

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

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# MIND-READING VS. SIMULATION IN EPISTEMICALLY HETEROGENEOUS SOCIAL NETWORKS

## 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

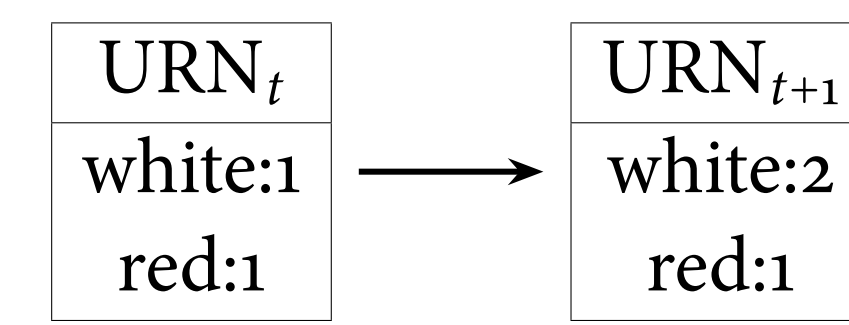
### Simulation Theory

(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)

## 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.



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

## 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

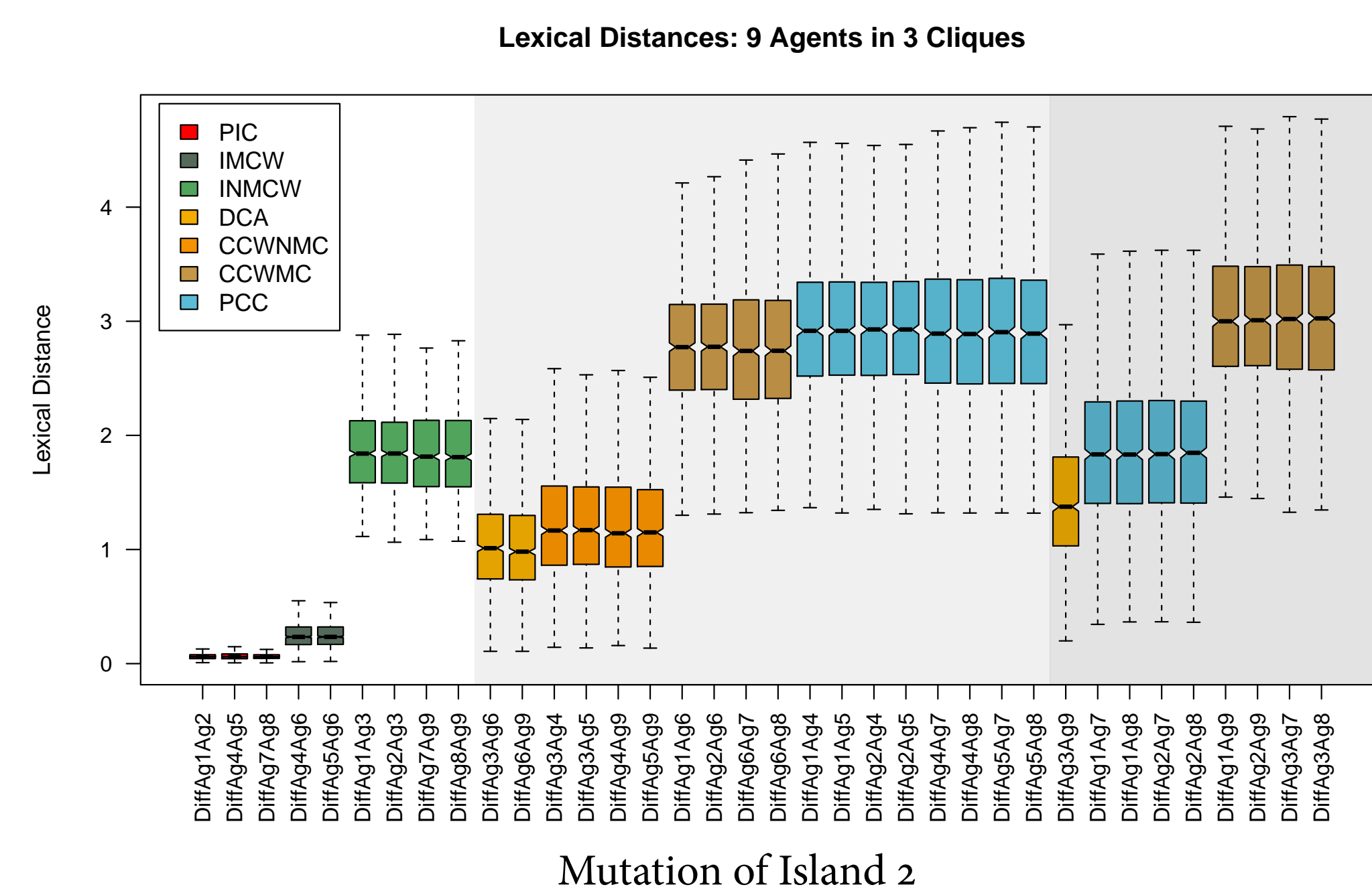
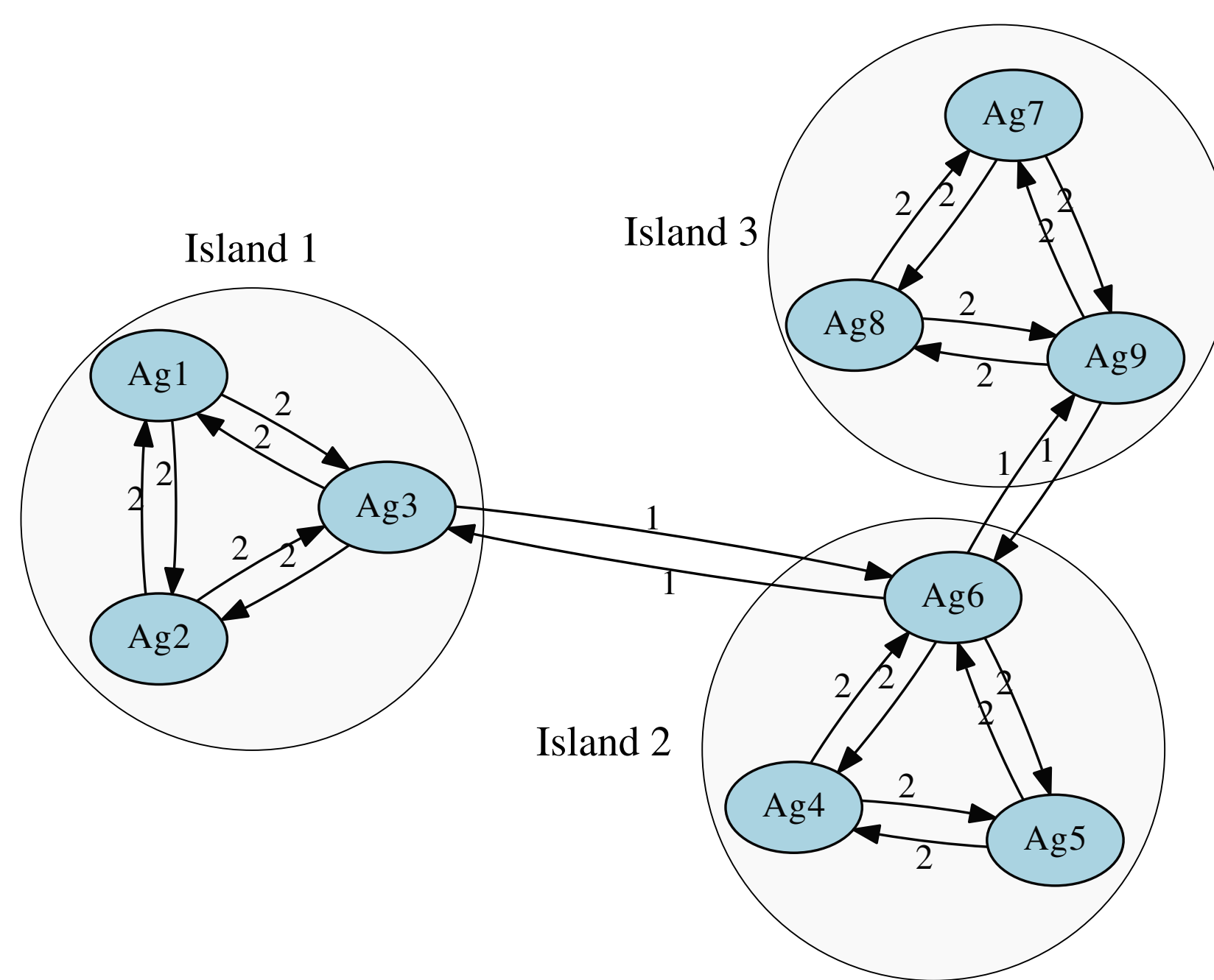
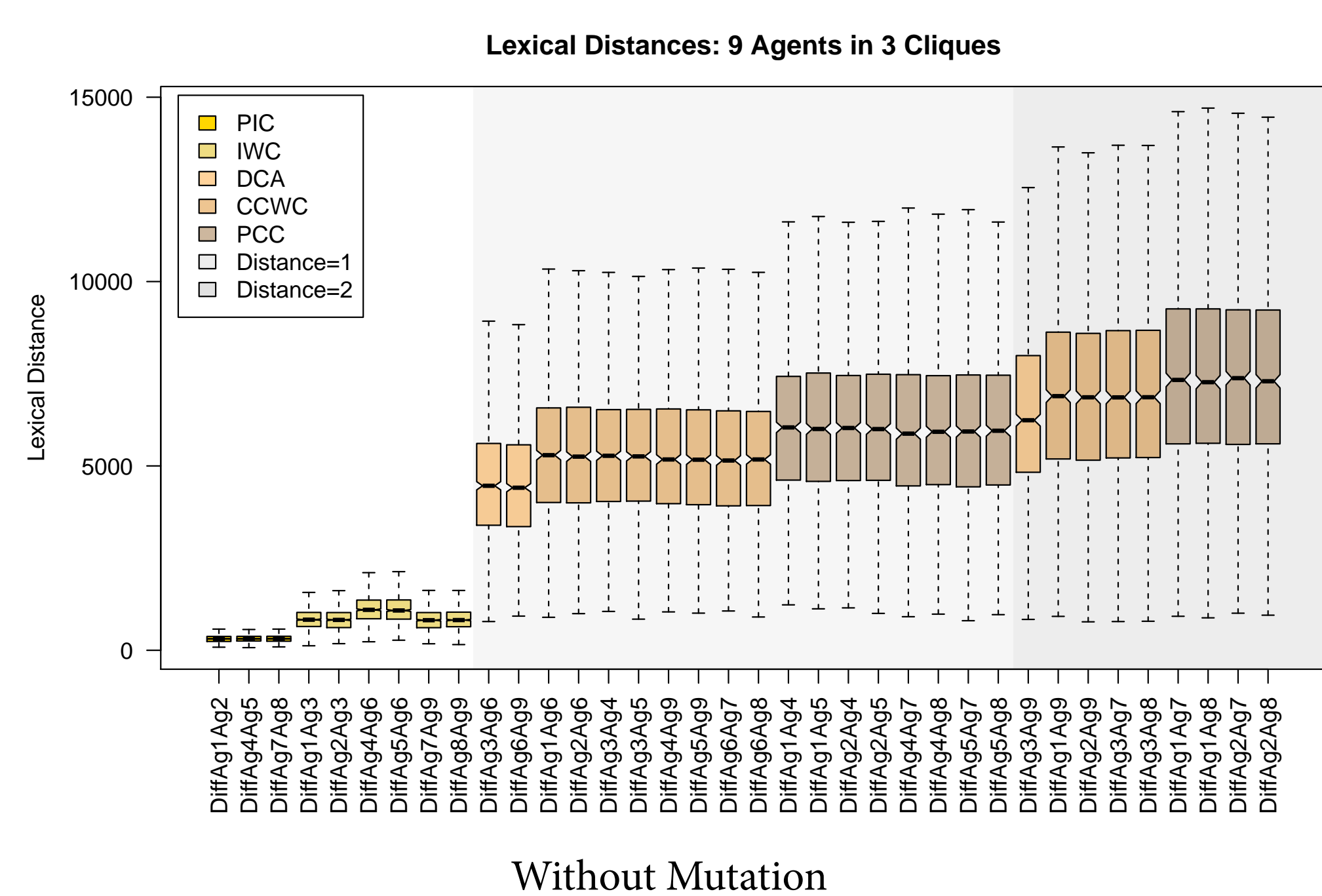
## Epistemically Heterogeneous Social Networks

