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	$\longrightarrow$	white:2
red:1		red:1

The probability of drawing "white" rises from 0.5 to $0.\dot{6}$

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:

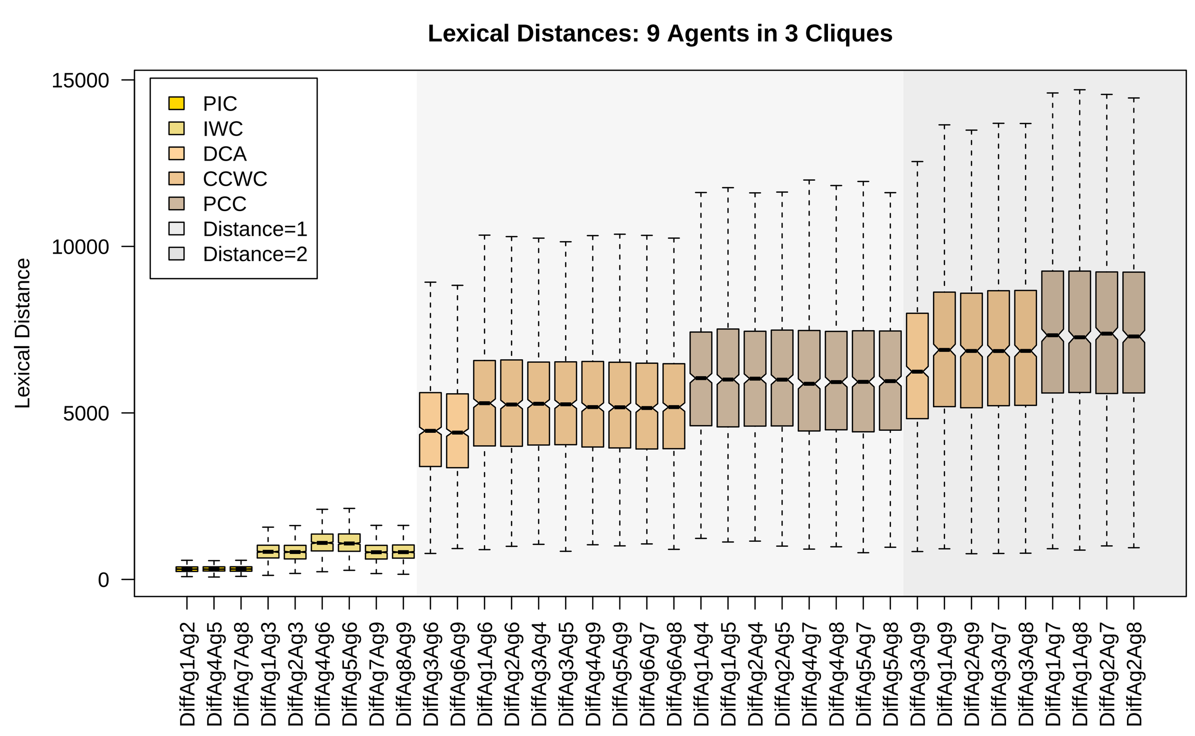
	W1Q1	W1Q2	W1Q3	W1Q4	W2Q1	W2Q2	W2Q3	W2Q4
Ag 1	1000	1000	1000	1000	1000	1000	1000	1000
Ag 2	2000	2000	2000	1	1	1	1	2000

