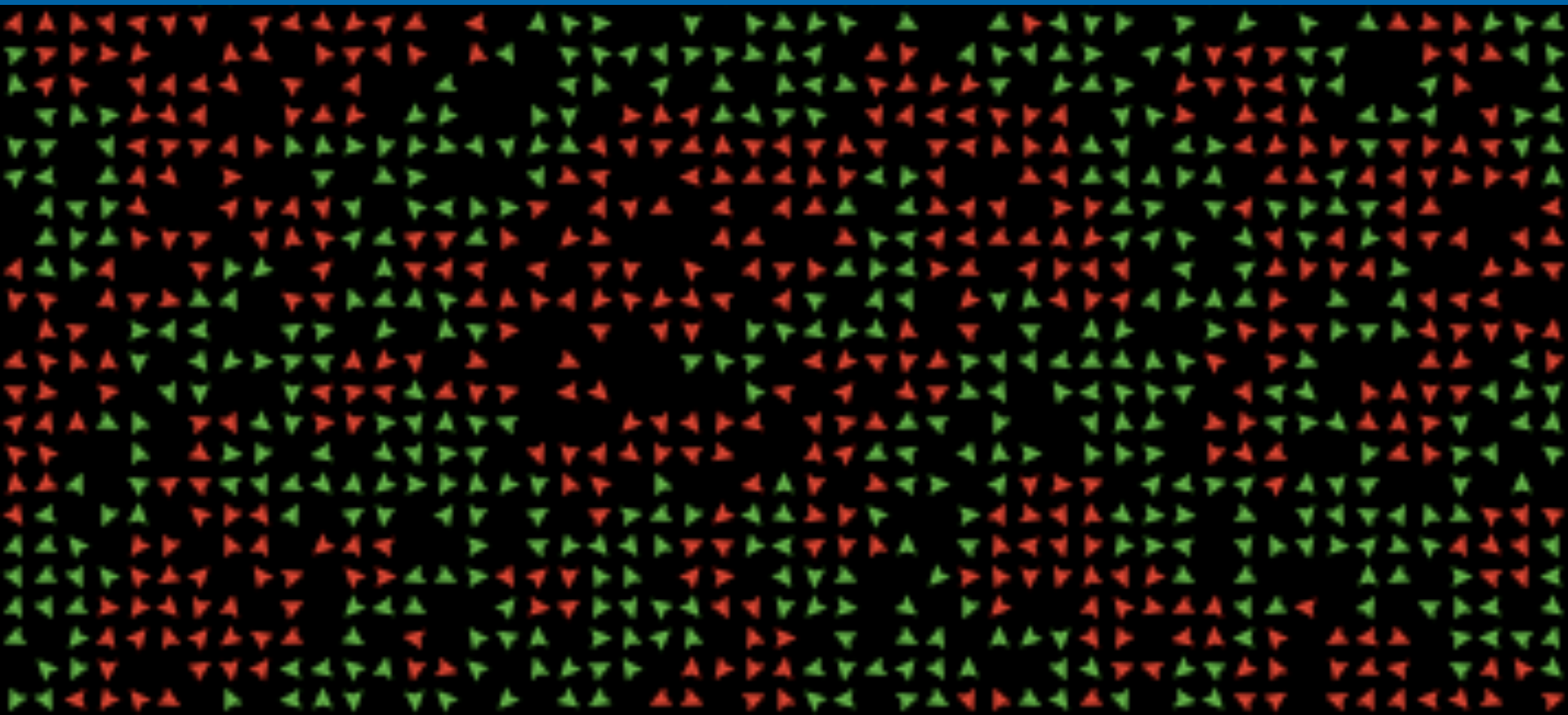
universität wien

A primer to Agent-Based Modeling w/NetLogo



universität wien

Outline

- Complex systems
- Principles of agent-based modeling (ABM)
- Example: The spiral of silence
- Network applications

universität wien

Complex systems

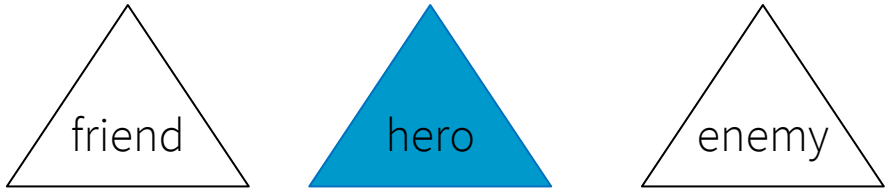
universität wien

What are complex systems?

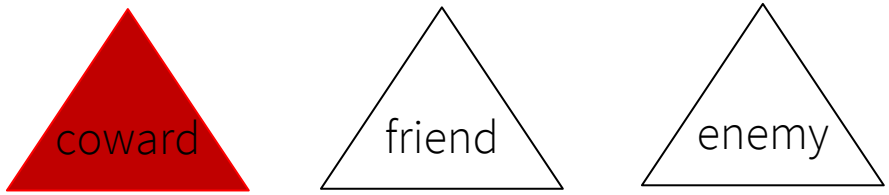
"Heroes and Cowards" (Wilensky & Rand, 2015)

Each person randomly selects two other people (an enemy and a friend).

Heroes: move between the enemy and the friend.

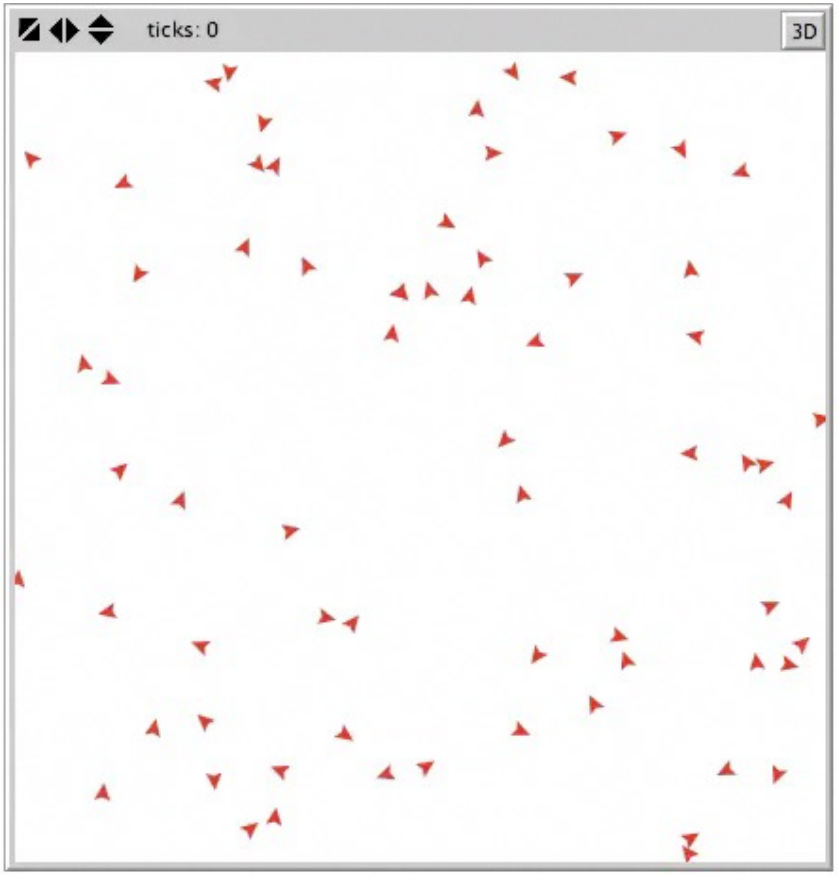


Cowards: move in such a way that the friend stands between them and the enemy.

