Simulating language change and dynamics — example of Setswana

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Stop devoicing in Setswana

- language from the Sotho-Tswana group of Bantu languages
- voiced and voiceless stops contrast in some contexts but stops are neutralized to voiceless post-nasally: /Nb/ → [Np]
  ☞ *unintuitive* in that greater articulatory effort is required to terminate voicing than to maintain it
- ***examples***:

voiced/voiceless contrast:			
Bana baa mpatla	*The children are looking for me*	Bana baa rebatla	*The children are looking for us*
post-nasal neutralization:			
m.pa.tla	*want me*	re.ba.tla	*want us*
m.po.tsa	*ask me*	re.bo.tsa	*ask us*
m.pu.le.la	*open (for) me*	re.bu.le.la	*open (for) us*

- strengthening and weakening in Setswana [1]:
  - observed variation: *voiced stop – voiceless stop – ejective*
- Coetzee and Pretorius [2] found:
  - one group of speakers applied aerodynamic and mechanical forces during closure voicing, without employing any phonological rule
  - another group realized the whole closure duration with voicing
  - speakers developed a rule of post-nasal voicing by phonologizing spontaneous partial voicing
  - phonological rules are phonologizations of phonetically driven sound changes [3]

Analyzed speech data

- data from Coetzee and Pretorius [2] & NCHTL Speech Corpus [4]

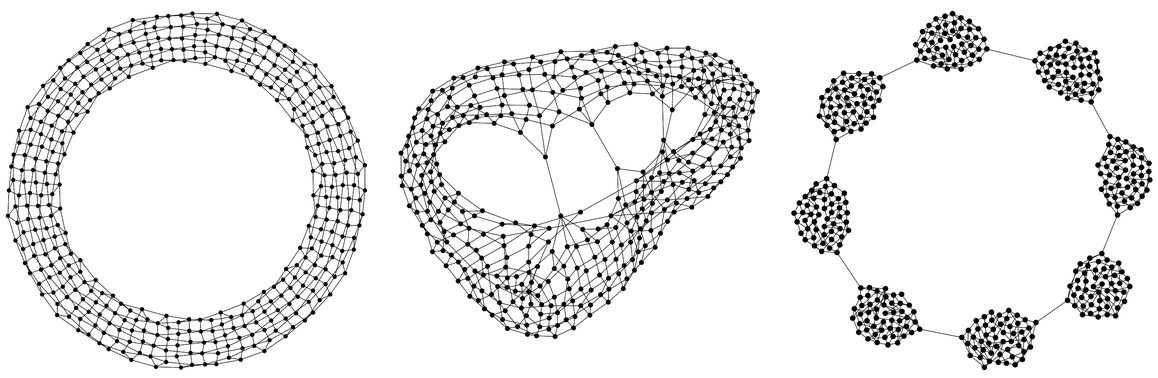
The KaMoso Framework

- computational multi-agent simulation framework
- based on Exemplar Theory [5, 6] and Social Impact Theory [7]

individual level	***population level***

• limited memory / life span
• percepts stored in memory
  ◦ perceptual warping
  ◦ rich phonetic detail
  ◦ social / indexical information
• exemplar-based production
  ◦ weighted target score:
  — α: phonetic prototypicality
  — β: status of original speaker
  — γ: closeness of original speaker
	• dynamics for many epochs
	• different network topologies
	  ◦ defining social distances
	  ◦ generated or pre-defined networks
	• different speaker–listener interactions based on social status or distance

- comparing different target selection weights, interaction schemes and different social network topologies:



