# Mind-Reading vs. Simulation in Epistemically Heterogeneous Social Networks

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## Background: The Nature of Pragmatic Inference

- Pragmatics concerns context-dependent inferences (generally assumed to be linked to rational use of language by situated agents)
- How is this done (beyond and independent of particular algorithms, e.g., Gricean conversational maxims, relevance theory or argumentation theory)?

**Mind-Reading**

(see, e.g., Sperber and Wilson, 2002)
– Figure out epistemic state of interlocutors
– Determine inferences based on inferred epistemic state of addressee

**Simulation Theory**

(see, e.g., Carruthers and Smith, 1996, p. 3)
– Assume that interlocutor has same epistemic state as yourself
– Simulate likely inferences

- Difference might matter when agents' epistemic contexts are not identical, that is, when they do not know and believe the same things (in real life: always)
- Not clear to which degree Mind-Reading is assumed to be psychologically real
- Mind-Reading is slow and error-prone (especially when agents share little common ground)

## Epistemically Heterogeneous Social Networks

- Humans are an unusually social and cooperative species (for primates). As a consequence, all langage learning (and most of language use) takes place in social networks.

> Linguistic theory is concerned primarily with an ideal speaker-listener, in a completely homogeneous speech-community [...] (Chomsky 1965, p. 3)

- This position necessarily ignores everything related to variation
- Variation is a key ingredient in language change
- Two kinds of heterogeneity will be investigated:
  – contact in social networks; and
  – partly differing epistemic contexts.

## Reinforcement Learning with Polya Urns

- Polya-Urns provide a mathematical model of reinforcement learning.
- Randomly draw a ball from the urn.
- If the ball corresponds to the correct answer, a further ball will be added to the urn.

| $URN_t$ | → | $URN_{t+1}$ |
|---|---|---|
| white:1 | | white:2 |
| red:1 | | red:1 |

The probability of drawing "white" rises from 0.5 to 0.6̇

## Learning Internally Differentiated Lexical Items

- I assume internally differentiated lexical representations like Pustejovsky's *qualia-structure*.

**Lexical Usage Profile of an Agent**

is represented as array of pondered submeanings with respect to these 2 words:

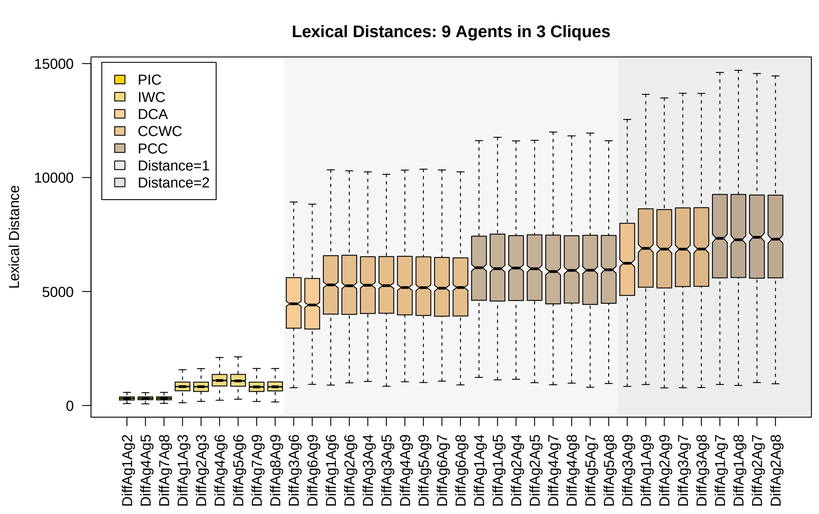
| | W1Q1 | W1Q2 | W1Q3 | W1Q4 | W2Q1 | W2Q2 | W2Q3 | W2Q4 |
|---|---|---|---|---|---|---|---|---|
| Ag 1 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 |
| Ag 2 | 2000 | 2000 | 2000 | 1 | 1 | 1 | 1 | 2000 |

- Scenario:
  – Two words are absolute synonyms (see Skyrms, 2010): any draw = success
  – Each submeaning is an independent Polya urn (balls correspond to Word1 & Word2)
  – Speaker draws a word, and signals to hearer
  – Speaker & Hearer update weights for the chosen word