- Humans are an unusually social and cooperative species (for primates). As a consequence, all language 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.

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



## Pragmatics in Production

### Mind-Reading Inferences

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

### Simulation Inferences

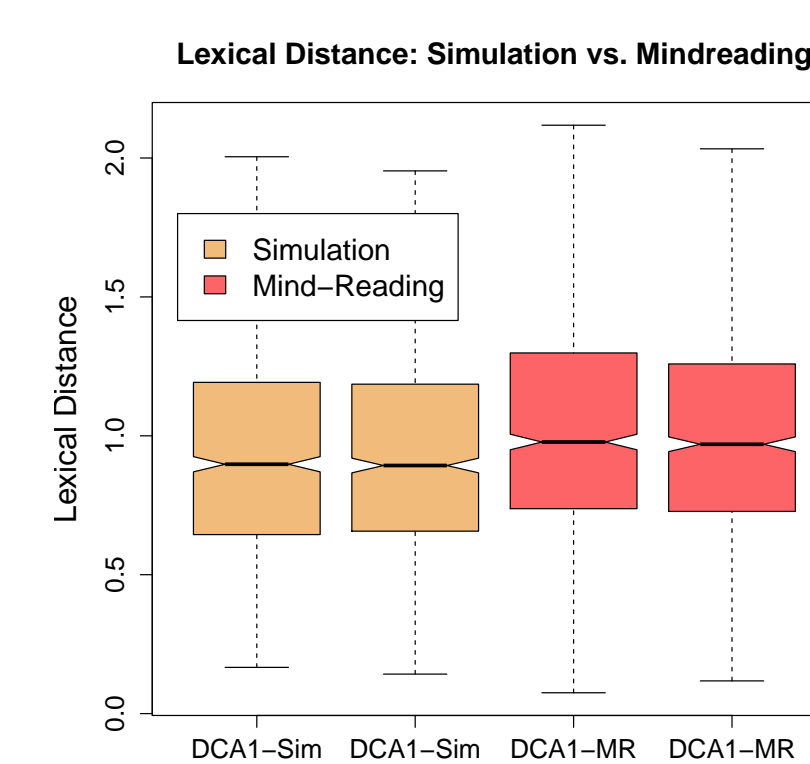
Agents always take into account their full epistemic state for production

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 **sicl** 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**.  
 [1] Carruthers, P. and P. K. Smith, eds. (1996). *Theories of Theories of Mind*. Cambridge: Cambridge University Press. [2] Chomsky, N. (1965). *Aspects of the Theory of Syntax*. Cambridge, MA: MIT Press. [3] Gansner, E. R. and S. C. North (2000). "An Open Graph Visualization System and its Applications to Software Engineering". In: *Software — Practice and Experience* 30.11: pp. 1203–1233. [4] Mühlenbernd, R. and M. Franke (2012). "Signaling Conventions: Who Learns What Where and When in a Social Network". In: *The Evolution of Language: Proceedings of EvoLang9*. Ed. by T. C. Scott-Phillips et al. Singapore: World Scientific: pp. 242–249. [5] Paul, H. (1995). *Prinzipien der Sprachgeschichte*. 9th ed. Tübingen: Niemeyer. [6] Pustejovsky, J. (1995). *The Generative Lexicon*. Cambridge: MIT Press. [7] Schaden, G. (2014). "Markedness, Frequency and Lexical Change in Unstable Environments". In: *Proceedings of the Formal & Experimental Pragmatics Workshop*. Ed. by J. Degen, M. Franke, and N. Goodman. ESSLT. Tübingen: pp. 43–50. [8] Skyrms, B. (2010). *Signals. Evolution, Learning, & Information*. Oxford: Oxford University Press. [9] Sperber, D. and D. Wilson (2002). "Pragmatics, Modularity and Mind-Reading". In: *Mind & Language* 17.1–2: pp. 3–23.