

The Evolution of Lexical Usage Profiles in Social Networks

Gerhard Schaden

► **To cite this version:**

Gerhard Schaden. The Evolution of Lexical Usage Profiles in Social Networks. Conférence annuelle du Cercle belge de linguistique: Computational Construction Grammar and Constructional Change, Jun 2015, Bruxelles, Belgium. 2015. hal-01258828

HAL Id: hal-01258828

<https://hal.univ-lille3.fr/hal-01258828>

Submitted on 19 Jan 2016

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



THE EVOLUTION OF LEXICAL USAGE PROFILES IN SOCIAL NETWORKS

Background: The Problem of Lexical Change

- Lexical Change is typically messy (as opposed to grammaticalization):
 - influenced by changes in the world (technology, etc.)
 - influenced by \pm random events (“big” history, behavioral micropatterns, etc.)
- It is not always clear whether changes are about *meaning*, or about *prototypical usage patterns*.

Example: French *voiture*

- 19th century and before: horse-drawn carriage
 - today: automobile, car
- The old meaning is still available today, even if it has become marginal.

- If random plays an important role, is it worth investigating?

What answer would the owner of a casino give you?

Language and 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.
- Network analysis is flourishing in the Social Sciences (see, e.g., Jackson, 2008), and is emerging in linguistics (see, e.g., Mühlendernd and Franke, 2012). A convergence is developing between game theory, social network analysis, and fairly old explanations developed by Hermann Paul in his *Prinzipien der Sprachgeschichte*.

Jede Veränderung des Sprachus ist ein Produkt aus den spontanen Trieben der einzelnen Individuen einerseits und [...] Verkehrsverhältnissen andererseits. (Paul, 1995, §25)

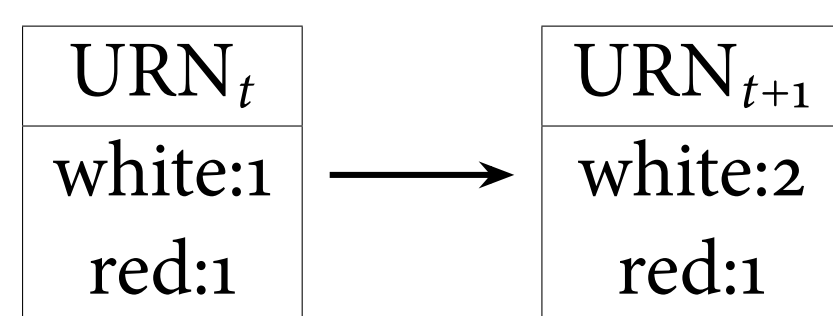
- Is (language) learning influenced by network size and structure? (**Yes!**, see, e.g., Mühlendernd and Franke, 2012)
- I will investigate reinforcement learning of (internally differentiated) lexical items in social networks, by performing multi-agent simulations.

Reinforcement Learning with Polya Urns

Learning in Behaviorism

Learning = shifting the probability of some behavior in an agent

- 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*. The basic theoretical commitment boils down to independently ponderable submeanings.
- Motivation: meaning shifts generally follow patterns of polysemy
- Scenario:
 - We have two words that 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
 - Hearer updates the weight for the chosen word (and maybe the speaker, too)