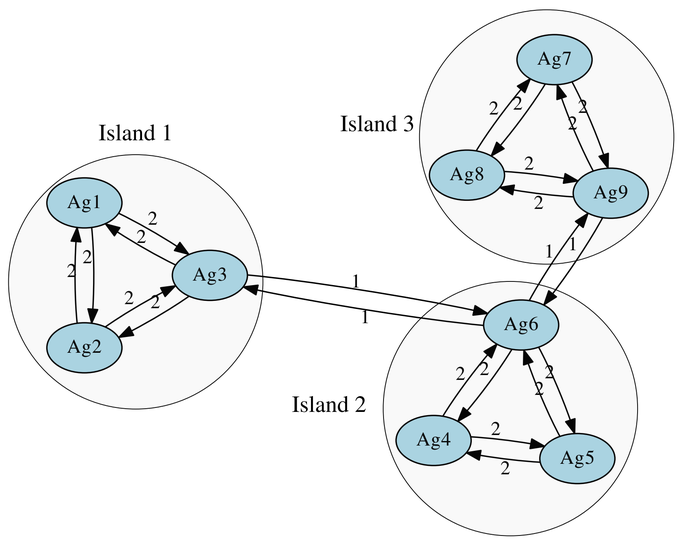
## Mutation

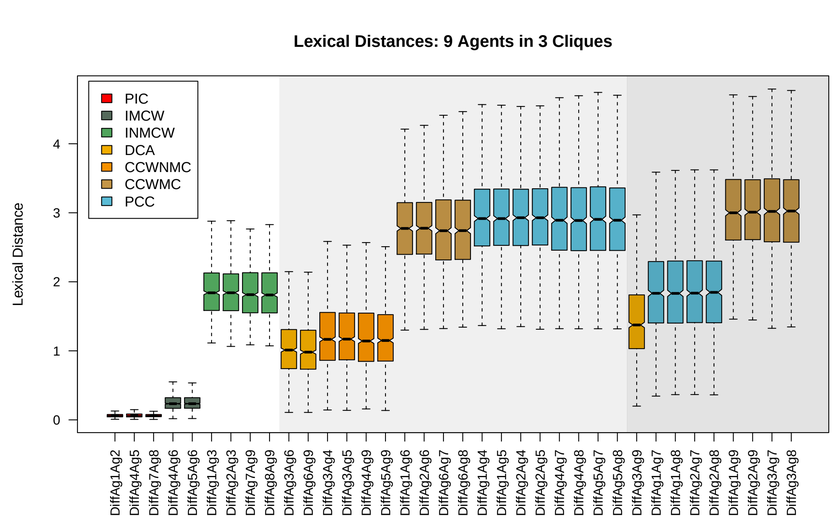
- At some point in simulation: change in the surrounding world → agents adapt lexical representations
- In a submeaning, two types are distinguished (Type1 keeps weight; Type2 initialized at 1)
- Instead of four submeanings, agents discriminate five different submeanings
- Epistemic state of mutants is superset of epistemic state of non-mutants

## General Pattern: Absence of Mutation vs. Mutation (Regardless of Inference Method)




Without Mutation




Mutation of Island 2

## Pragmatics in Production

**Mind-Reading Inferences**

Agents discard for production parts of their own epistemic state the interlocutor lacks

**Simulation Inferences**

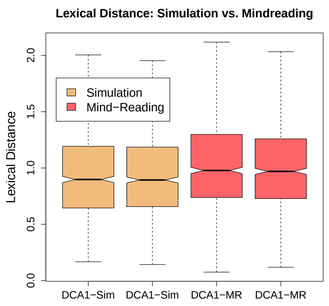
Agents always take into account their full epistemic state for production

Significant differences (p-values from Kruskal-Wallis test for network of 3 × 10 agents):

| DCA1 | CCWNMC1 | CCWMC1 | PCC1 | DCA2 | PCC2 |
|---|---|---|---|---|---|
| 1.54385e-09 | 1.689598e-49 | 0.008774732 | 8.998603e-12 | 0 | 4.782354e-09 |

## Mind-Reading Increases Lexical Distance

- With Mind-Reading inference, the lexical distance between agents of different islands is bigger than with Simulation inference
- Because Mind-Readers discard non-shared epistemic states, they leave a smaller footprint of their epistemic differences
- All things being equal, the less agents take into account other's epistemic states, the more similar they become




## Acknowledgments & Sample References

All simulations have been performed with **sbcl** Common Lisp, using the **graph**-library by Eric Schulte (`https://github.com/eschulte/graph`). Networks have been drawn with **graphviz** (Gansner and North, 2000). Data analysis has been performed with **GNU R**.

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