Iterations = 100



Results

- Parameters:
  - Probability of Death = 0.0
  - Number of Individuals = 50
  - Number of Interactions = 10 , Iterations = 500



Results

S/likes(john,y) -> T/y n
T/alice -> sq
T/bob -> i
S/likes(mary,parker) -> q
…

- More experiments need to be carried out.
- Lack of convergence needs to be examined.

References

- Smith, Kenny, Kirby, Simon and Brighton, Henry (2003), “Iterated Learning: a framework for the emergence of language. *Artificial Life”*.
- Kirby, Simon (2000), “*Syntax without Natural Selection: How compositionality emerges from vocabulary in a population of learners”*, *The Evolutionary Emergence of Language: Social function and the origins of linguistic form*. Cambridge University Press.
- Kirby, Simon (1999), “*Learning, Bottlenecks and the Evolution of Recursive Syntax”*, in Briscoe, Edward, Eds. *Linguistic Evolution through Language Acquisition: Formal and Computational Models*. Cambridge University Press.