Social Influence Modelling

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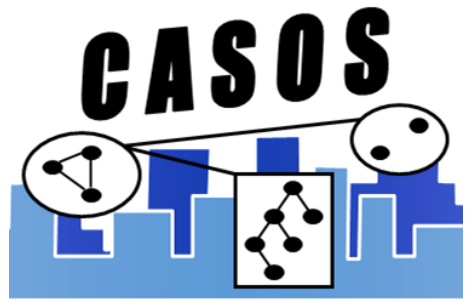
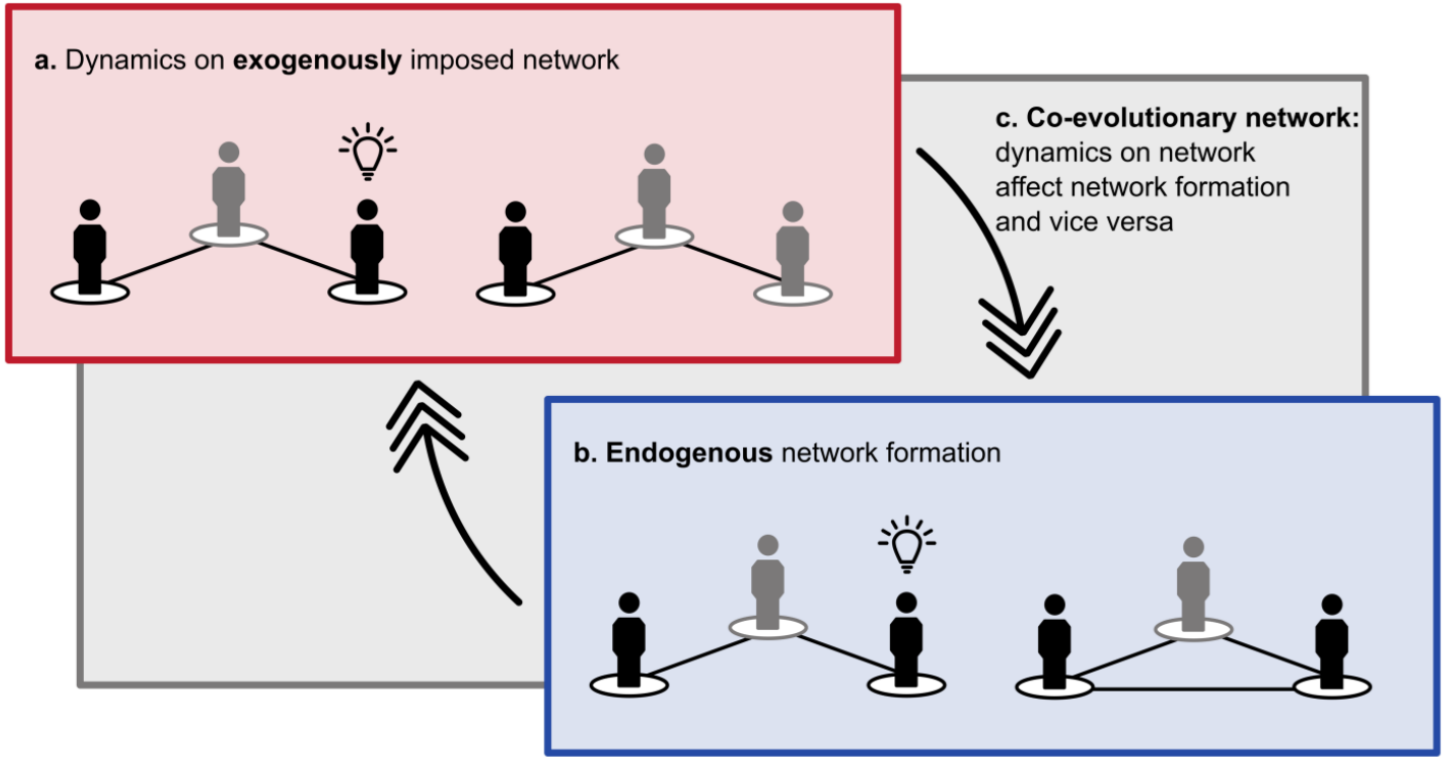


SNA x ABM: Exogenous vs Endogenous



Will, M., J. Groeneveld, K. Frank, and B. Muller. 2020, Feb.. "Combining social network analysis and agent-based modelling to explore dynamics of human interaction: A review". Socio-Environmental Systems Modelling 2:16325.

