Universität Trier

CENTER FOR INFORMATICS RESEARCH AND TECHNOLOGY

Analytics, Agents, and Algorithms: Where is the *Social* in Computational Social Science?

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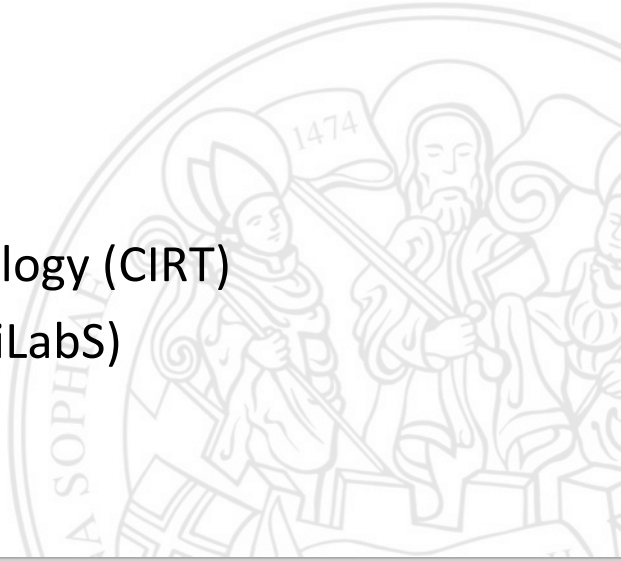
Trier University, Germany

Center for Informatics Research & Technology (CIRT)

Trier Research Lab for Simulation (TriLabS)



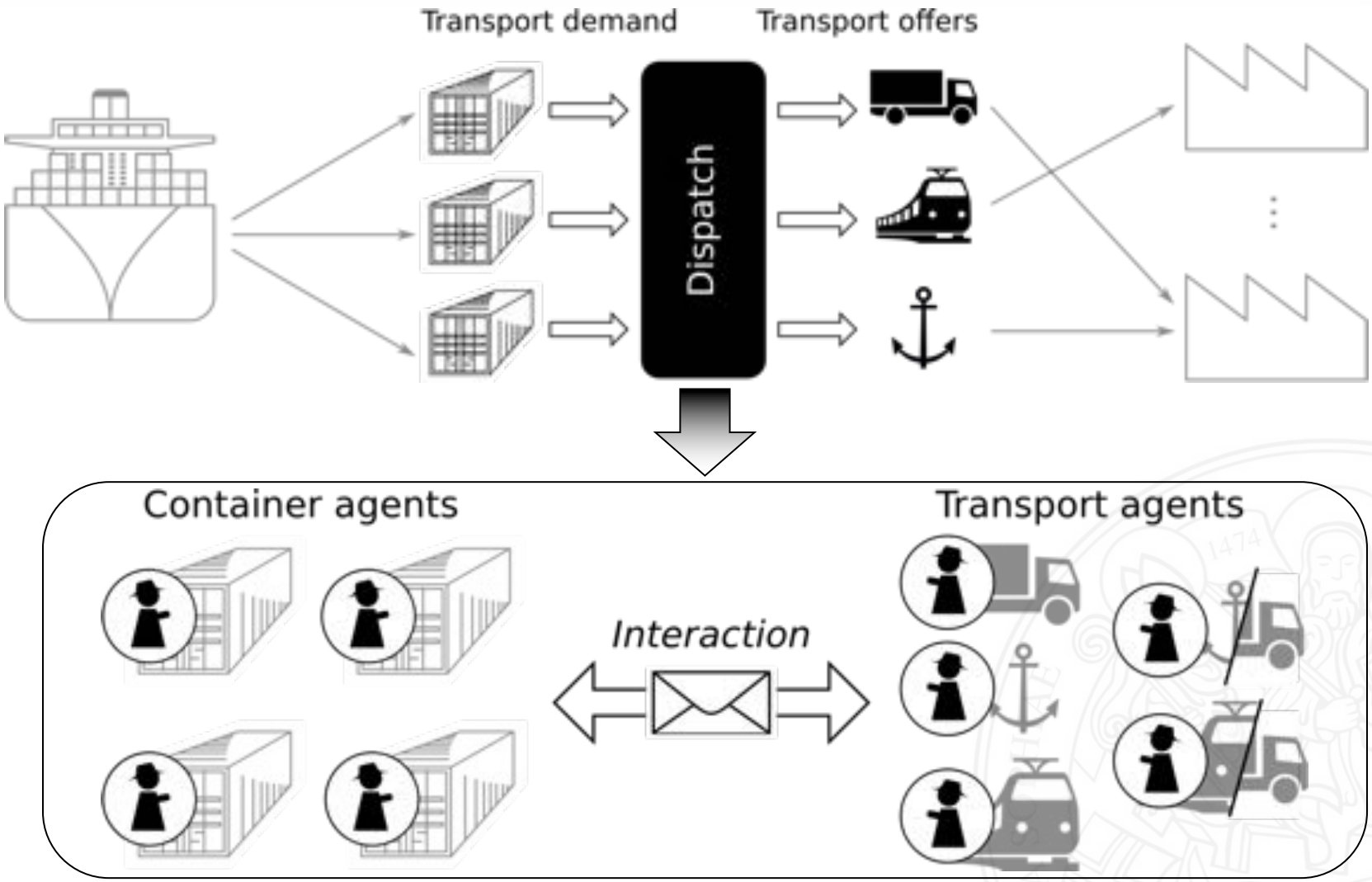
Outline

- Background Information

- Sociophysics,
  Computational Social Science,
  Agent-Based Social Simulation

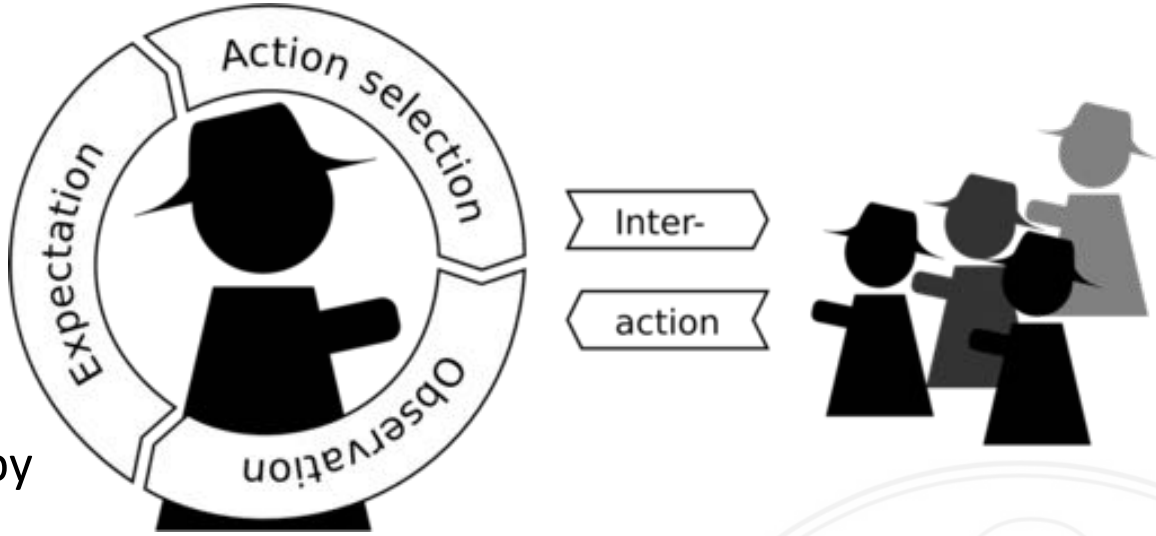
- Putting the *Social* in Computational Social Science:
  3 Case Studies

My Scientific Background: Autonomous Logistics Process Control



Self-Organization in Multiagent Systems

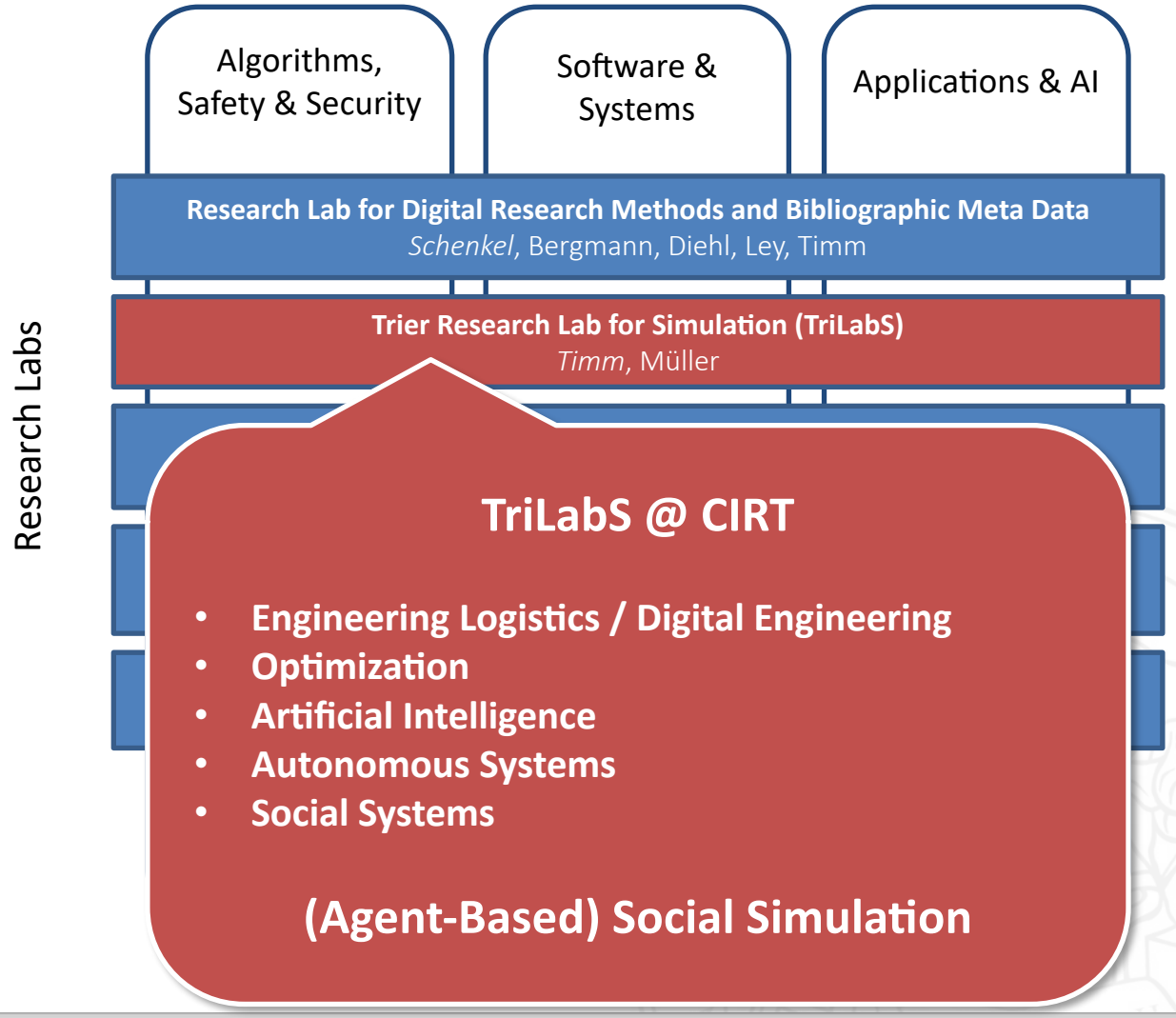
- Action selection according to expected reactions
- Observation of actual reactions
- Adaptation of existing expectations
- Simultaneous adaptation by multiple agents
  - Convergence to social order (self-organization)