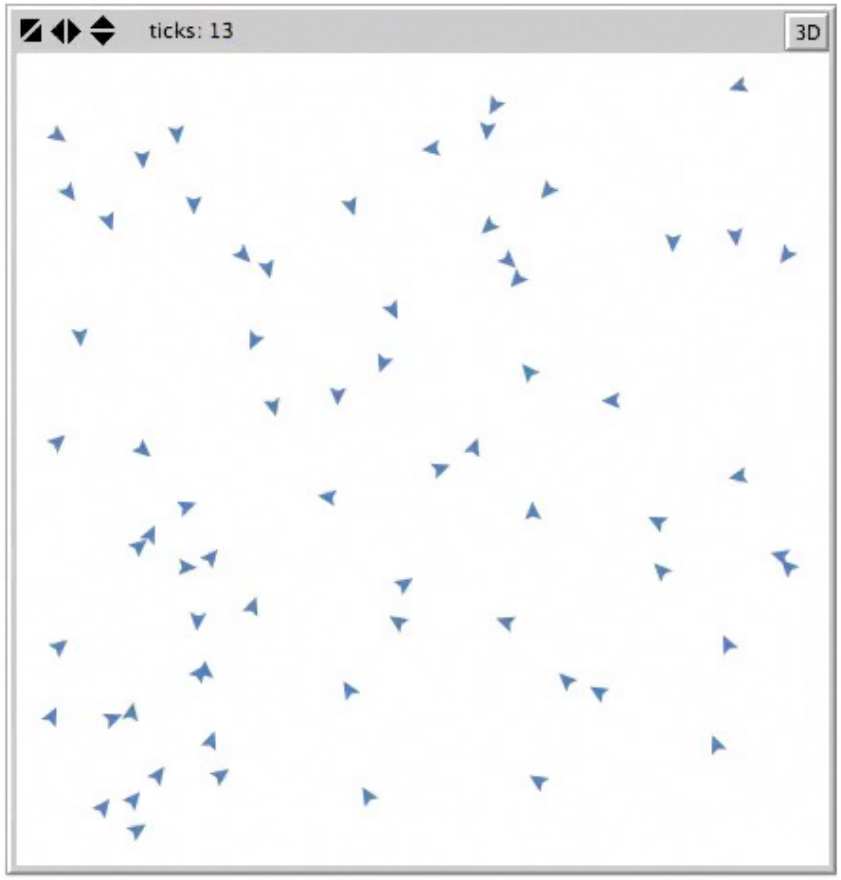


universität wien

Only cowards



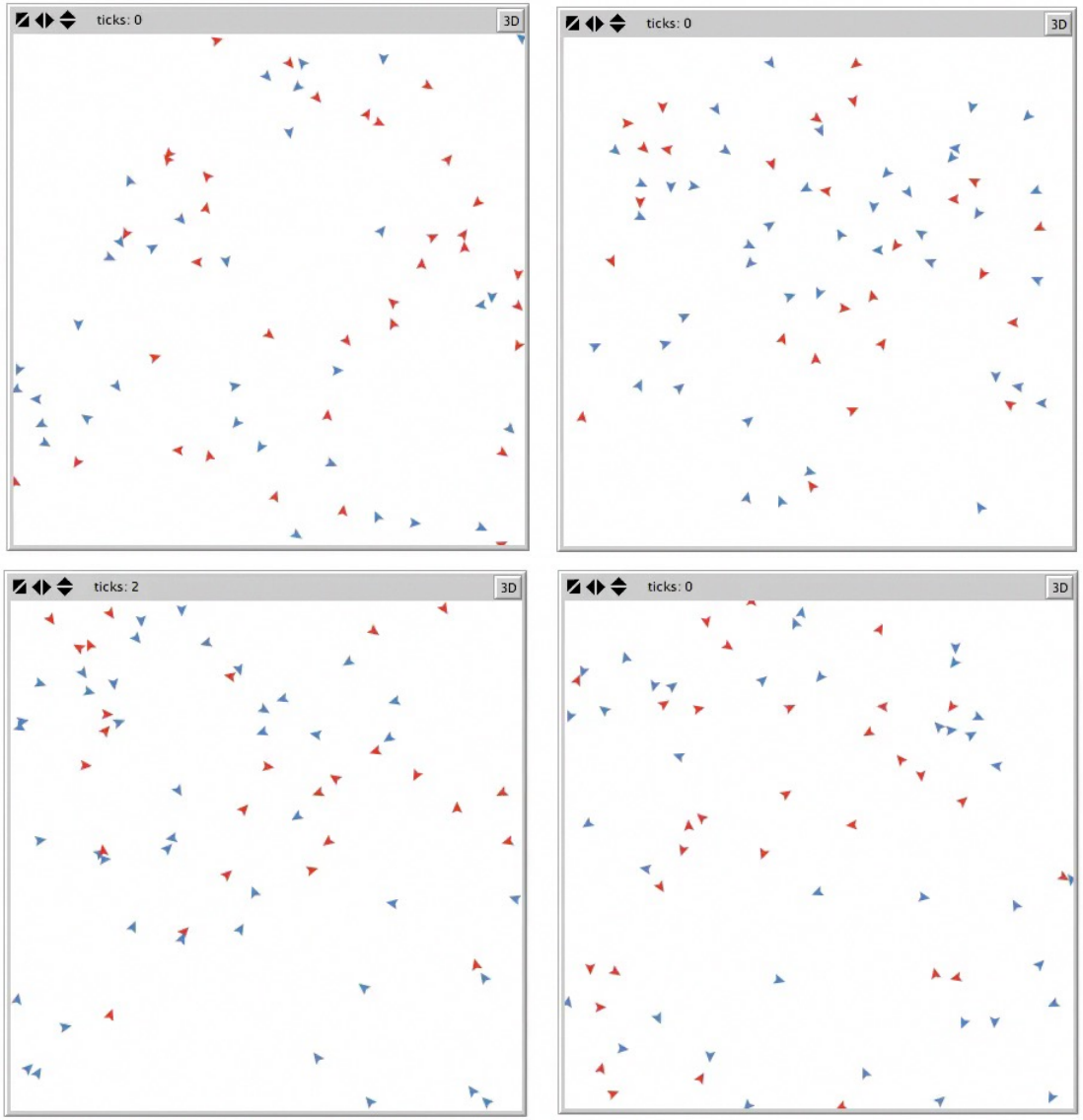
Only heroes



universität wien

Heroes and Cowards

- Networks
- Heterogeneity
- Self-organization
- Nonlinearity
- Emergence



universität wien

Principles of ABM

universität wien

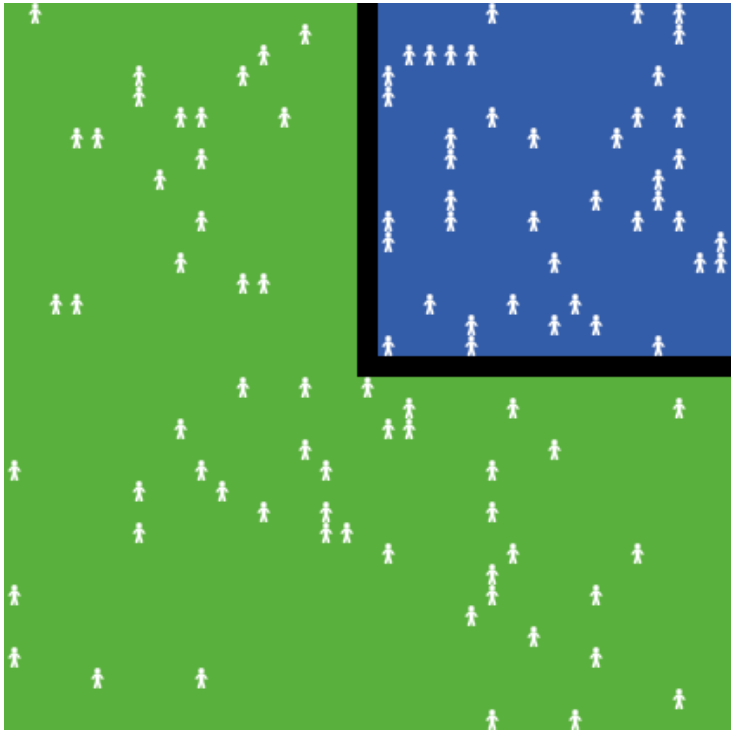
What are agent-based models (ABMs)?

Object-oriented computer models consisting of...

Agents: autonomous software objects with properties and objectives that receive, process and act on information.

Environment: virtual environment in which the agents move (e.g. topography, network, abstract space).