Lexical Usage Profile of an Agent w.r.t. Denotation-Equivalents

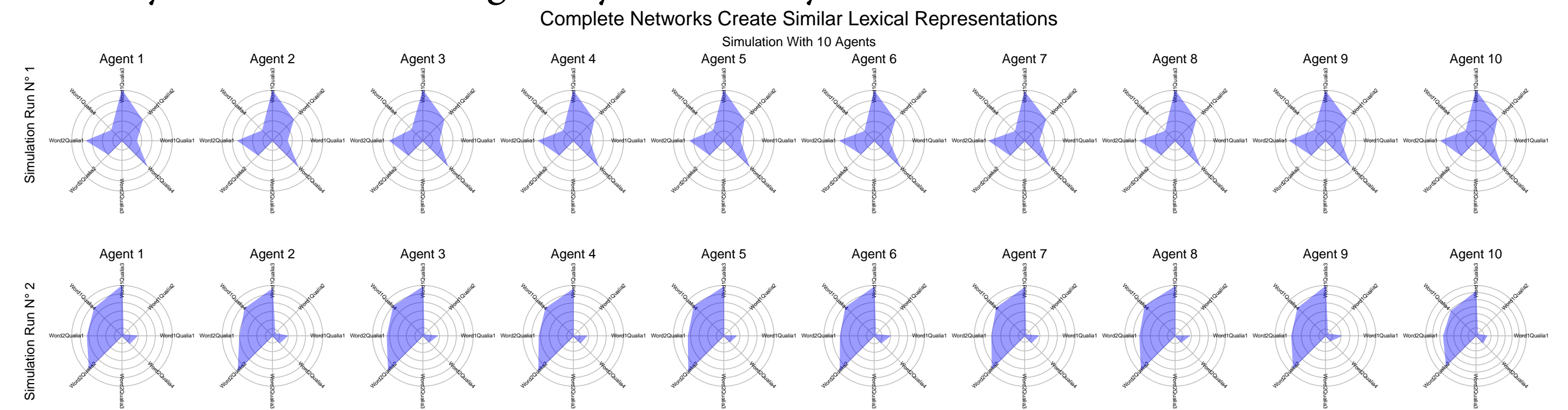
is represented as array of pondered submeanings with respect to these 2 words:

	W ₁ Q ₁	W ₁ Q ₂	W ₁ Q ₃	W ₁ Q ₄	W ₂ Q ₁	W ₂ Q ₂	W ₂ Q ₃	W ₂ Q ₄
Ag 1	1000	1000	1000	1000	1000	1000	1000	1000
Ag 2	2000	2000	2000	1	1	1	1	2000

Should we assume that a speaker reinforces (and therefore influences) himself? This has consequences for the outcome!

Complete Networks: Contact Creates Uniformity

Within a simulation run in a complete network, the lexical usage profiles of the agents are extremely similar, even though they can be very dissimilar across simulation runs.