Berndt, J.O.; Herzog, O. (2011): *Efficient Multiagent Coordination in Dynamic Environments*. In: IEEE / WIC / ACM International Conferences on Web Intelligence and Intelligent Agent Technology (WI-IAT 2011). pp. 188-195. IEEE Computer Society: Lyon, France.
Berndt, J.O. (2013): *Self-organizing Logistics Process Control: An Agent-based Approach*. In: Filipe, J.; Fred, A. (Eds.): Agents and Artificial Intelligence 2011. Revised Selected Papers. pp. 397-412. Springer: Heidelberg.
Berndt, J.O. (2018): *Self-Organizing Multiagent Negotiations. Cooperation and Competition of Concurrently Acting Agents with Limited Knowledge*. DISKI vol. 344. AKA: Berlin, IOS Press: Amsterdam.

CIRT @ Trier University

- Founded in 2016
- 10 Professors, ca. 45 Researchers
- 3 Fields of competence
- 5 Research Labs
- Multiple scientific and industrial cooperations



What is Computational Social Science?

- Computational Social Science
- Data-Driven Modeling
- Complex Systems
- Interdisciplinarity

Schweitzer, F. (2018). *Sociophysics*. Physics Today, 71, 40-6.

Analytics

- Addressing Big Societal Challenges with Digital Behavioral Data
- Quantitative Text Analysis

Agents

- Agent-Based Modeling of Complex Systems
- Self-Organization and Emergence

Algorithms

- Interpretability of Algorithmic Systems
- Charting Collections of Connections in Social Media

And Where Exactly is the *Social*?

Faced with massive data, this approach to science—hypothesize, model, test—is becoming obsolete.

As our collection of facts and figures grows, so will the opportunity to find answers to fundamental questions. Because in the era of Big Data, more isn't just more. More is different.

(Chris Anderson)

Fallacies ... arise when trying to explain complex phenomena in real-world social systems by means of overly simple, physics-inspired models.

(Ingo Scholtes)

Indeed, the lack of awareness and of understanding of their work is one of the major criticisms raised by social scientists when confronted with the papers of sociophysicists.

(Frank Schweitzer)

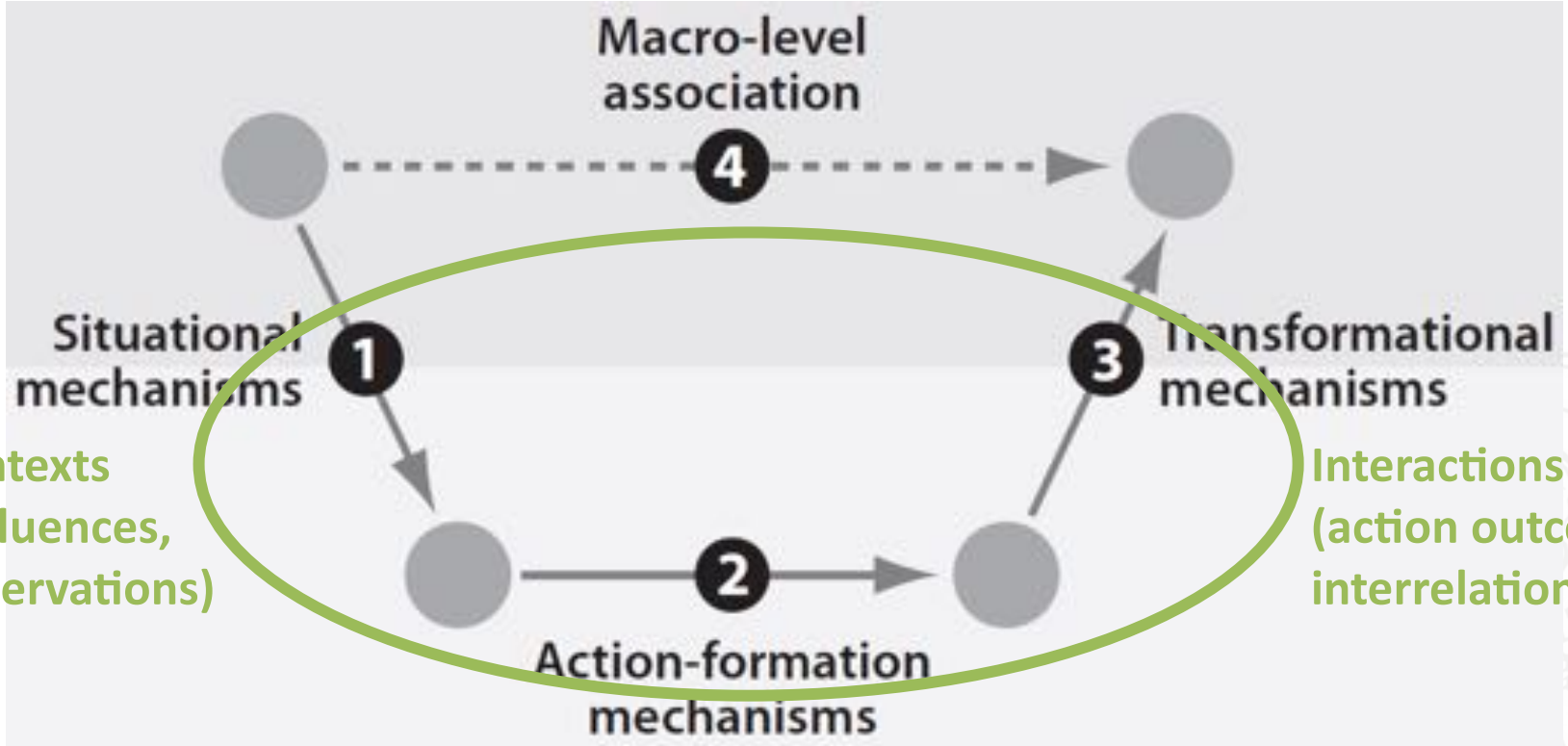
Schweitzer, F. (2018). *Sociophysics*. Physics Today, 71, 40-6.

Agent-Based Social Simulation

- Well-established since the 1990s
- DFG focus program on “Socionics” 1999 – 2006
- Complex systems
- Generate macro-social effects from micro-social interactions
- Systematic analysis using simulation: “what-if scenarios”

Macro- and Micro-Social Behavior

- Macro: Functional relation between input and output
- Micro: Individual system components, their properties, and interactions

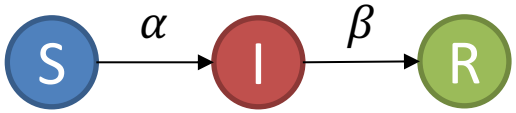


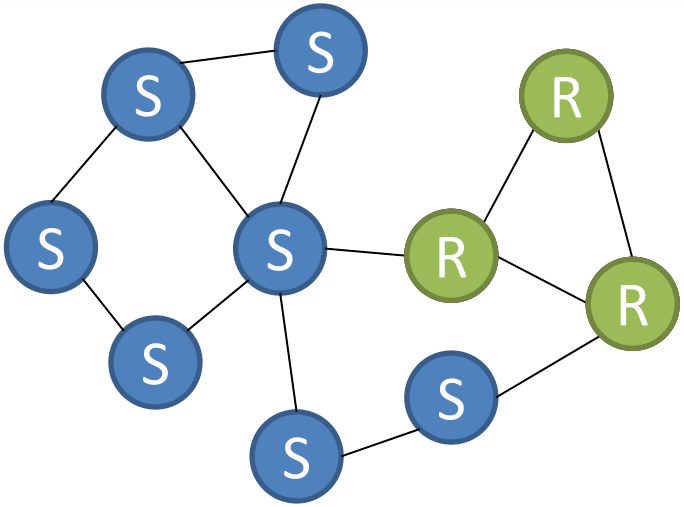
Coleman, J.S. (1990): *Foundations of Social Theory*. The Belknap Press: Cambridge, MA, USA

Hedström, P.; Ylikoski, P. (2010): *Causal Mechanisms in the Social Sciences*. Annual Review of Sociology 36(1):49–67

Example: Social Contagion Models

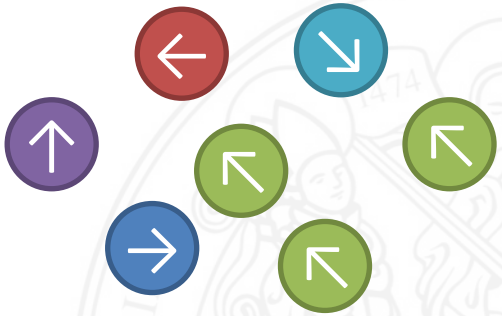
- SIS/SIR- Models:
  - Susceptible
  - Infected
  - Recovered