Rules: define what the agents do under what conditions.



"El Farol" NetLogo model
(Rand & Wilensky 2007)

universität wien

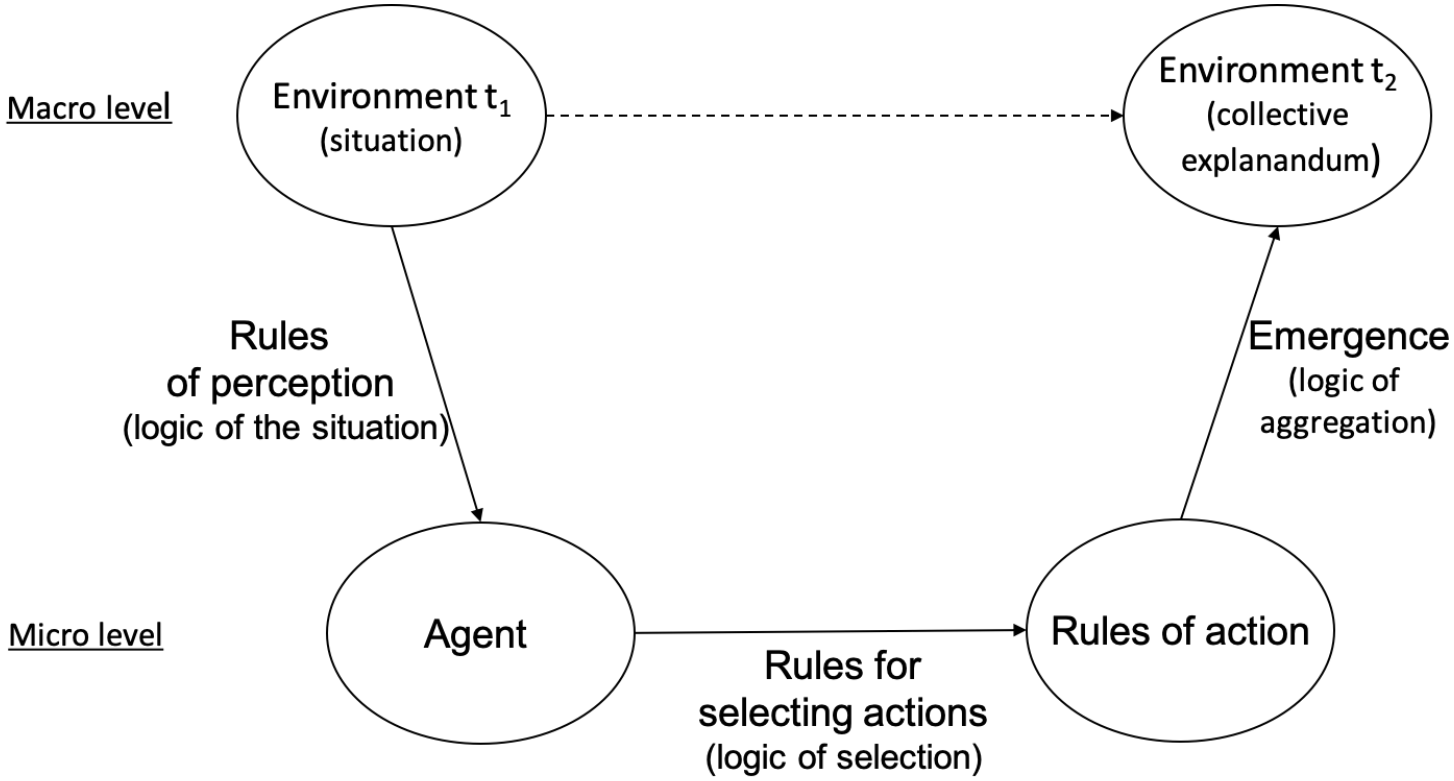
What is agent-based simulation?

„Given some macroeconomic explanandum – a regularity to be explained – the canonical agent-based experiment is as follows: Situate an initial population of autonomous heterogeneous agents in a relevant spatial environment; allow them to interact according to simple local rules, and thereby **generate – or ‚grow' – the macroscopic regularity from the bottom up**."