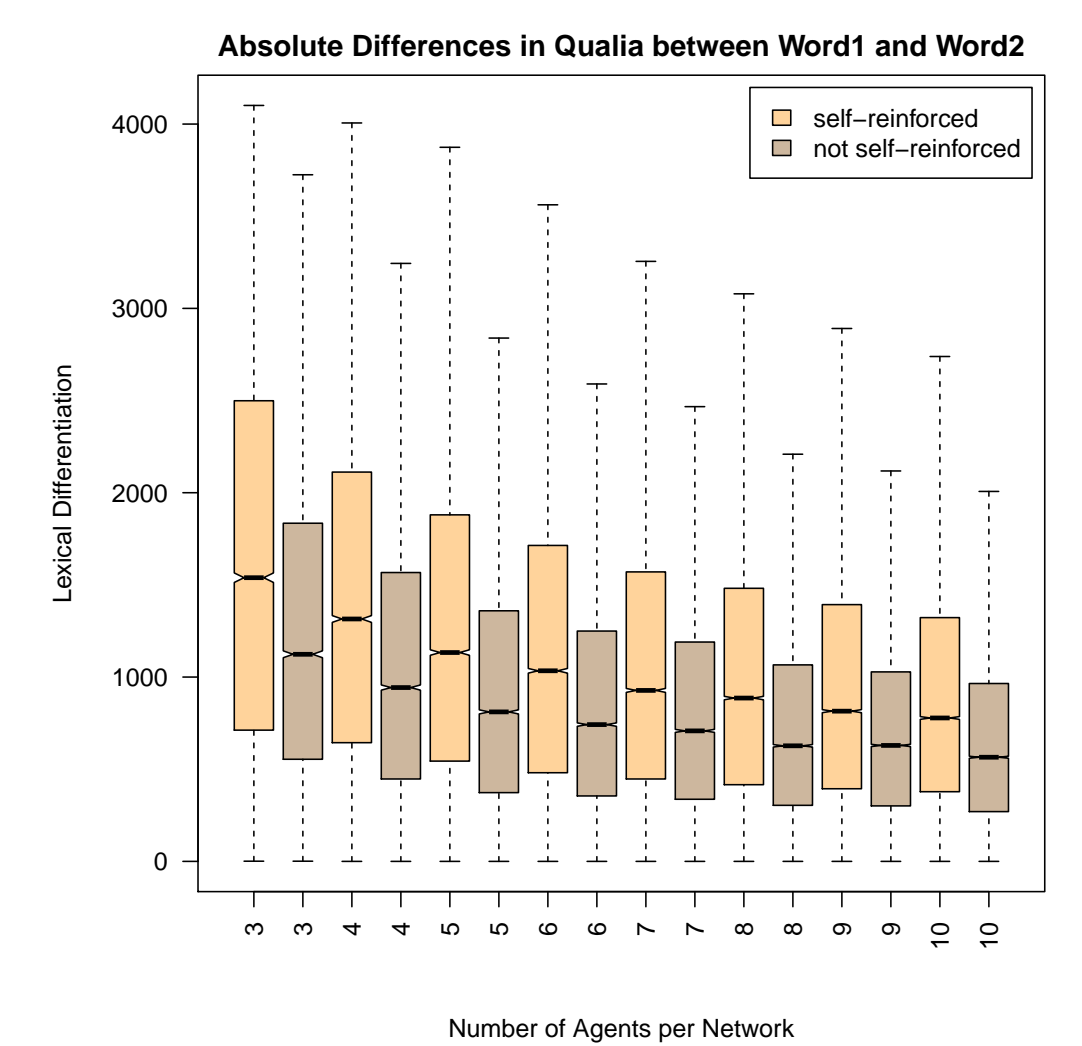


Complete Networks: Lexical Differentiation and Network Size

Definition: Lexical Differentiation between Word₁ and Word₂ at Submeaning_i

is the absolute difference of submeaning_i of Word₁ and submeaning_i of Word₂, or:
 $|\text{submeaning}_i(\text{Word}_1) - \text{submeaning}_i(\text{Word}_2)|$

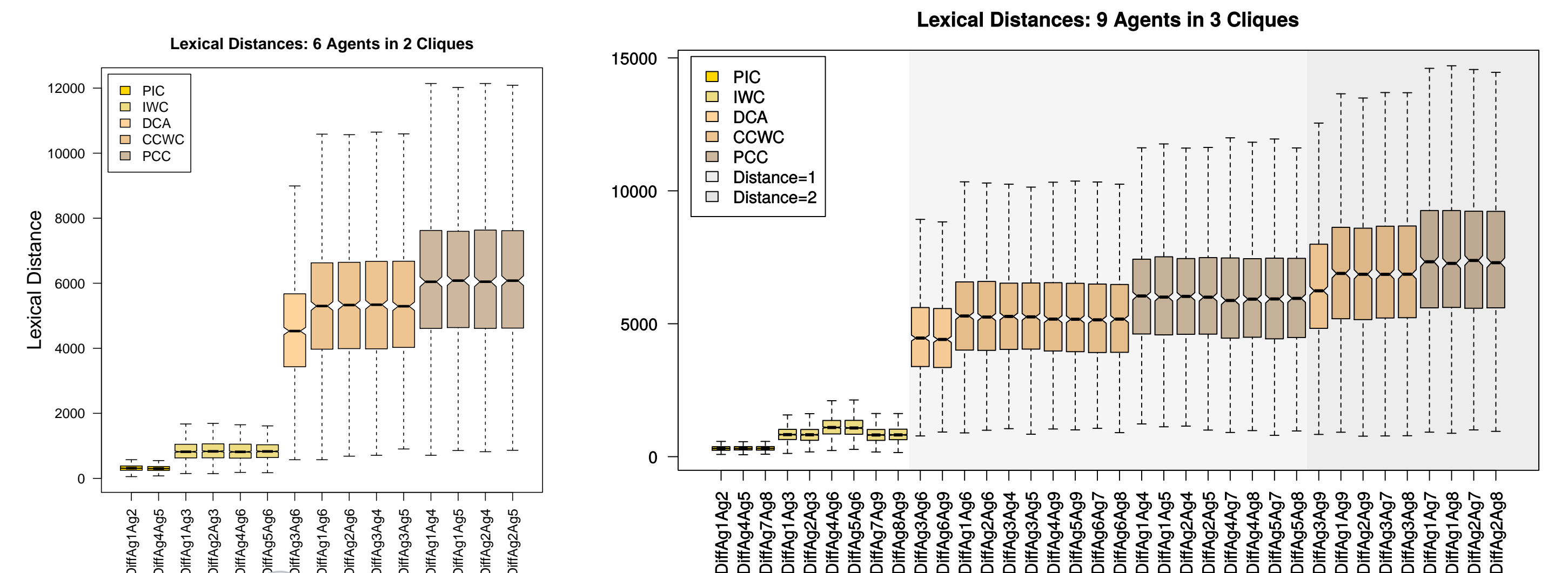
- In the simulation, we keep stable the number of reinforcements per agent.
- The bigger the (complete) network, the less differentiated the submeanings.
- If the speaker reinforces himself, differentiation is more important than if he does not reinforce himself.
- Differentiation strongly depends on the initial tendency. Self-reinforcement and small network size increase the chance of moving away from the initial configuration.