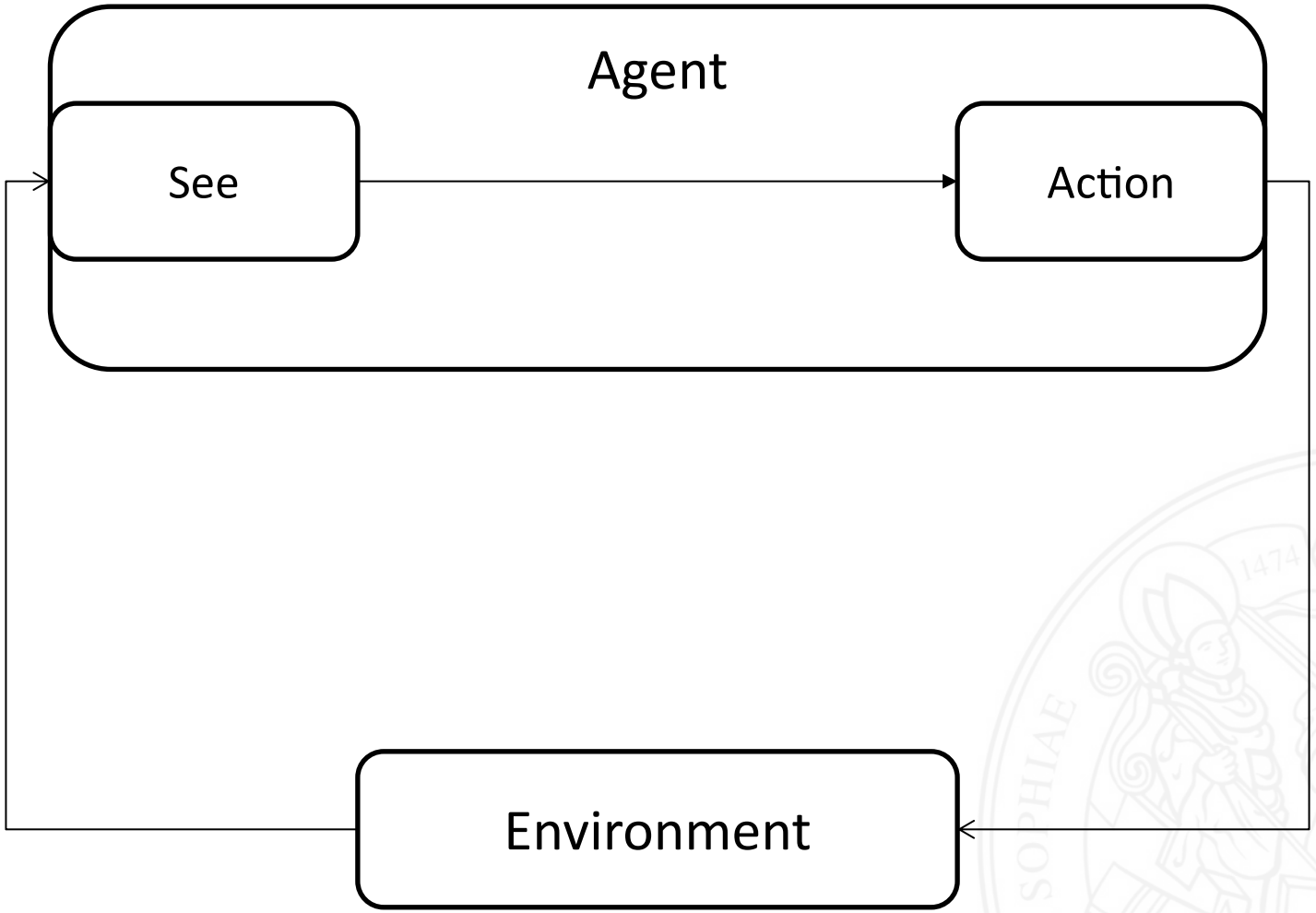
- Thresholds Models
  - Nodes activated by active neighbors
  - Activation after *n* encounters

- Gas kinetics
  - Opinion dynamics similar to gas clouds
  - Random encounters
  - Direction of movement

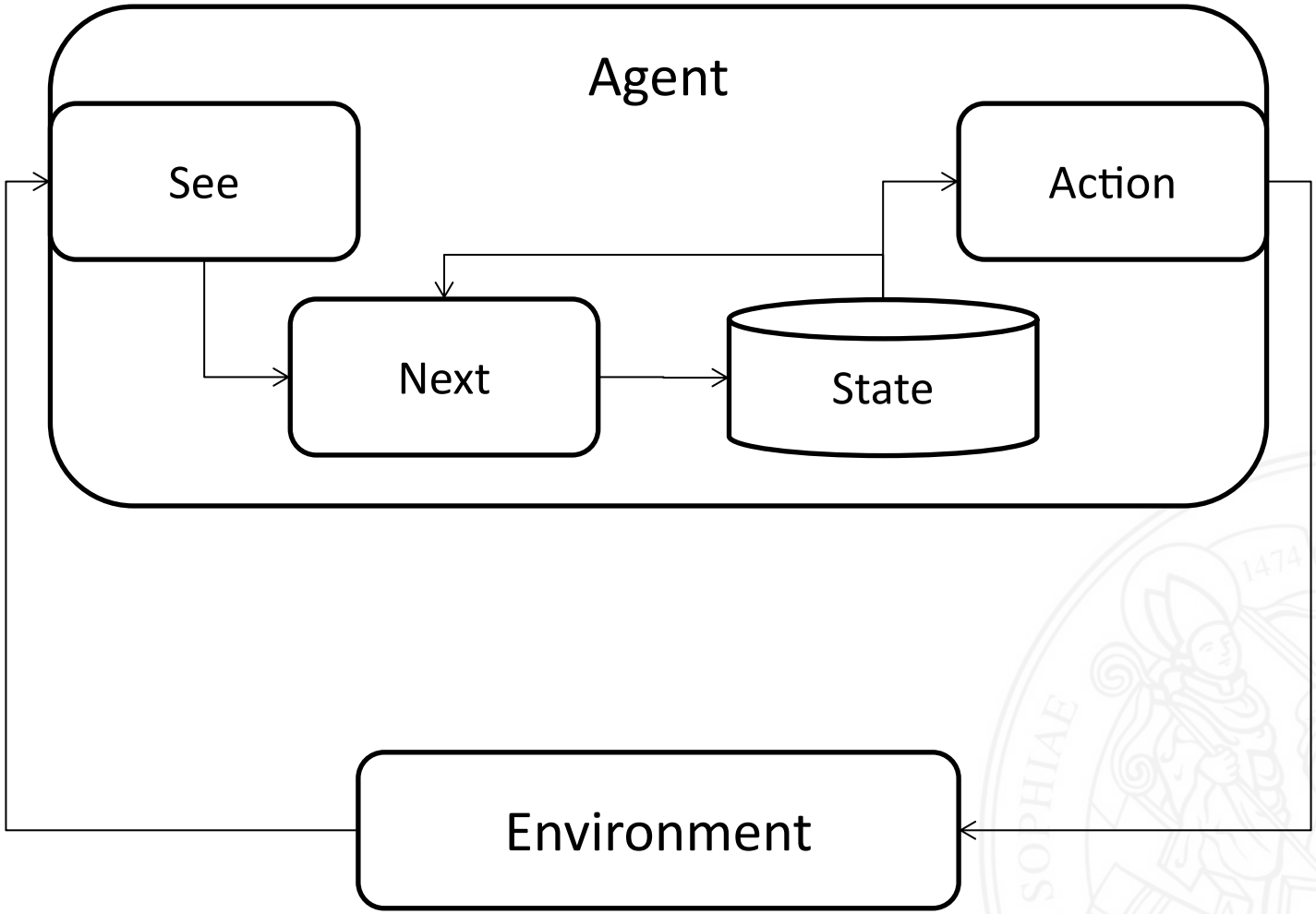


Dodds, P. S., and D. J. Watts. (2005): *A generalized model of social and biological contagion*. Journal of theoretical biology 232(4):587–604.
S. Monica and F. Bergenti (2016): *Opinion dynamics in multi-agent systems: selected analytic models and verifying simulations*. Computational and Mathematical Organization Theory, pp. 1–28.