(Epstein 2006, S. 7)

universität wien

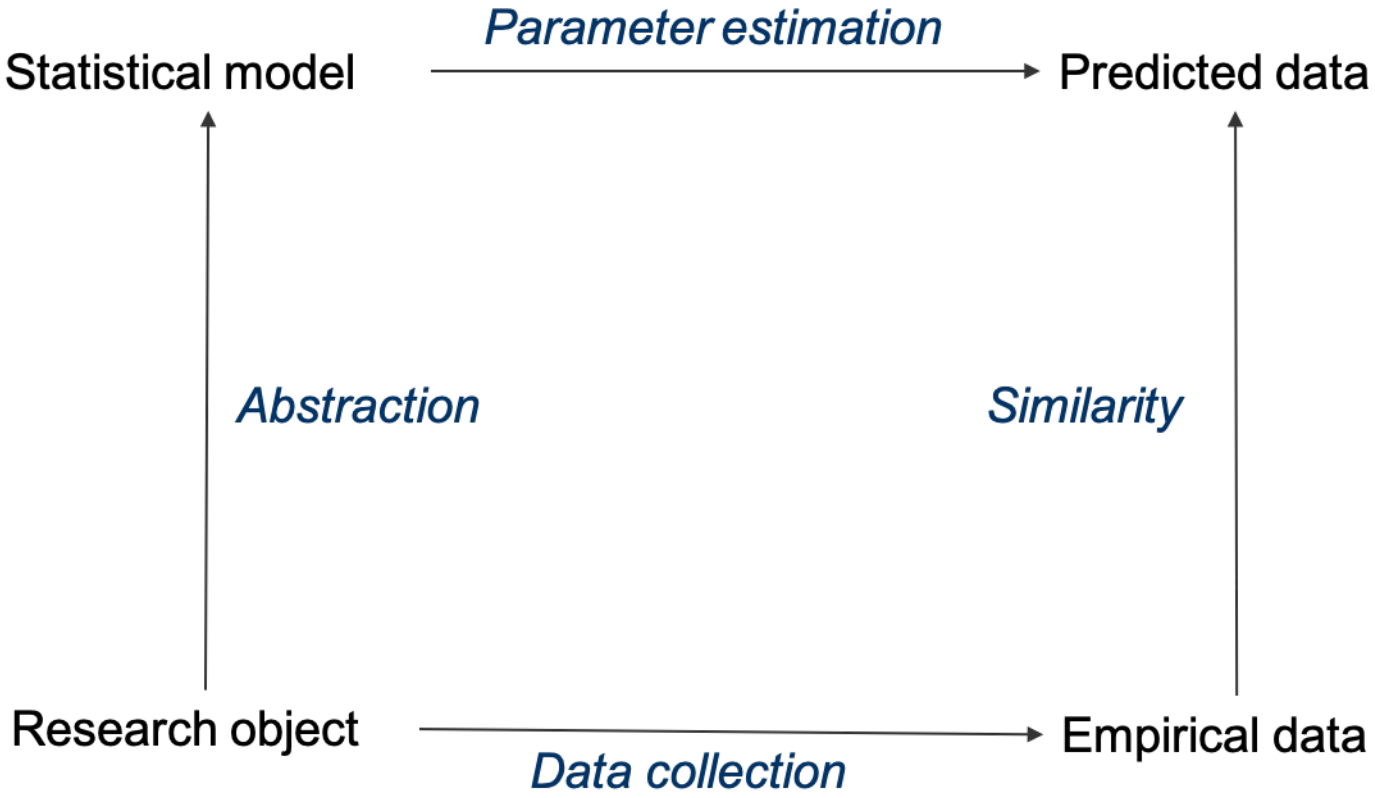
What is agent-based simulation?



Modification of the bathtub model according to Esser (1993)
(Source: Waldherr & Wettstein, 2019, p. 3979)