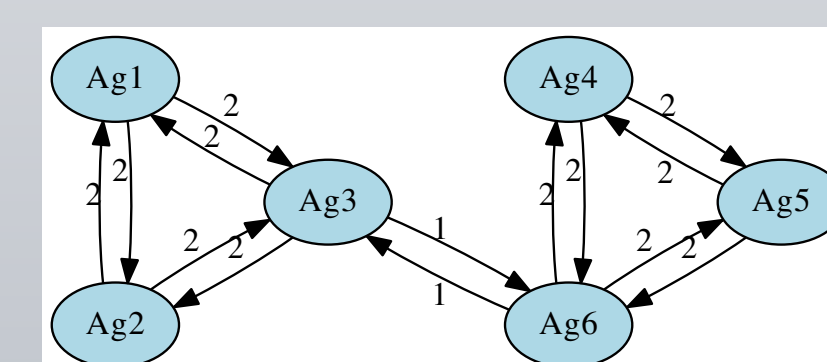
Lexical Distance Reflects Network Structure

Definition: Lexical Distance between Agent₁ and Agent₂

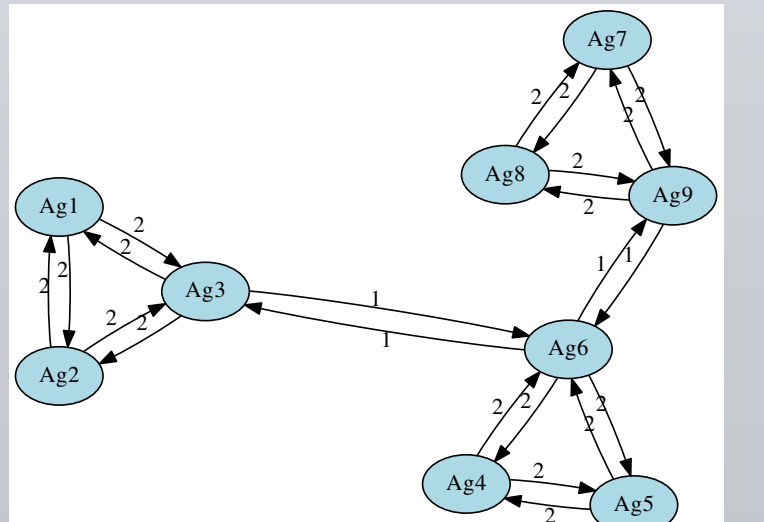
The lexical distance between two agents is the sum of the absolute differences of their respective pondered submeanings, or: $\sum_{i=1}^k |\text{submeaning}_i(\text{Ag}_1) - \text{submeaning}_i(\text{Ag}_2)|$



Underlying Network:



Underlying Network:



Acknowledgements & Sample References

I had the opportunity to present a previous version at the University Lille 3, and I would like the audience for their input. I would also like to thank Sylvain Billiard and Cédric Patin for their comments and encouragements. All errors and omissions are mine alone. 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**.

[1] 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. [2] Jackson, M. O. (2008). *Social and Economic Networks*. Princeton: Princeton University Press. [3] Mühlendernd, R. and M. Franke (2012). “Signaling Conventions: Who Learns What Where and When in a Social Network”. In: *The Evolution of Language: Proceedings of EvoLang*. Ed. by T. C. Scott-Phillips et al. Singapore: World Scientific: pp. 242–249. [4] Paul, H. (1995). *Prinzipien der Sprachgeschichte*. 9th ed. Tübingen: Niemeyer. [5] Pustejovsky, J. (1995). *The Generative Lexicon*. Cambridge: MIT Press. [6] 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. ESSLLI. Tübingen: pp. 43–50. [7] Skyrms, B. (2010). *Signals. Evolution, Learning, & Information*. Oxford: Oxford University Press.