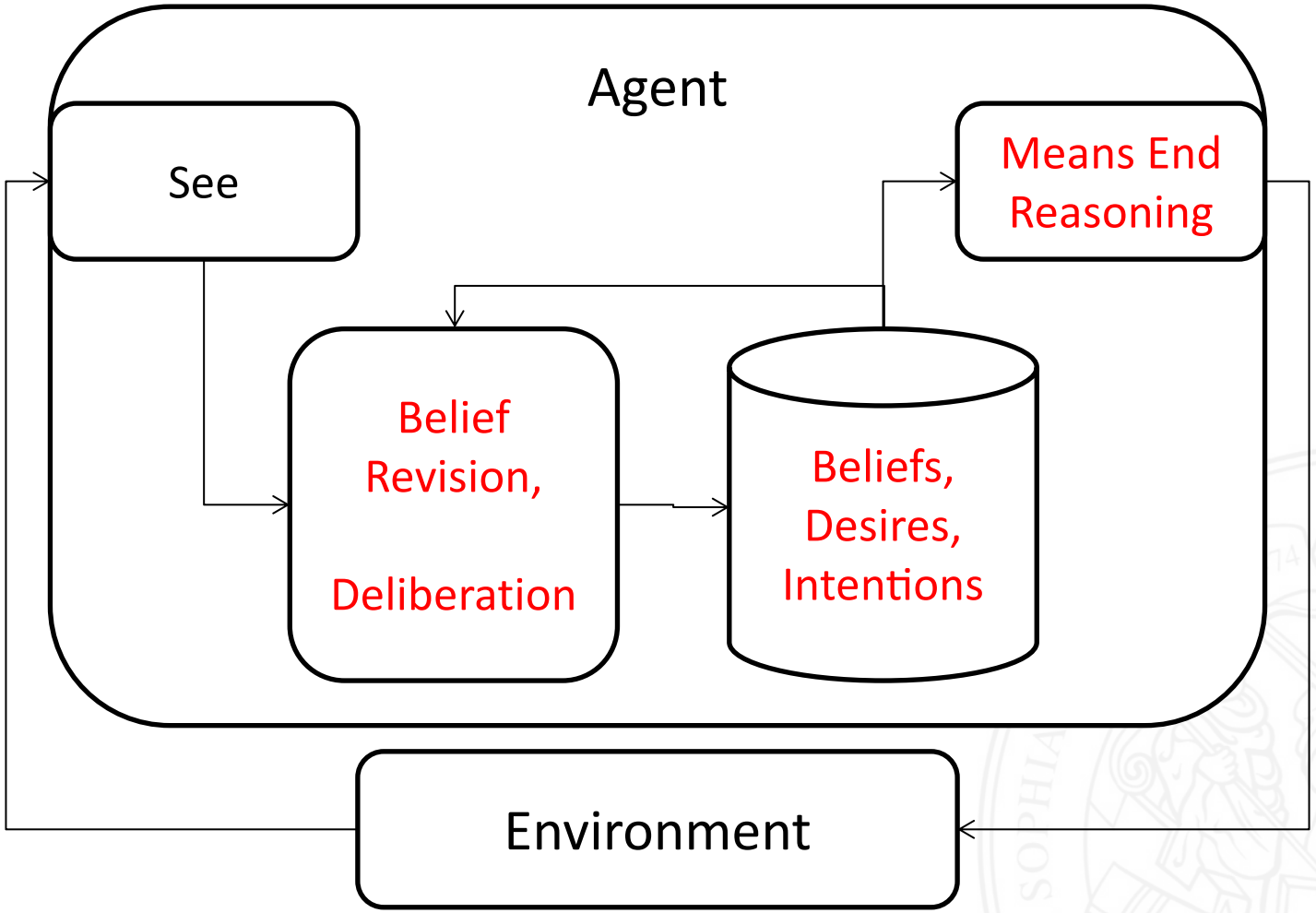
Agent Architectures in Distributed AI



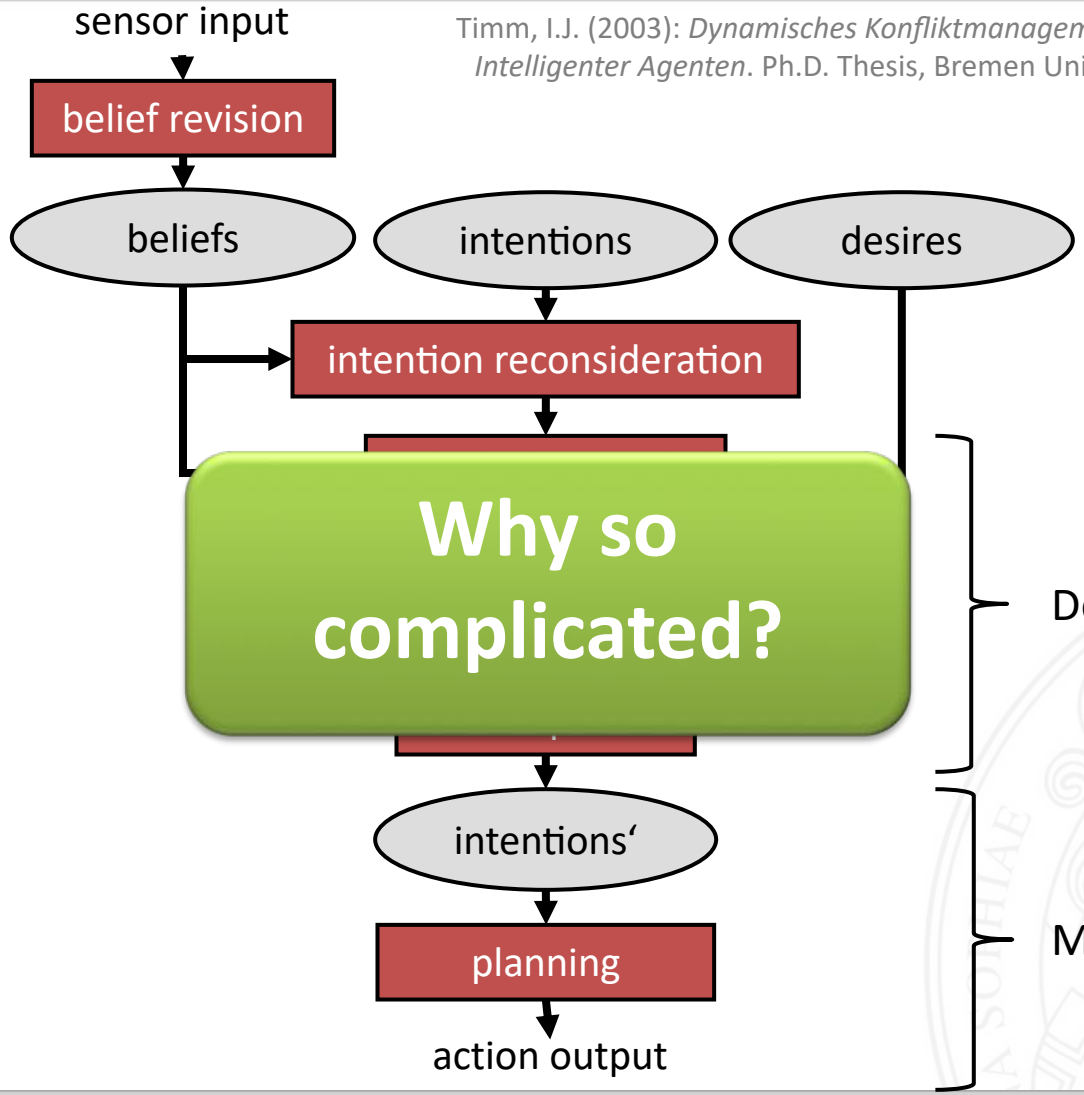
Agent Architectures in Distributed AI



Agent Architectures in Distributed AI



Agent Architectures in Distributed AI



Timm, I.J. (2003): *Dynamisches Konfliktmanagement als Verhaltenssteuerung Intelligenter Agenten*. Ph.D. Thesis, Bremen University

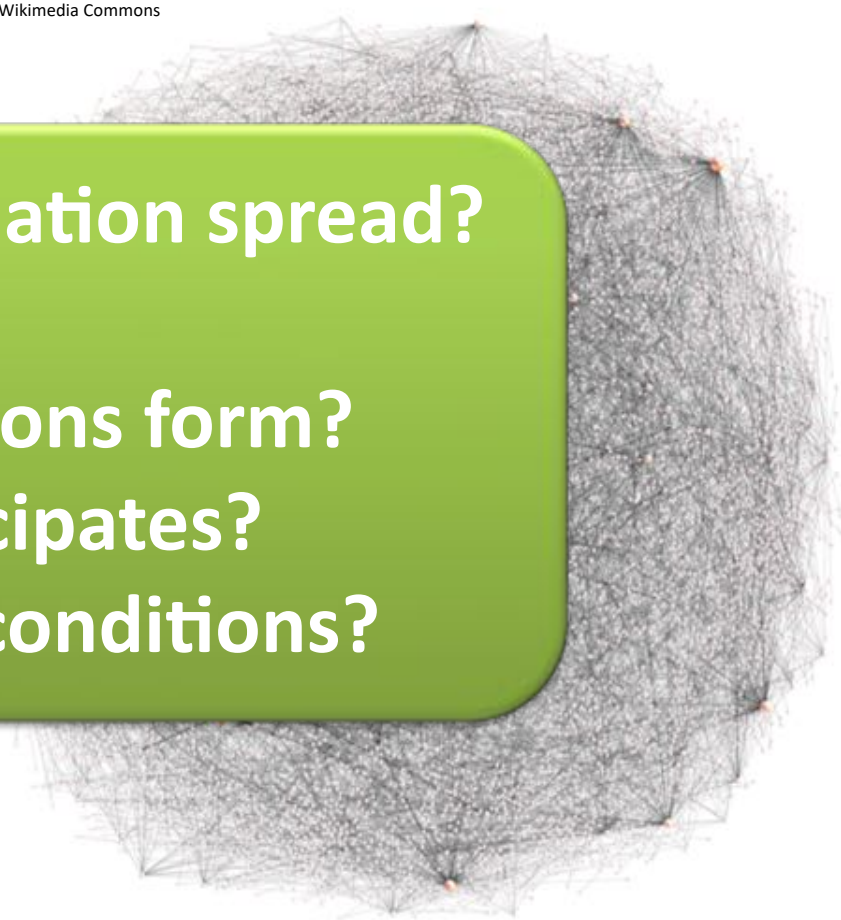
Case Study:
Social Media Communication

Opinion Formation in Social Media

https://upload.wikimedia.org/wikipedia/commons/b/bf/Socialmedia-pm.png
By Ibrahim.ID [CC BY-SA 4.0 (http://creativecommons.org/licenses/by-sa/4.0)], via Wikimedia Commons

How does information spread?

Why do opinions form?
Who participates?
Under which conditions?



Berndt, J.O.; Lorig, F.; Timm, I.J.; Barth, C.; Bucher, H.-J. (2017): *A Systematic Approach to Agent-Based Dynamic Analysis of Social Media Communication*. International Journal On Advances in Internet Technology, 10(1&2), 57-69.