- 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

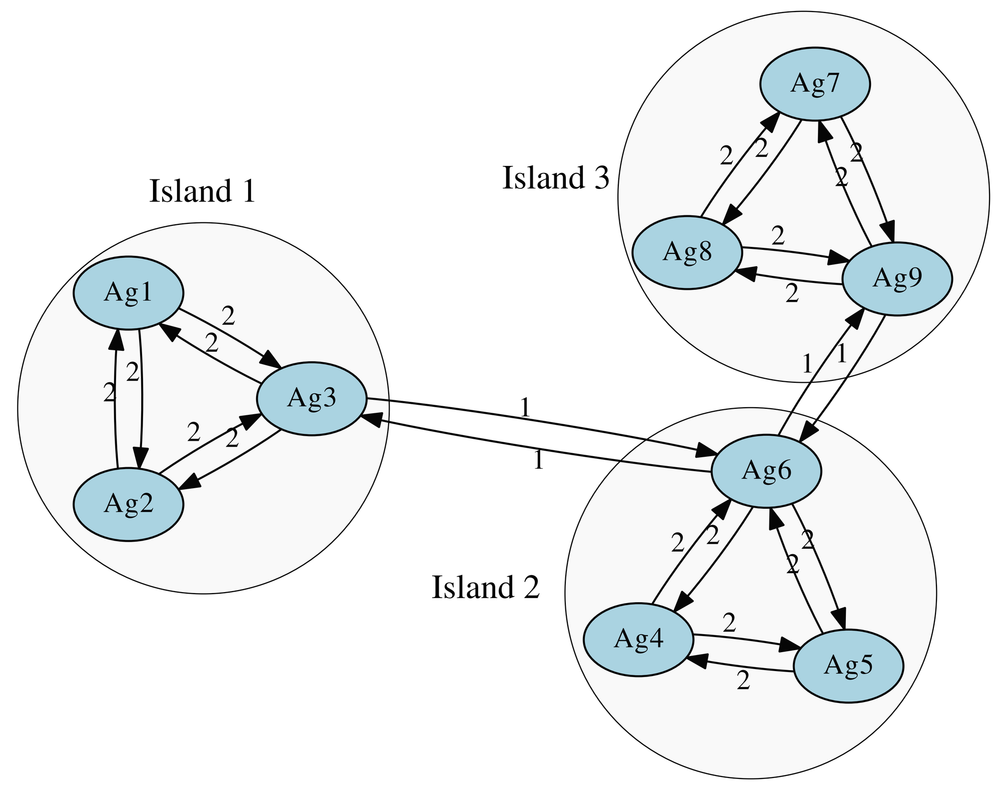
Mutation

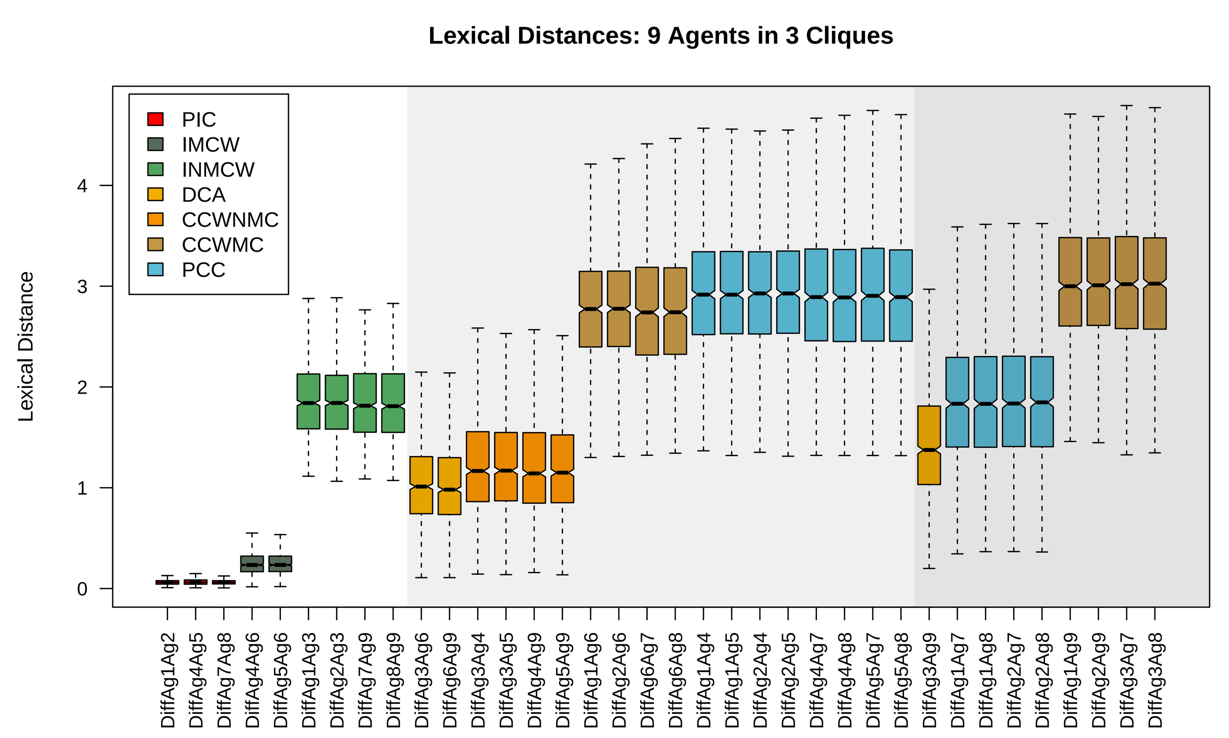
- At some point in simulation: change in the surrounding world → agents adapt lexical representations
- In a submeaning, two types are distinguished (Type1 keeps weight; Type2 initialized at 1)
- Instead of four submeanings, agents discriminate five different submeanings
- Epistemic state of mutants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

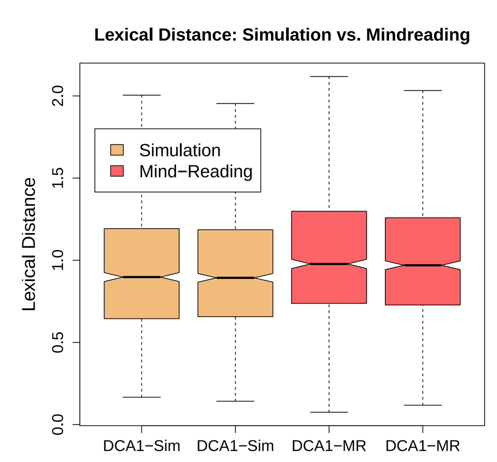
Agents always take into account their full epistemic state for production

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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