universität wien

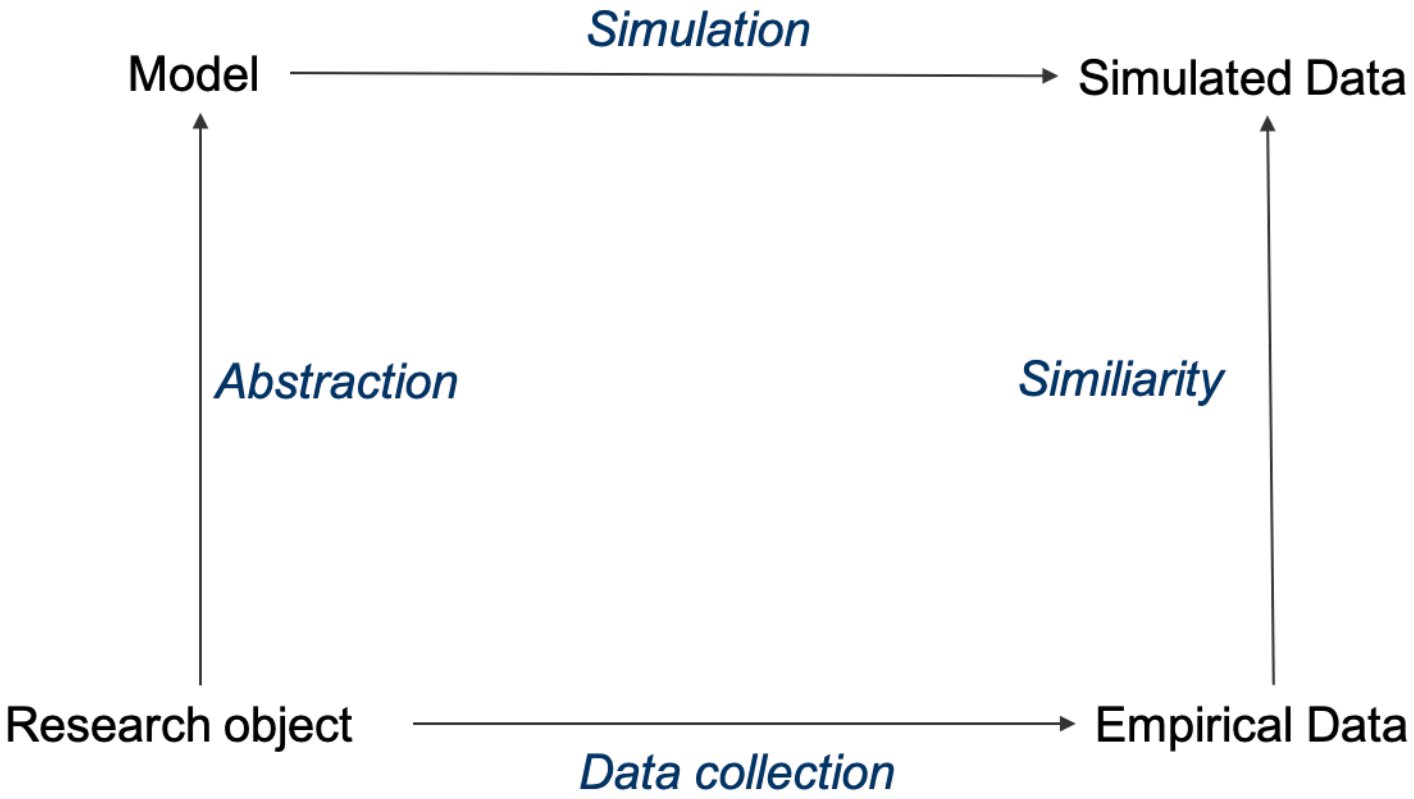
The logic of statistical modeling



Source: Gilbert & Troitzsch 2005, p. 16

universität wien

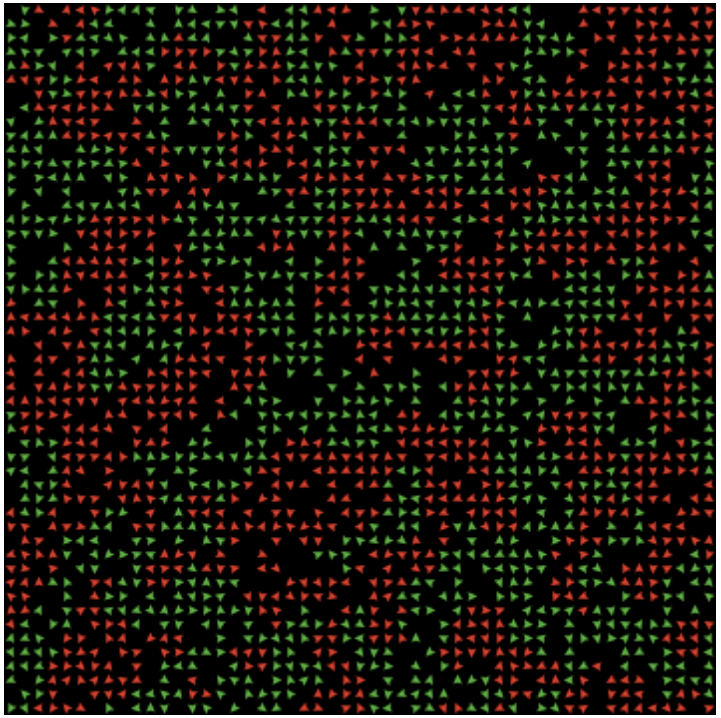
The logic of social simulation



Source: Gilbert & Troitzsch 2005, p. 17

universität wien

Why agent-based modeling (ABM)?



Example: Schellings (1978) Segregation Model
NetLogo model by Wilensky (1997)

universität wien

Why agent-based modeling (ABM)?

- Emergent Macro Phenomena
- Heterogeneous agents
- Local and potentially complex interactions of agents
- Adaptive Agents
- Medium numbers
- Rich and dynamic environment
- Dynamic processes

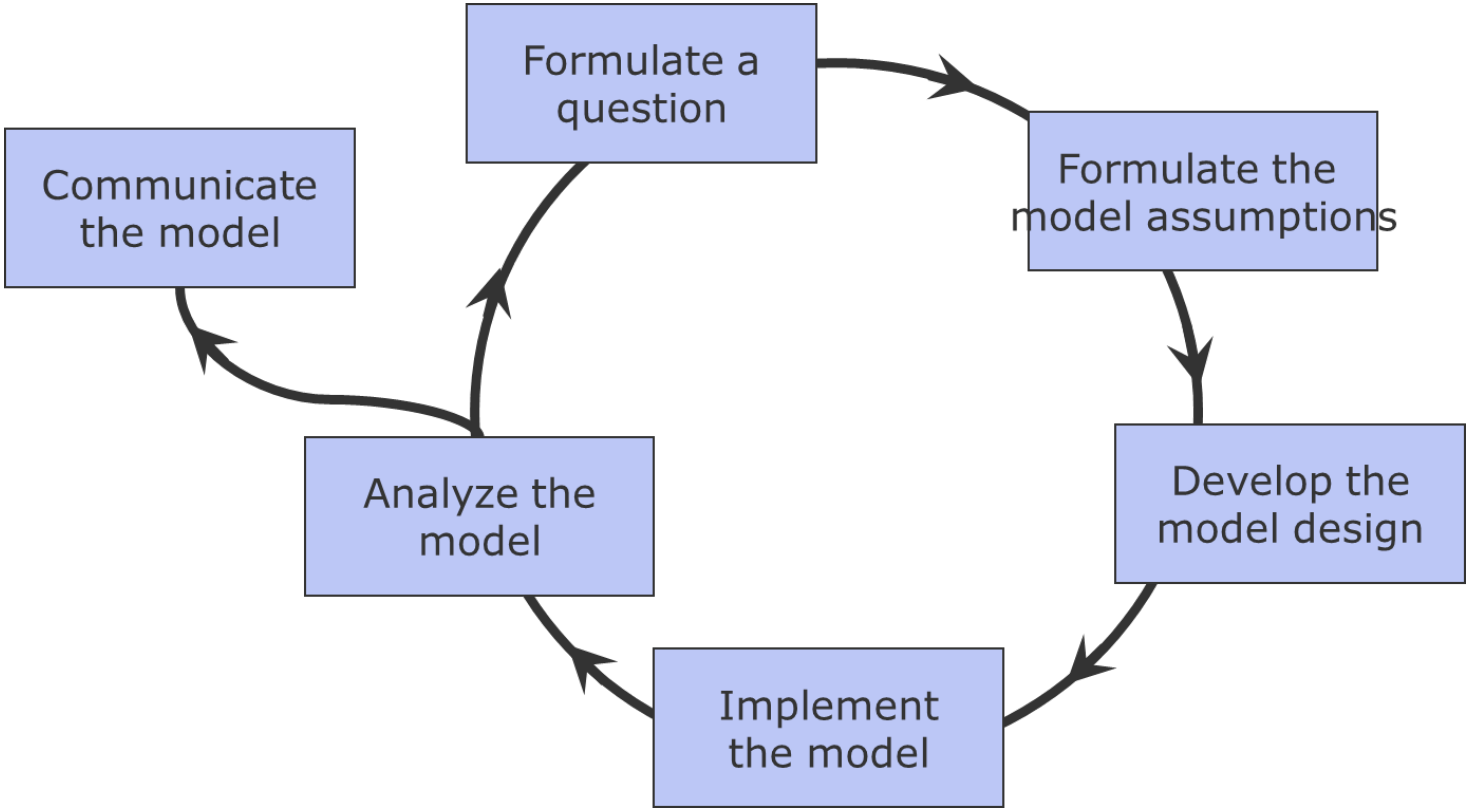
(Rand & Rust, 2011)

universität wien

Example: Spiral of Silence

universität wien

The modeling cycle



Source: Railsback & Grimm 2012, p. 7

universität wien

Why model the spiral of silence?