Modeling Actor Motivations in Social Media

- Social actor types

Schimank, U. (2010): *Handeln und Strukturen: Einführung in die akteurtheoretische Soziologie*. 4th Ed. Beltz Juventa: Weinheim

Homo Economicus  Utility

- Casual user sharing expected majority opinion
- Attempts to maximize communicative reach

Norms / Acceptance  **Homo Sociologicus**

- Norm-driven user following social obligations
- Attempts to reach social acceptance

Emotional Man  Emotions

- Dissatisfied and angry user
- Attempts to express anger

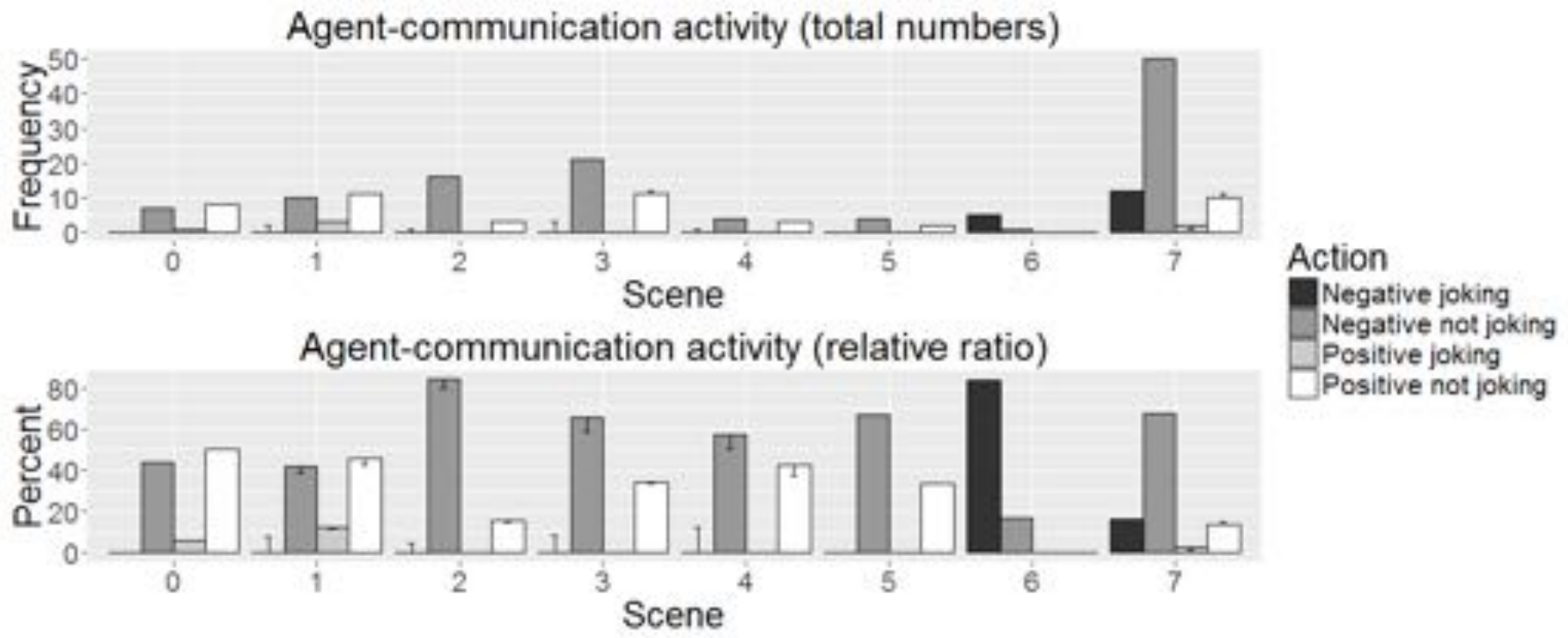
Identity  **Identity Keeper**

- Genuine content producer
- Attempts to keep conversation going

Berndt, J.O.; Rodermund, S.C.; Lorig, F.; Timm, I.J. (2017): *Modeling User Behavior in Social Media with Complex Agents*. In: Third International Conference on Human and Social Analytics (HUSO 2017). pp. 18-24. IARIA.

Rodermund, S.C.; Lorig, F.; Berndt, J.O.; Timm, I.J. (2017): *An Agent Architecture for Simulating Communication Dynamics in Social Media*. In: Multiagent System Technologies, 15th German Conference, MATES 2017, pp. 19-37. Springer: Berlin.

Simulating Realistic Communication Behavior



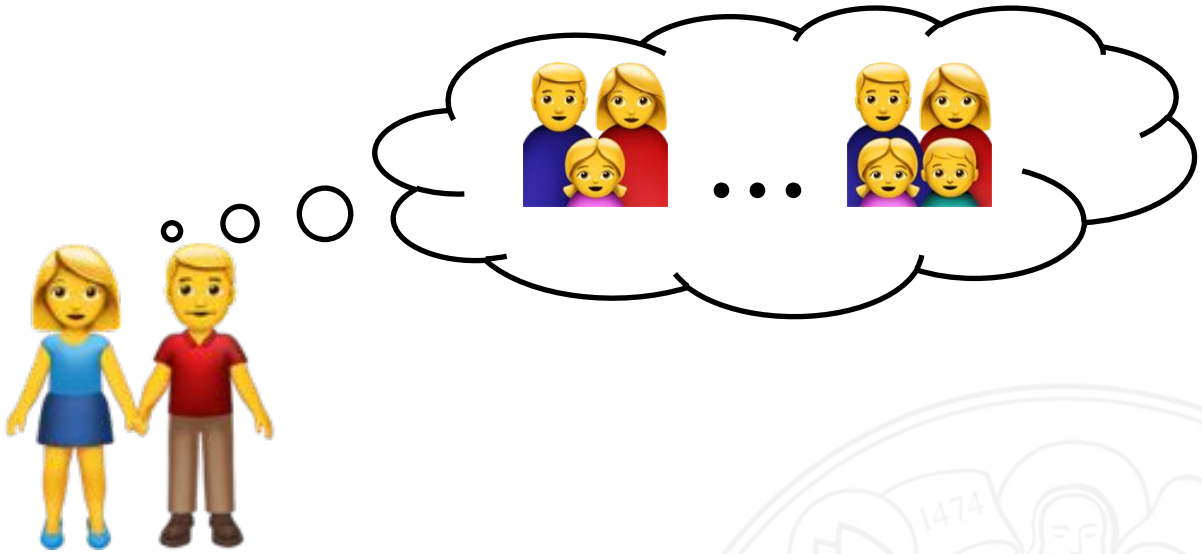
Rodermund, S.C.; Lorig, F.; Berndt, J.O.; Timm, I.J. (2017): *An Agent Architecture for Simulating Communication Dynamics in Social Media*. In: Multiagent System Technologies, 15th German Conference, MATES 2017, pp. 19-37. Springer: Berlin.

Lorig, F.; Rodermund, S.C.; Berndt, J.O.; Timm, I.J. (2018): *Modeling and Simulation of Complex Agents for Analyzing Communication Behavior in Social Media*. Accepted for: International Journal On Advances in Internet Technology, 11(1&2)

Case Study:
Social Contagion of Fertility

Social Contagion of Fertility

- When and why do couples decide to have (additional) children?



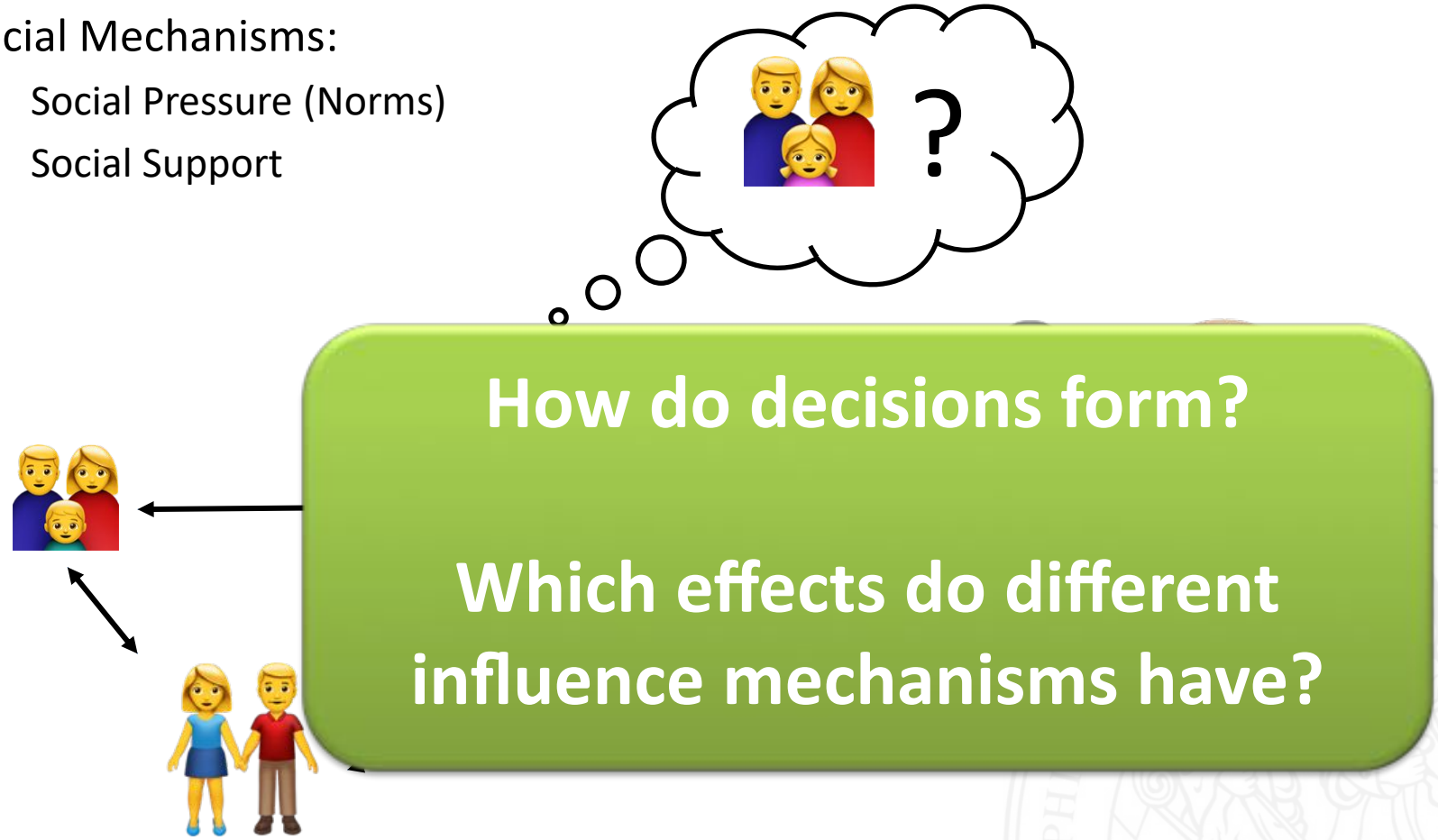
- Individual properties, conditions, and preferences, e.g.,
  - Age
  - Value of children
  - Financial status
  - ...