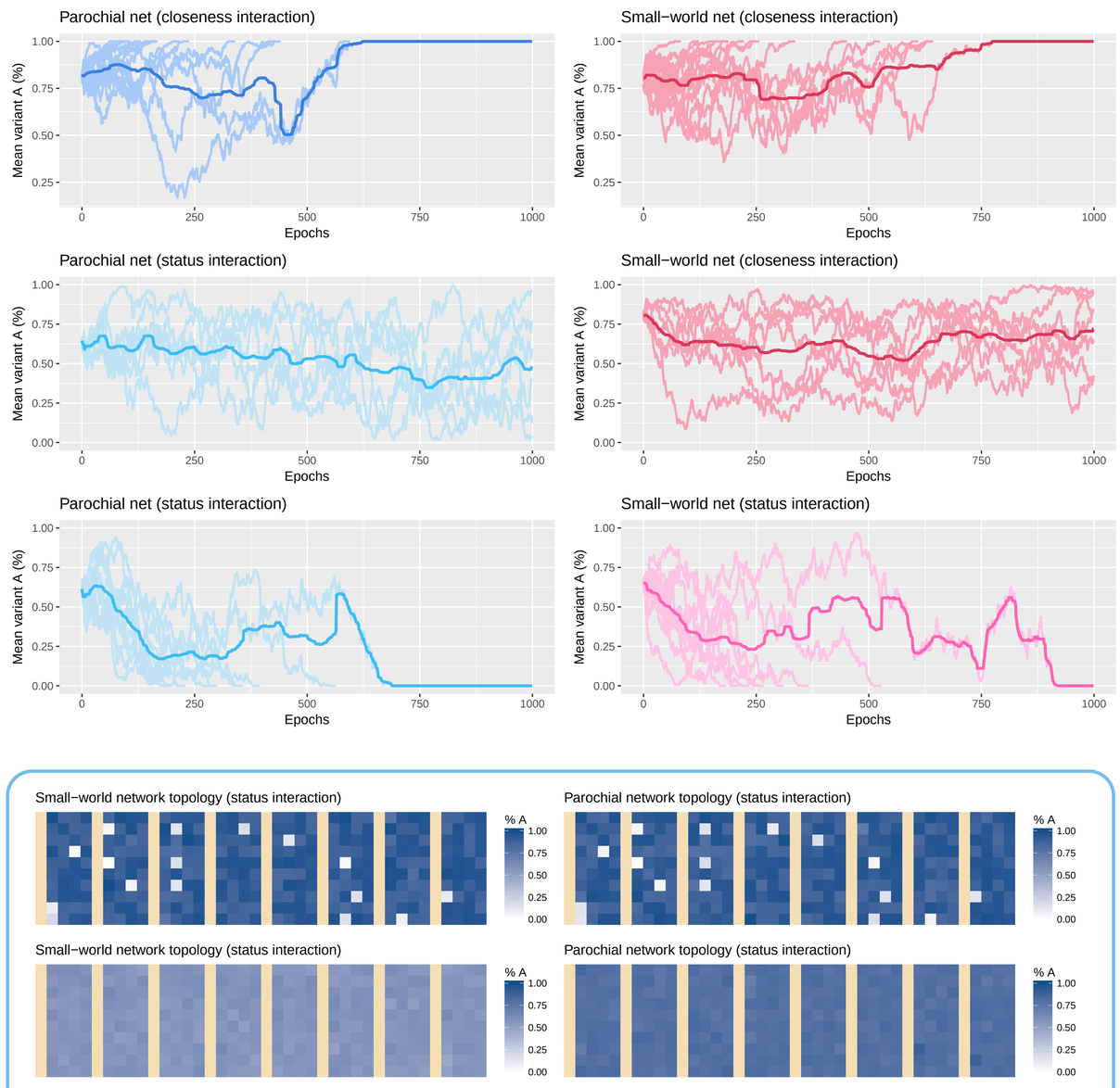
regular torus (closed 40×10 grid) | small world network (based on 40×10 grid) | parochial network (5×10×8 nodes)