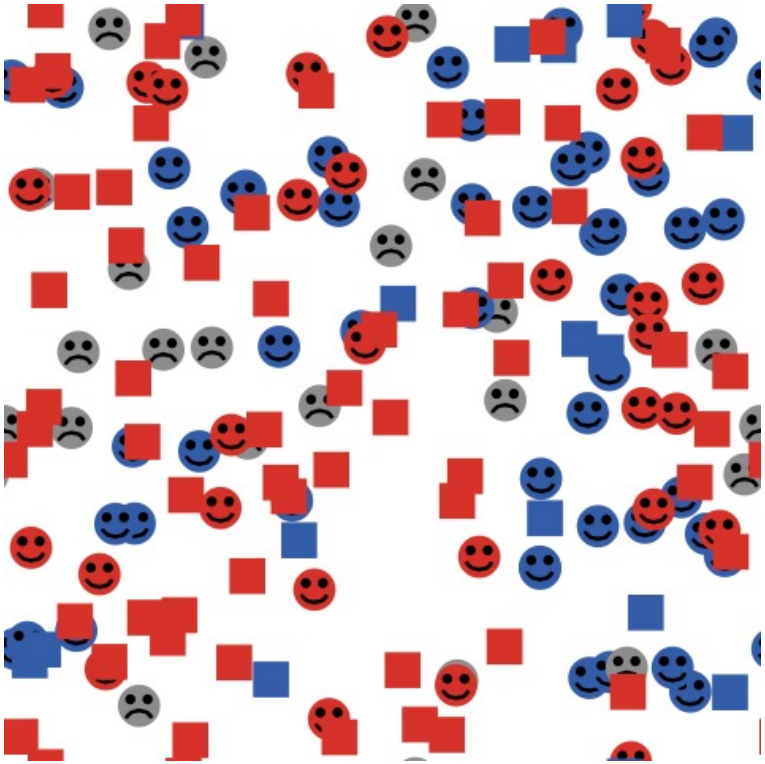
- *Micro-macro theory:* starts from micro assumptions and postulates a macro spiral process (Noelle-Neumann, 1974)

- *Question of internal consistency:* does the assumed micro behavior of actors lead to the assumed macro outcomes, and under which circumstances?

- *Complexity out of simplicity:* simple rules, easy implementation example

universität wien

Netlogo Model Setup (Waldherr & Bachl, 2011)



Individuals

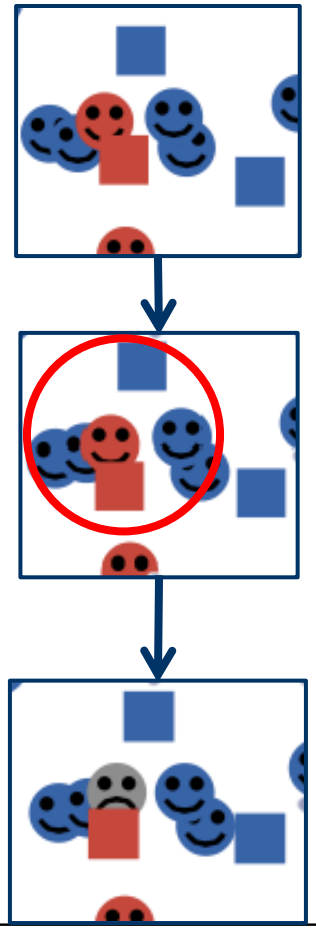
- are of opinion or ,
- are willing to speak out, or not
- have a threshold of fear of isolation normally distributed with M=50%.

Mass media

- report opinion or
- do not fear isolation and are always willing to speak out.

universität wien

Netlogo Model Setup



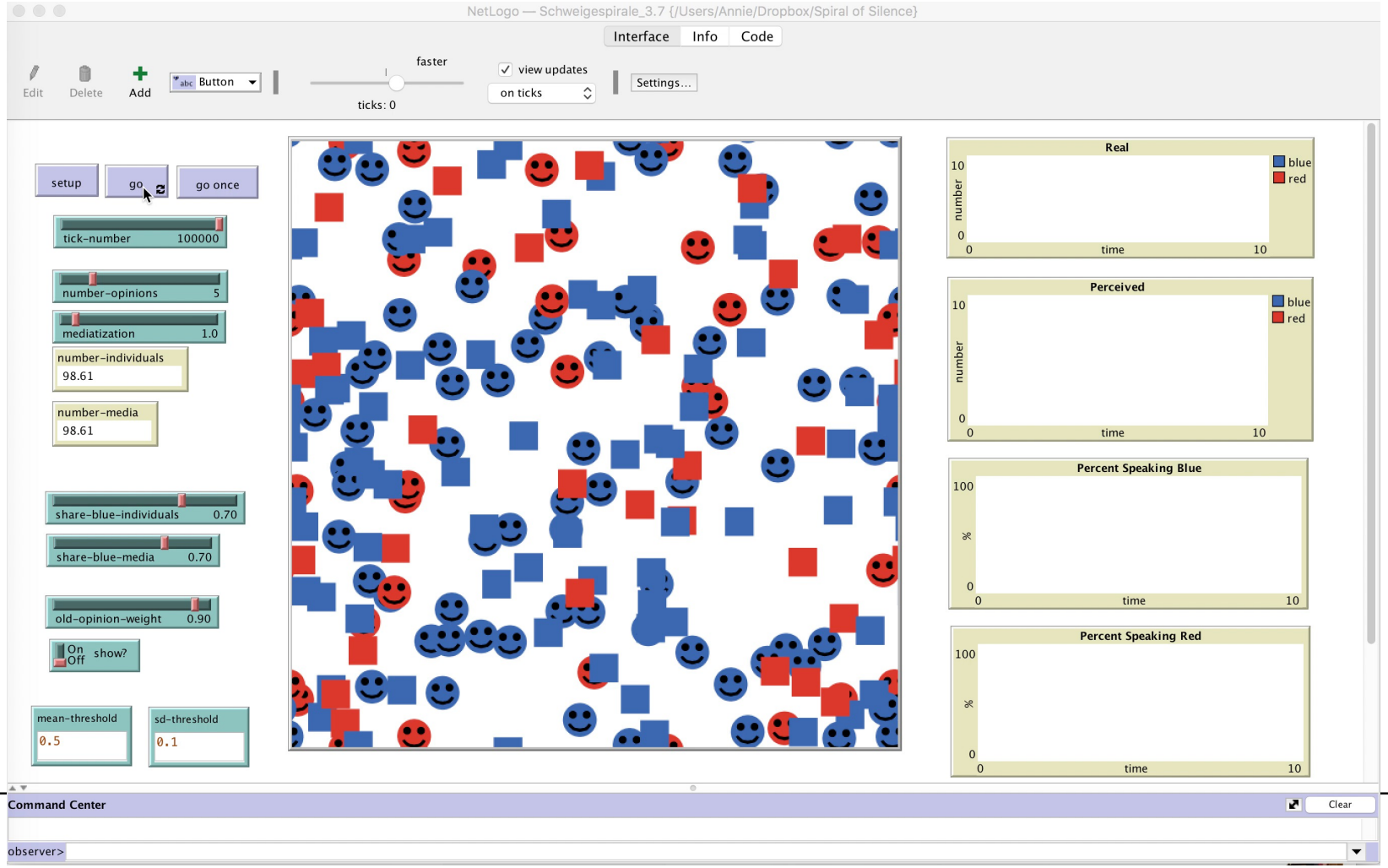
move-turtles:
Individuals move slowly and in random directions through space.

compute-public-opinion:
They compute the opinion climate as the share of their own opinion of the total of spoken out opinions in their neighborhood, weighted with past experiences

compute-willingness-to-speak:
If the opinion climate supports their own opinion, the individuals speak out; if not, they choose to be silent.