Richter, N. (2016): *Fertilität und die Mechanismen sozialer Ansteckung*. Ph.D. Thesis, Trier University

Berndt, J.O.; Rodermund, S.C.; Timm, I.J. (2018): *Social Contagion of Fertility: An Agent-Based Simulation Study*. Accepted for: 2018 Winter Simulation Conference (WSC 2018)

Social Mechanisms of Contagion

- Social Mechanisms:
  - Social Pressure (Norms)
  - Social Support



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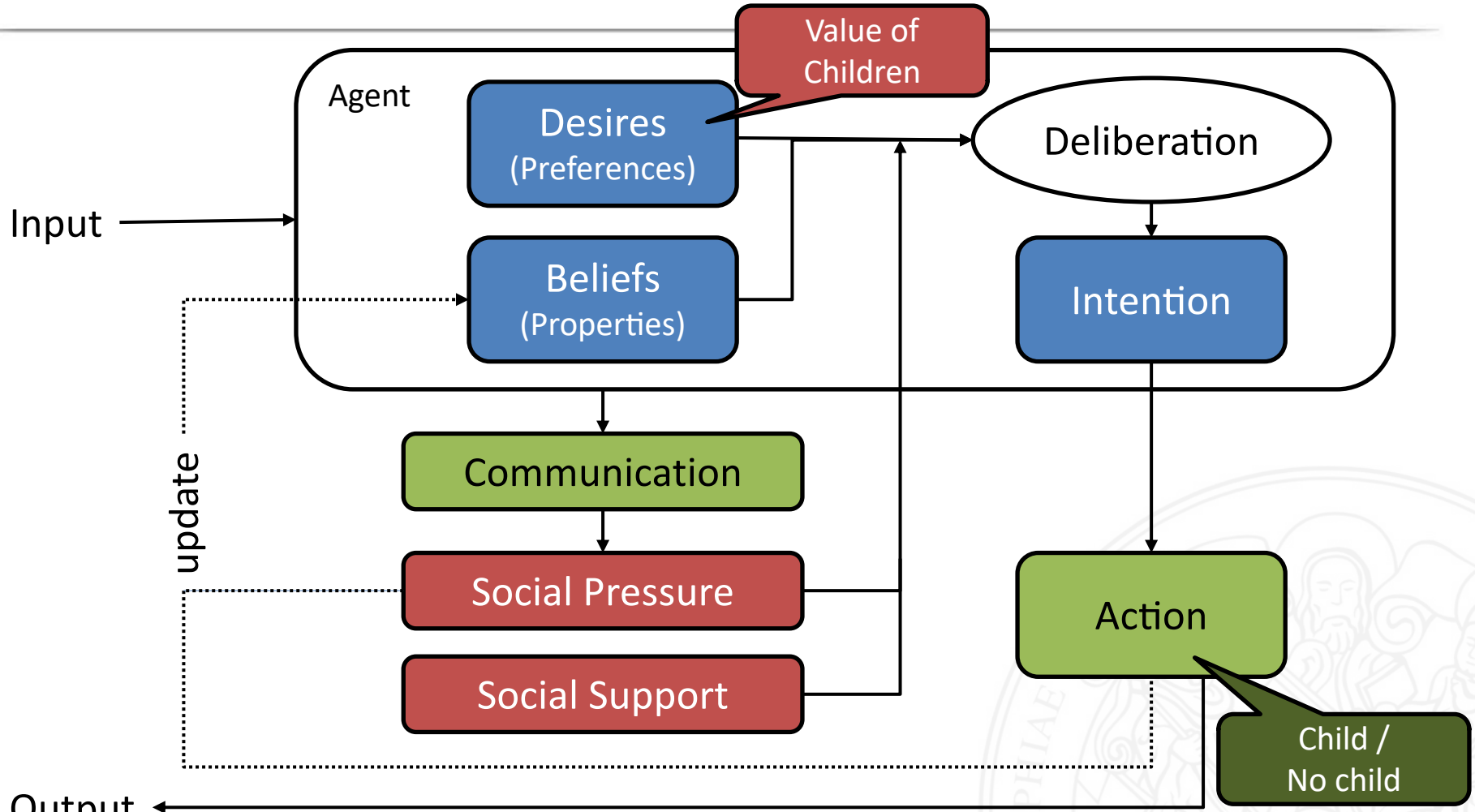
Modeling Social Contagion of Fertility



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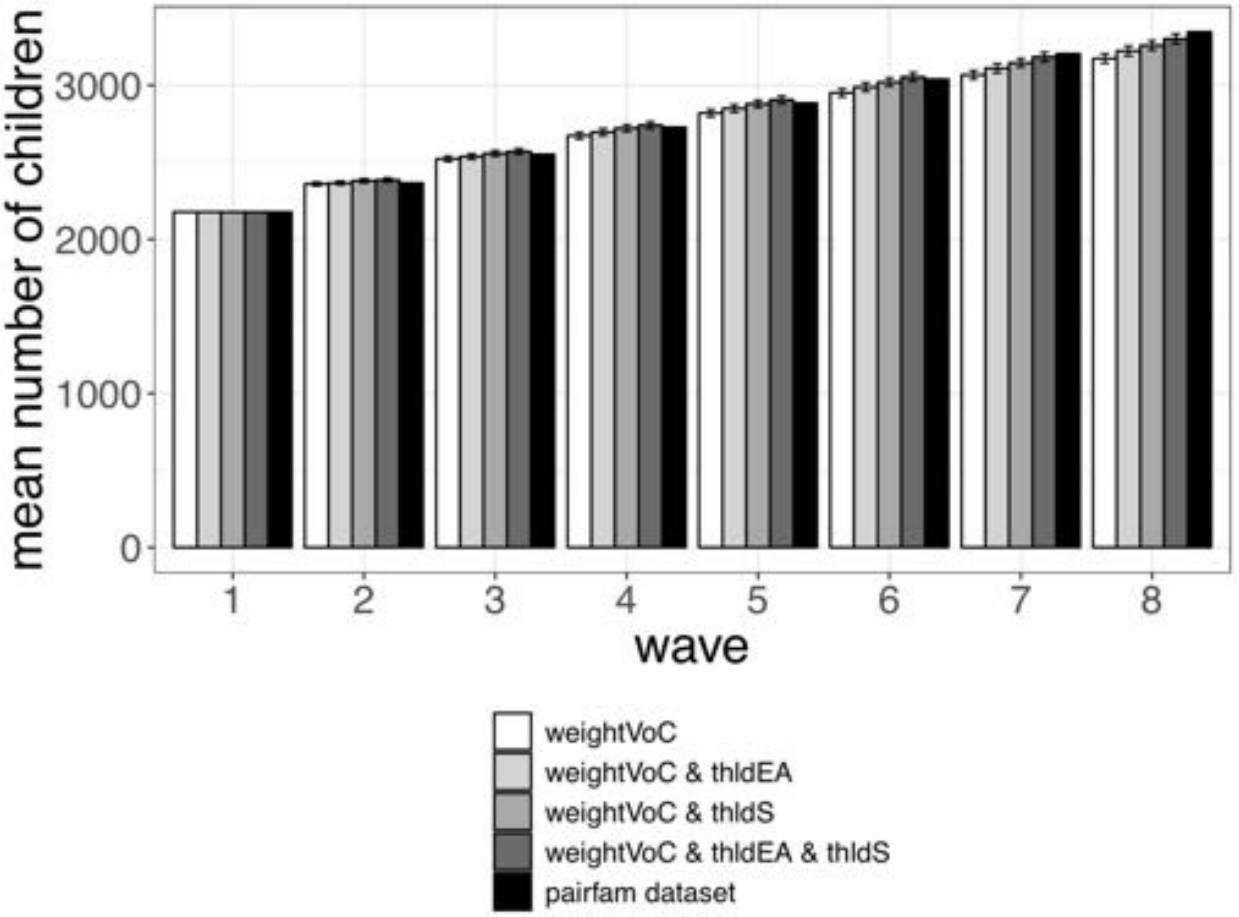
Simulating Mechanisms of Social Contagion



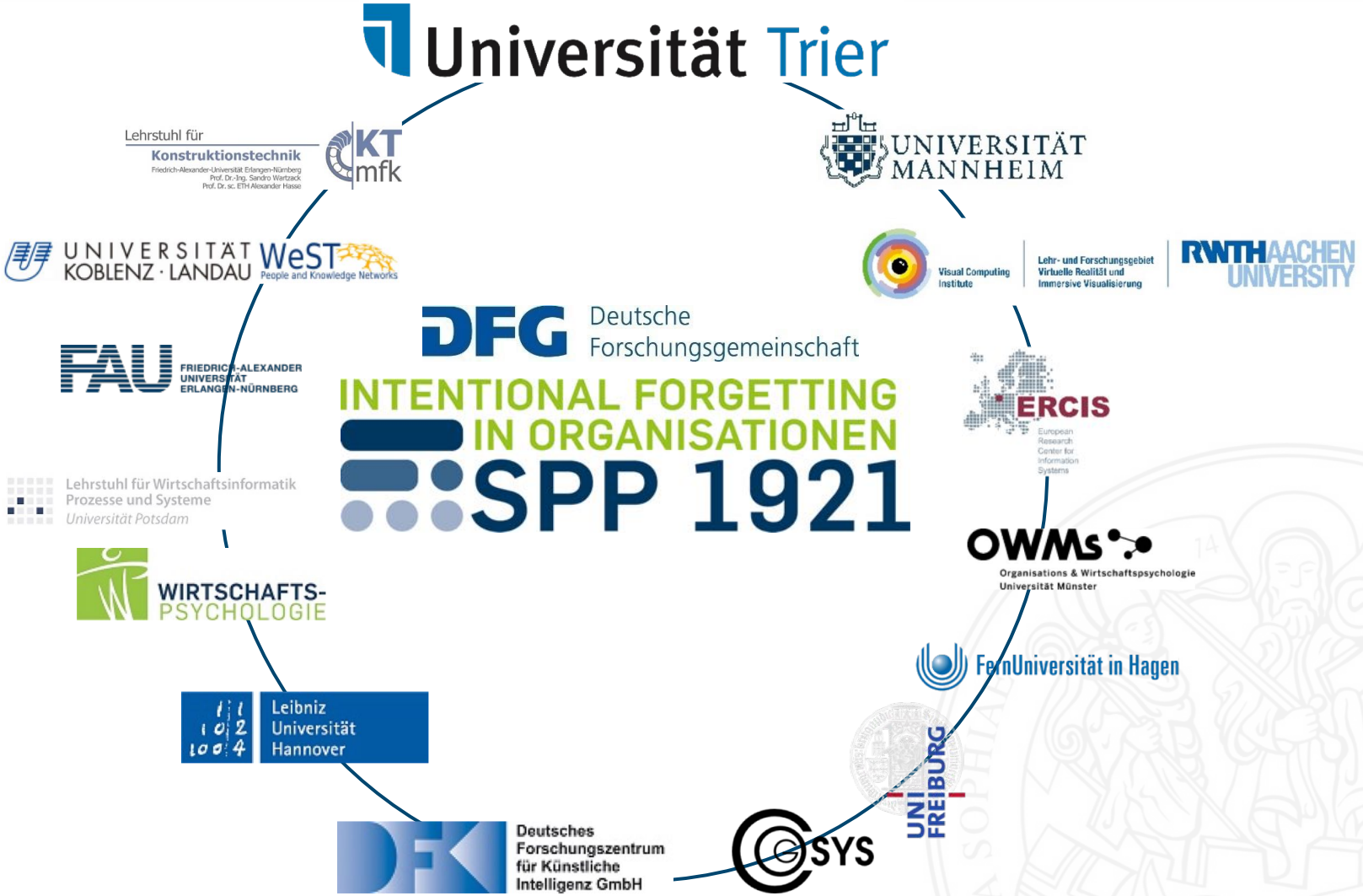
- Real-world dataset: *pairfam* (German family panel)
- Longitudinal study (9th annual wave just released)
- 2333 out of >12,000 interviewed couples
- Representation of fertile behavior
- Quantifying impact of social mechanisms