Java source code, R scripts and sample data can be downloaded at:
https://github.com/simphon/KaMoso

www.ims.uni-stuttgart.de

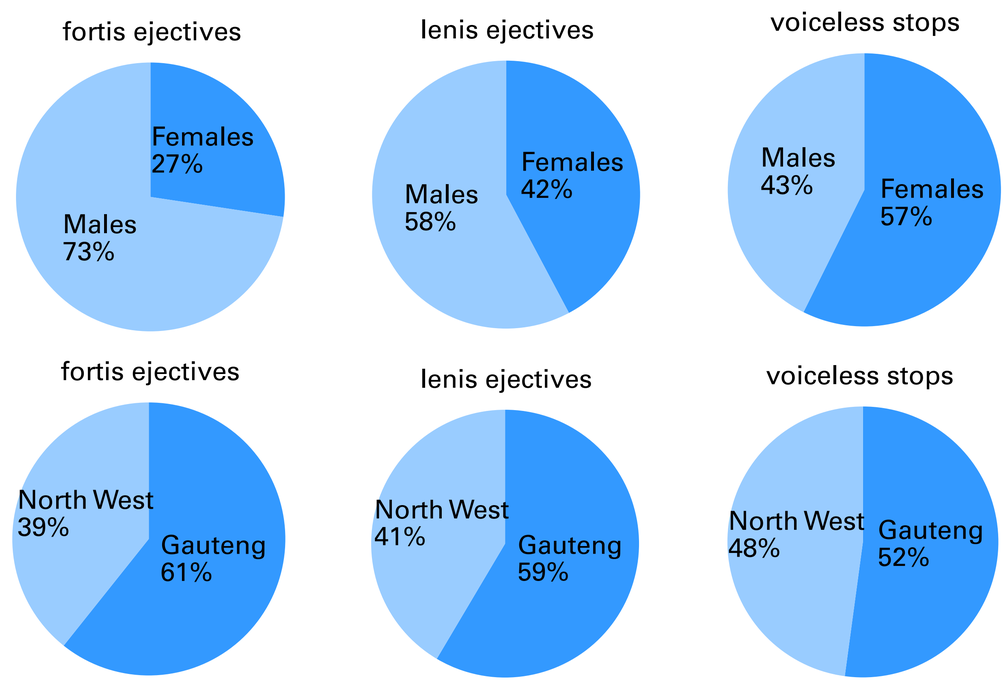
Simulations with KaMoso

- variant A (initial majority) vs. variant B (initially with high status)
- using parameter optimization to match observed variant distribution:



A-variant exemplar distribution in lexicons of all agents. Top panel: state at beginning of simulation. Bottom panel: state at the beginning of epoch 800.

Social factors in production of ejectives



Acoustic classification of ejectives using parameters according to Kingston [8]

Acknowledgments: This work is funded by the German Research Foundation (**DFG**), grant SFB 732 (A2). We thank Andries W. Coetzee, Michael Walsh and Justus Roux for discussions on the modeling framework and issues of Setswana stop (de)voicing. We thank Andries W. Coetzee for kindly sharing his data.

References

[1] J. Bruni, D. Duran, and G. Dogil. Usage-based phonology and simulations as means to investigate unintuitive voicing behavior. *Proc. Annual Meetings on Phonology*, 2, 2016.

[2] A. W. Coetzee and R. Pretorius. Phonetically grounded phonology and sound change: The case of Tswana labial plosives. *J. of Phonetics*, 38 (3):404–421, 2010.

[3] L. M. Hyman. The limits of phonetic determinism in phonology: *NC revisited. In Elizabeth Hume and Keith Johnson, editors, *The role of speech perception in phonology*, pages 141–185. Academic Press, New York, 2001.

[4] E. Barnard, M. H. Davel, Ch. van Heerden, F. de Wet, and J. Badenhorst. The NCHLT Speech Corpus of the South African languages. In *Proc. of SLTU*, pages 194–200, St. Petersburg, Russia, 2014.

[5] A. Wedel. Category competition drives contrast maintenance within an exemplar-based production/perception loop. In *Proc. 7th Meeting of the ACL SIG Computational Phonology*, pages 1–10, 2004.

[6] A. Wedel. Exemplar models, evolution and language change. *The Linguistic Review*, 23:247–274, 2006.

[7] D. Nettle. Using social impact theory to simulate language change. *Lingua*, 108(2-3):95–117, 1999.

[8] J. C. Kingston. *The Phonetics and Phonology of the Timing of Oral and Glottal Events*. Dissertation, University of California, 1985.