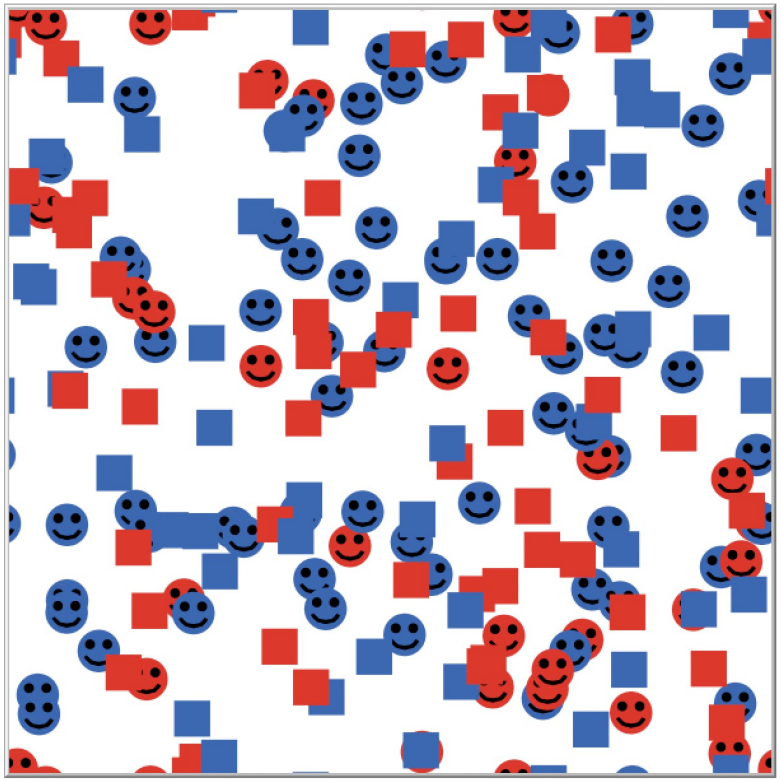
universität wien

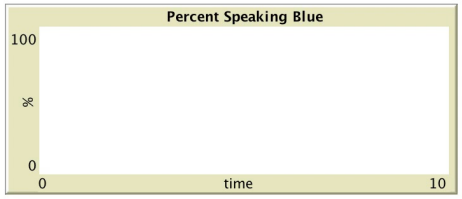
Sample Run

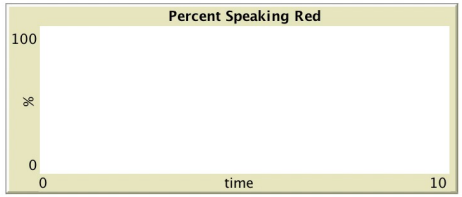


universität wien

More Sample Runs (with mediatization = 1)

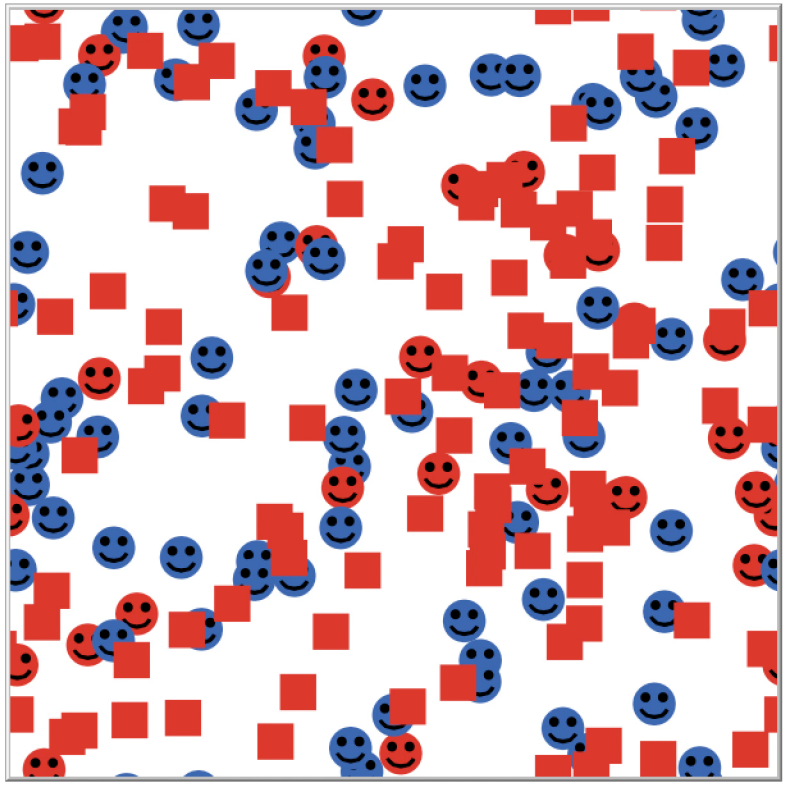


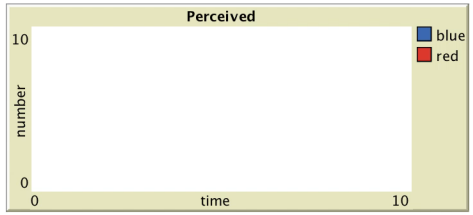


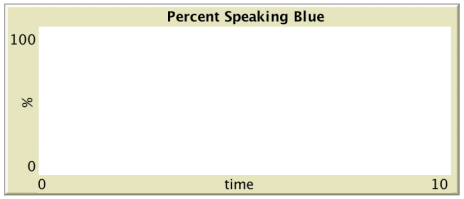


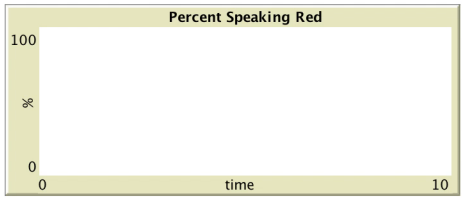
universität wien

More Sample Runs (with mediatization = 1)