Berndt, J.O.; Rodermund, S.C.; Timm, I.J. (2018): *Social Contagion of Fertility: An Agent-Based Simulation Study*. Accepted for: 2018 Winter Simulation Conference (WSC 2018)

Case Study:
Process and Role Design in Organizations

Funded by:
DFG
INTENTIONAL FORGETTING IN ORGANISATIONEN
SPP 1921

AdaptPRO – Part of the Priority Program 1921 (Intentional Forgetting in Organizations)



Team Cognition: Distributed and Shared Knowledge

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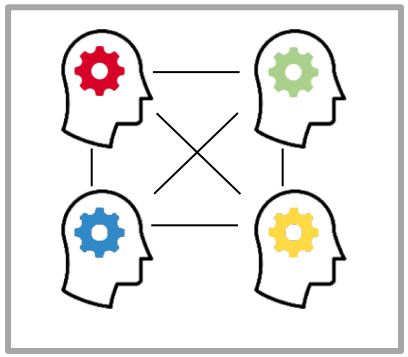
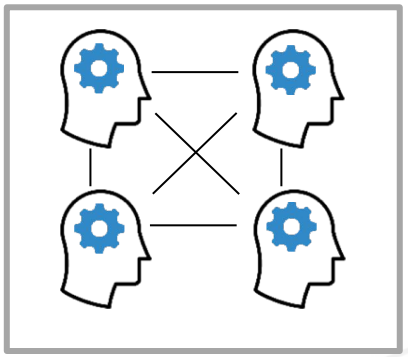
Distributed Knowledge



Transactive Memory Systems (TMS)

- Meta-knowledge about expertise location
- Awareness of expertise distribution

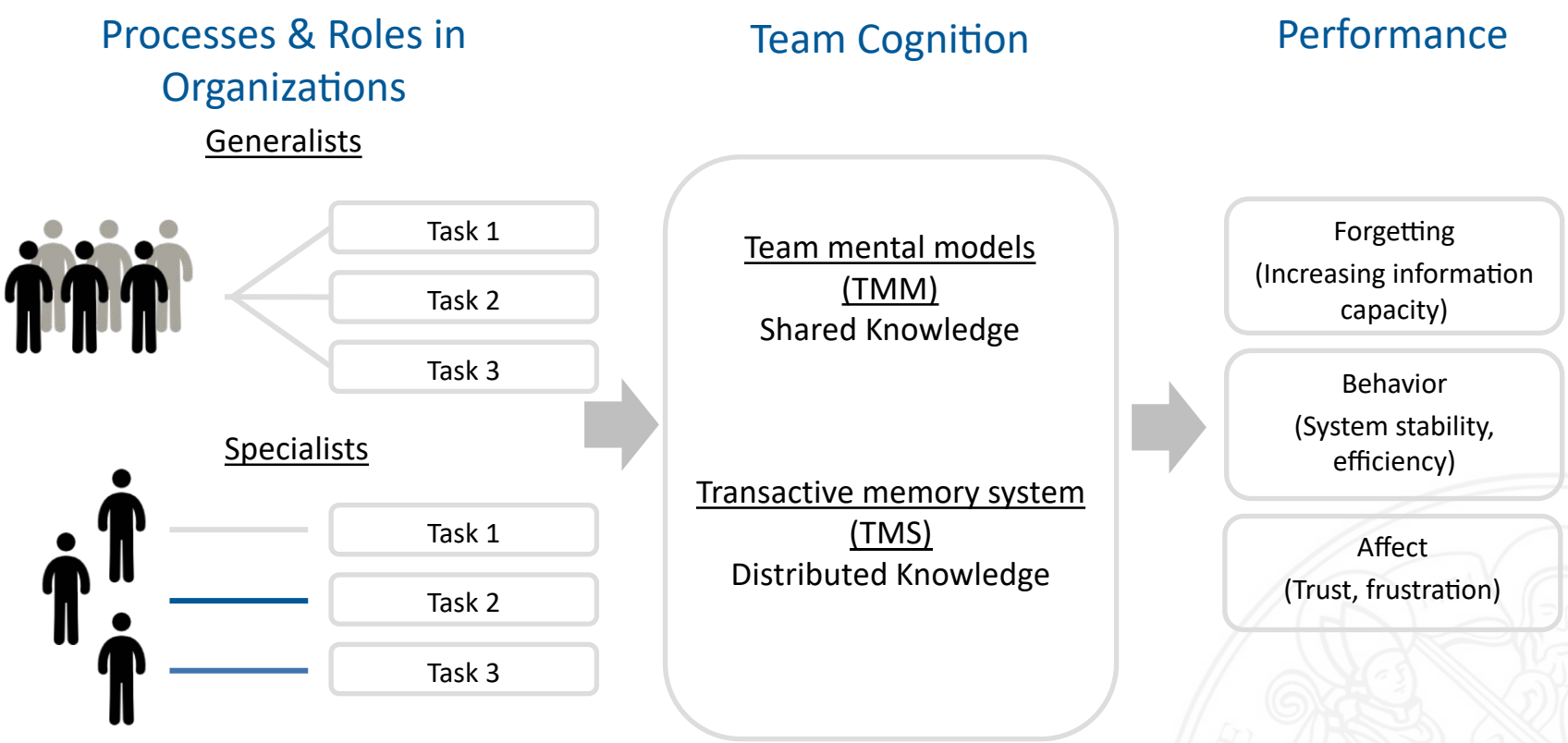
Shared Knowledge



Shared Mental Models (SMM)

- Shared task-related knowledge

Process and Role Design

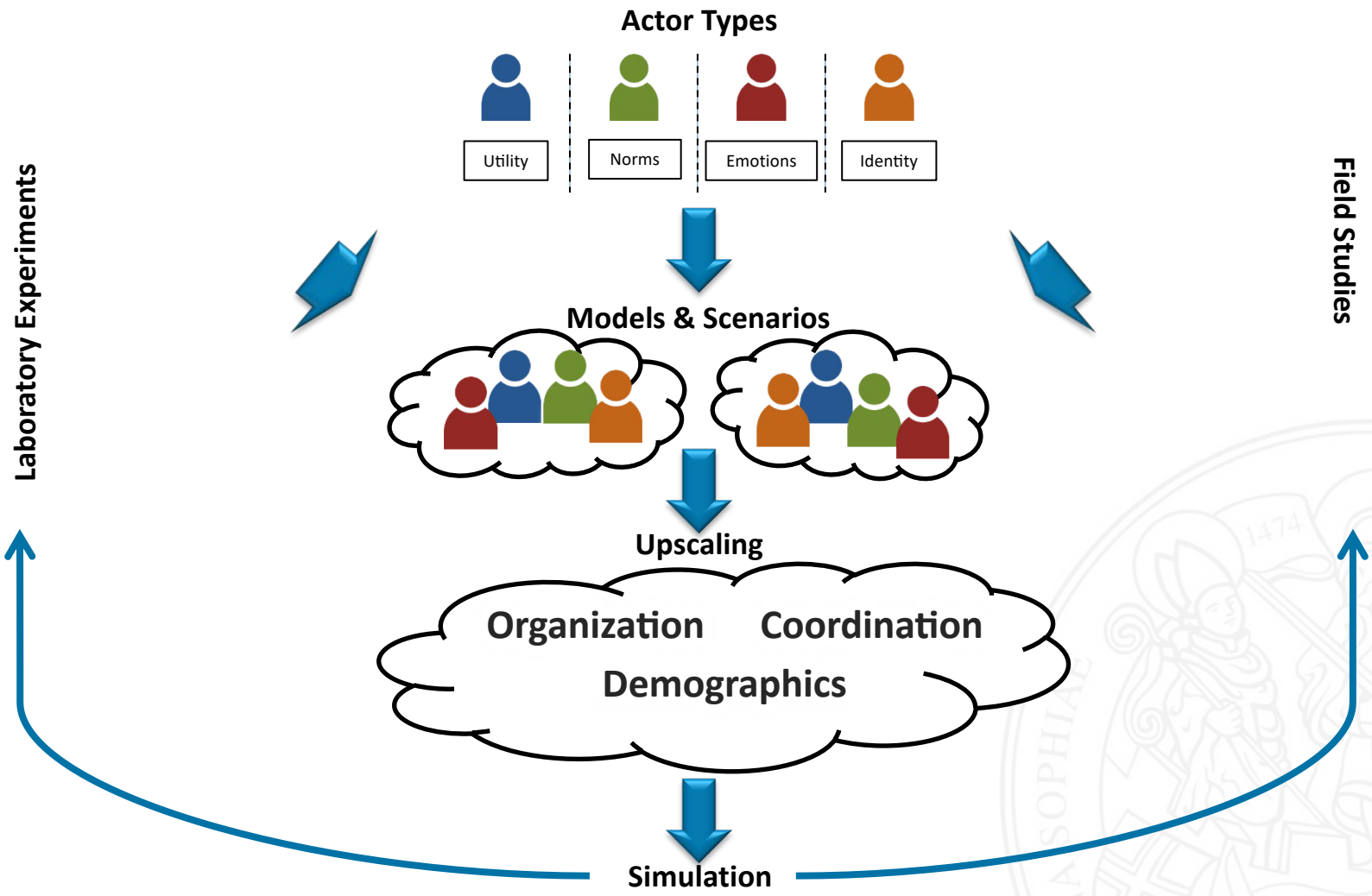


Mohammed, S., Ferzandi, L., & Hamilton, K. (2010): *Metaphor no more: A 15-year review of the team mental model construct*. Journal of Management, 36 (4), 876-910.