universität wien

3-Factorial Simulation Design

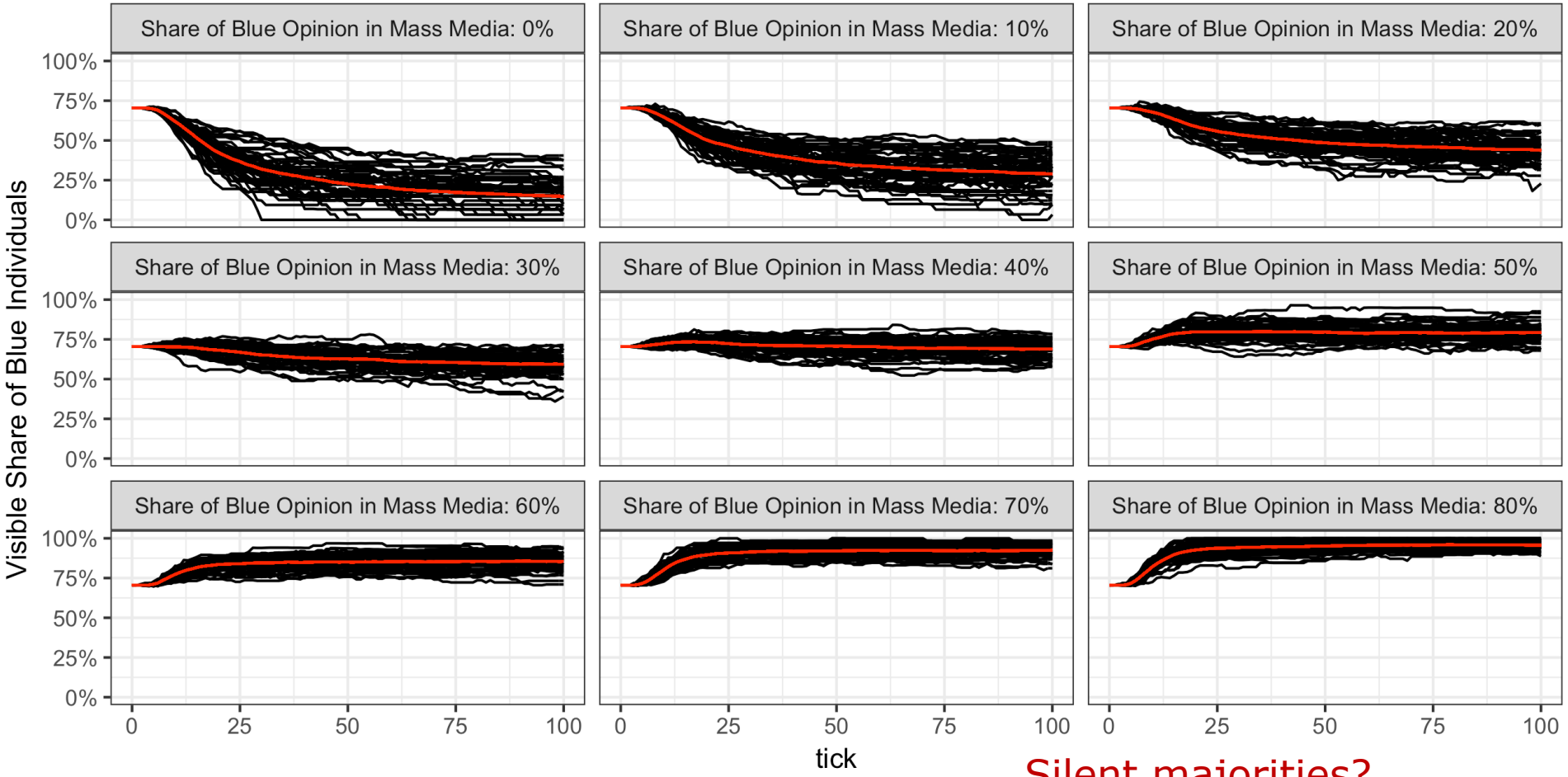
- *mediatization* (relative importance of perceived opinions from individuals and mass media, ratio media / individuals):
  - 0, 1/2, 1/1, 2/1
- *share-blue-individuals* (share of individuals with blue opinions):
  - 50% to 90% in 10%-steps
- *share-blue-media* (share of mass media information with blue opinions):
  - 0% to 100% in 10%-steps

- Overall: 200 conditions, 50 replication runs per condition

universität wien

Simulation Results

for share-blue-individuals = 70%, mediatization = 1, and varying share-blue-media



Silent majorities?

universität wien

References

Epstein, J. M. (Ed.). (2006). *Generative social science: Studies in agent-based computational modeling*: Princeton University Press.

Gilbert, N. & Troitzsch, K. G. (2005). *Simulation for the social scientist*. Maidenhead, UK: Open University Press.

Rand, W., & Rust, R. T. (2011). Agent-based modeling in marketing: Guidelines for rigor. *International Journal of Research in Marketing, 28*(3), 181-193. doi:10.1016/j.ijresmar.2011.04.002

Railsback, S. F. & Grimm, V. (2012). Agent-based and individual-based modeling: A practical introduction. Princeton, NJ: Princeton University Press.

Schelling, T. (1978). *Micromotives and Macrobehavior.* New York: Norton.

universität wien

References

Squazzoni, F. (2012). *Agent-based computational sociology.* Chichester, UK: Wiley.

Waldherr, A. & Bachl, M. (2011). Simulation of social media processes using the example of the spiral of silence. In M. Suckfüll, H. Schramm, & C. Wünsch (ed.*), reception and effect in temporal perspective* (pp. 203-220). Baden-Baden: Nomos.

Waldherr, A. & Wettstein, M. (2019). Bridging the gaps: Using agent-based modeling to reconcile data and theory in computational communication science. International Journal of Communication, *13*, 3976-3999.

Wilensky, U. (1997). NetLogo Segregation model. http://ccl.northwestern.edu/netlogo/models/Segregation. Center for Connected Learning and Computer-Based Modeling, Northwestern University, Evanston, IL.

universität wien

Further Reading

- *Basic textbooks*

Railsback, S. F. & Grimm, V. (2012). *Agent-based and individual-based modeling: A practical introduction.* Princeton, NJ: Princeton University Press.

Wilensky, U., & Rand, W. (2015). *An introduction to agent-based modeling: Modeling natural, social, and engineered complex systems with NetLogo*. Cambridge, MA: MIT Press.

- *Documentation standards (ODD protocol)*

Grimm, V., Berger, U., Finn, B., Eliassen, S., Ginot, V., Giske, J., . . . Jespsen, J. U. (2006). A standard protocol for describing individual-based and agent-based models. *Ecological Modelling, 198*, 115-126.

universität wien

Further Reading

- *Model analysis*

Lee, J.-S., Filatova, T., Ligmann-Zielinska, A., Hassani-Mahmooei, B., Stonedahl, F., Lorscheid, I., . . . Parker, D. C. (2015). The complexities of agent-based modeling output analysis. *Journal of Artificial Societies and Social Simulation, 18*(4), 4. doi:10.18564/jasss.2897

Lorscheid, I.; Heine, B.-O. & Meyer, M. (2012): Opening the black box of simulations: Increased transparency and effective communication through the systematic design of experiments. *Computational & Mathematical Organization Theory, 18*, 22-62.

Thiele, J. C. (2014). R Marries NetLogo: Introduction to the RNetLogo Package. *Journal of Statistical Software, 58*(2), 1-41. http://www.jstatsoft.org/v58/i02/

universität wien

Helpful resources

- Journal of Artificial Societies & Social Simulation (JASSS): jasss.soc.surrey.ac.uk
- NetLogo resources: ccl.northwestern.edu/netlogo/resources
- Computational Model Library (CoMSES/ Open ABM): www.comses.net
- European Social Simulation Association (ESSA): www.essa.eu.org
  - Social Simulation Conference (SSC 2020 in Milano, Sep 14-18)
  - ESSA Summer School, Aug 31 – Sep 11 2020 in Brescia (behavelab.org/behave-summer-school)
  - Open Lab Initiative
- Simsoc Mailing List: www.jiscmail.ac.uk/cgi-bin/webadmin?A0=simsoc
- Complexity Explorer by the Santa Fe Institute: www.complexityexplorer.org
- Complexity Explorables by Dirk Brockmann: www.complexity-explorables.org