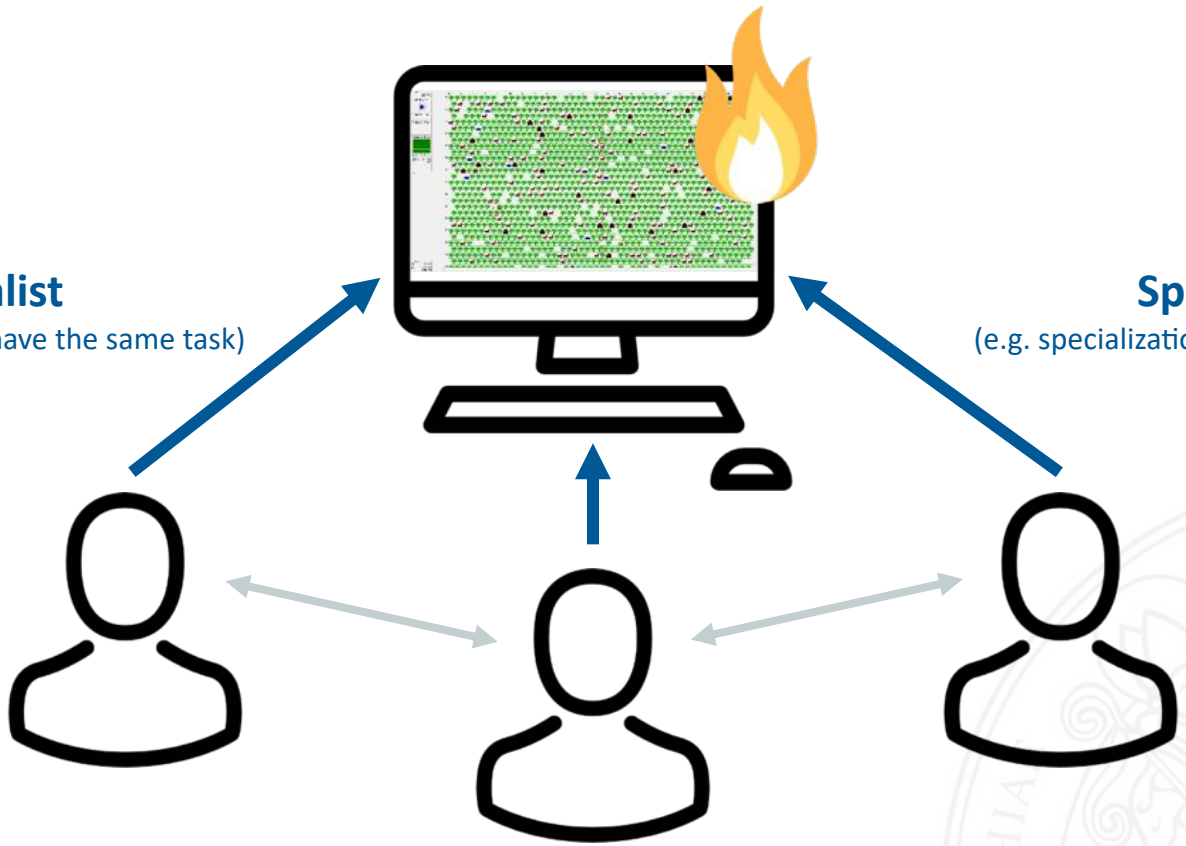
DeChurch, L. A., & Mesmer-Magnus, J. R. (2010): *The cognitive underpinnings of effective teamwork: A meta-analysis*. Journal of Applied Psychology, 95, 32–53.

Ellwart, T. Konradt, U. & Rack, O. (2014): *Team mental models of expertise location*. Small Group Research, 45, 119-153.

Agent-Based Simulation of Experiments (and Field Studies)



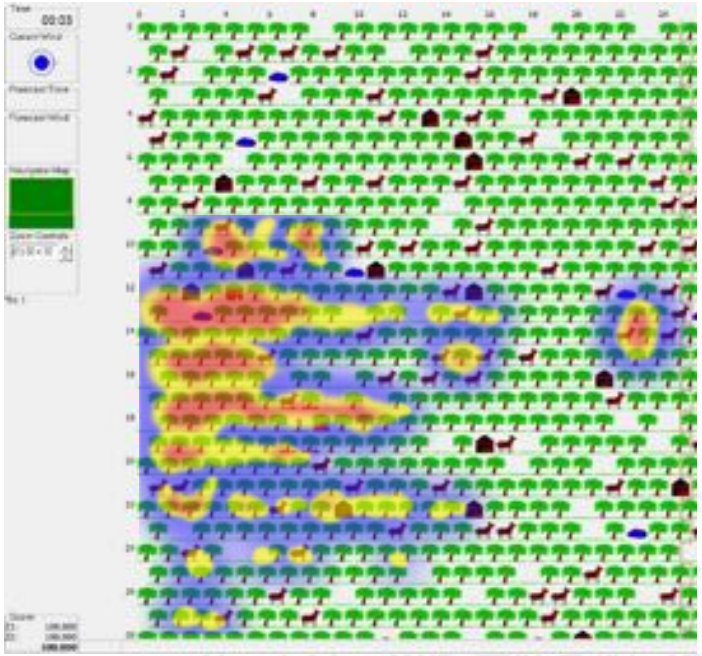
Laboratory Experiment



Laboratory Experiment

- Efficiency (e.g. burnt areas)
- Information capacity (e.g. were all vehicles used)
- System stability (e.g. cooperation in case of disturbance)
- Affect & trust (e.g. trust in fellow players)

- Eye tracking for measuring attention / information capacity



- Formalization of actions and behaviors for agent-based simulations
- Adaptation of team structures for performance optimization

Timm, I.J.; Berndt, J.O.; Reuter, L.; Ellwart, T.; Antoni, C.H.; Ulfert, A.-S. (2017): *Towards Multiagent-Based Simulation of Knowledge Management in Teams*. In: Flexible knowledge practices and the Digital Workplace (FKPDW). Workshop within the 9th Conference on Professional Knowledge Management. KIT: Karlsruhe.

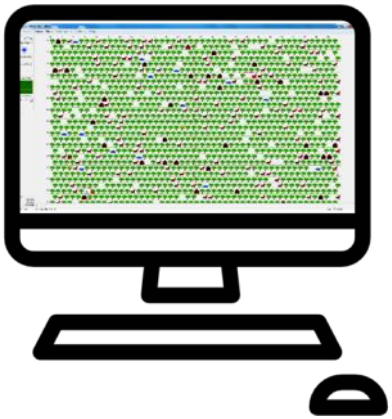
Reuter, L.; Berndt, J.O.; Timm, I.J. (2017): *Towards Simulation-based Role Optimization in Organizations*. In: KI 2017: Advances in Artificial Intelligence - 40th Annual German Conference on AI, 2017, pp. 359-365. Springer: Berlin

Merging Experiment and Simulation

Experiment

Simulation

Test Subject



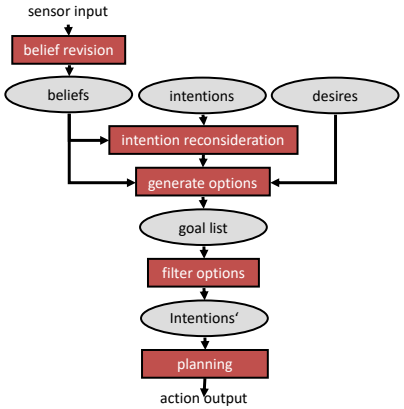
Scenario

Roles

Processes

Firefighter Task

Agent



Reuter, L.; Berndt, J.O.; Timm, I.J. (2017): *Challenges Of Simulating Teamwork In Organizational Scenarios*. In: Proceedings of the 2017 Winter Simulation Conference (WSC 2017). pp. 4552-4553. IEEE.

Adaptive Process and Role Design in Organizations

Work, Industrial and Organizational Psychology (Business Psychology)

Prof. Dr.
Thomas Ellwart

Prof. Dr.
Conny Antoni

Dr.
Anna-Sophie Ulfert

Universität Trier

Business Informatics

Prof. Dr.
Ingo Timm

Dr.
Jan Ole Berndt

Lukas Reuter
(M.Sc.)

Putting the *Social* in Computational Social Science: Next Generation Social Simulation

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- Physics-based (and similar) approaches:
  - Great for large scale systems
  - Show *which* social phenomena emerge and *how* they do it
- AI-based agent decision-making:
  - Perfect for detailed analysis of individuals and small groups
  - Explain *why* social phenomena emerge
- Experiment-based validation:
  - Complement survey data with controlled data generation
  - Provide a toolbox of validated model components / settings
- Challenges:
  - Integrating different aggregation levels
  - Hybrid models for fast computation and elaborate decisions

Thank You!

https://www.uni-trier.de/index.php?id=58465

https://www.researchgate.net/profile/Jan_Ole_Berndt