Stance flipping & Tipping Points

- Endogenous & exogenous features are equally important in predicting pro/ anti vaccine stance flips on Twitter [1]
- SI process is vulnerable to manipulative actors.
  - Empirical: 25% confederates for tipping point in language adoption [3]
  - Simulation: 2-4% confederates for tipping point in social networks [2]

1 Ng, L. H. X., and K. M. Carley. 2022. “Pro or Anti? a Social Influence Model of Online Stance Flipping”. IEEE Transactions on Network Science and Engineering:1–18
2 Centola, D., J. Becker, D. Brackbill, and A. Baronchelli. 2018, June. “Experimental evidence for tipping points in social convention”. Science 360(6393):1116–1119
3 Ross, B., L. Pilz, B. Cabrera, F. Brachten, G. Neubaum, and S. Stieglitz. 2019, July. “Are social bots a real threat? An agent-based model of the spiral of silence to analyse the impact of manipulative actors in social networks”. European Journal of Information Systems 28(4):394–412

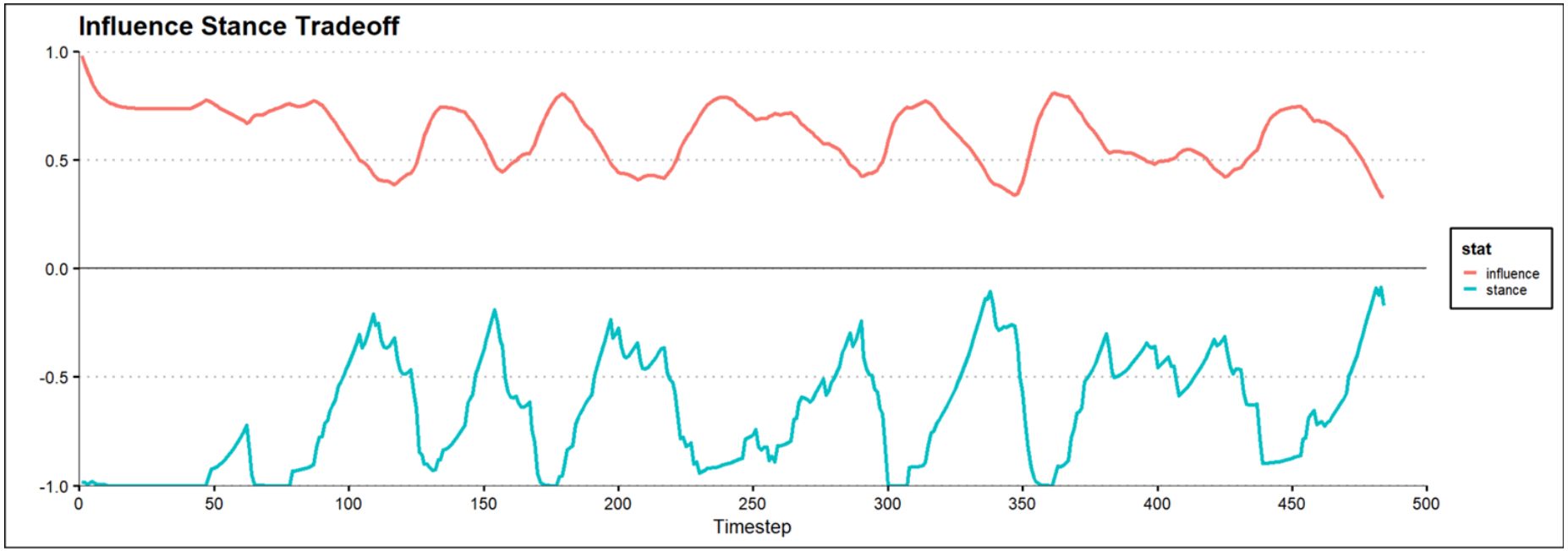
Term Definitions

- Stance **y**: pro/ anti (1.0, -1.0)
- Susceptibility **A**: how 'open-minded' is the agent?
- Influence **W**: how much an agent effects its neighbors stances

- Perturbation: an agents attempt to 'nudge' stances
- Confederates: agents that are perturbing the network
- Tipping Point: % confederates required to change consensus

Co-evolutionary SI Model

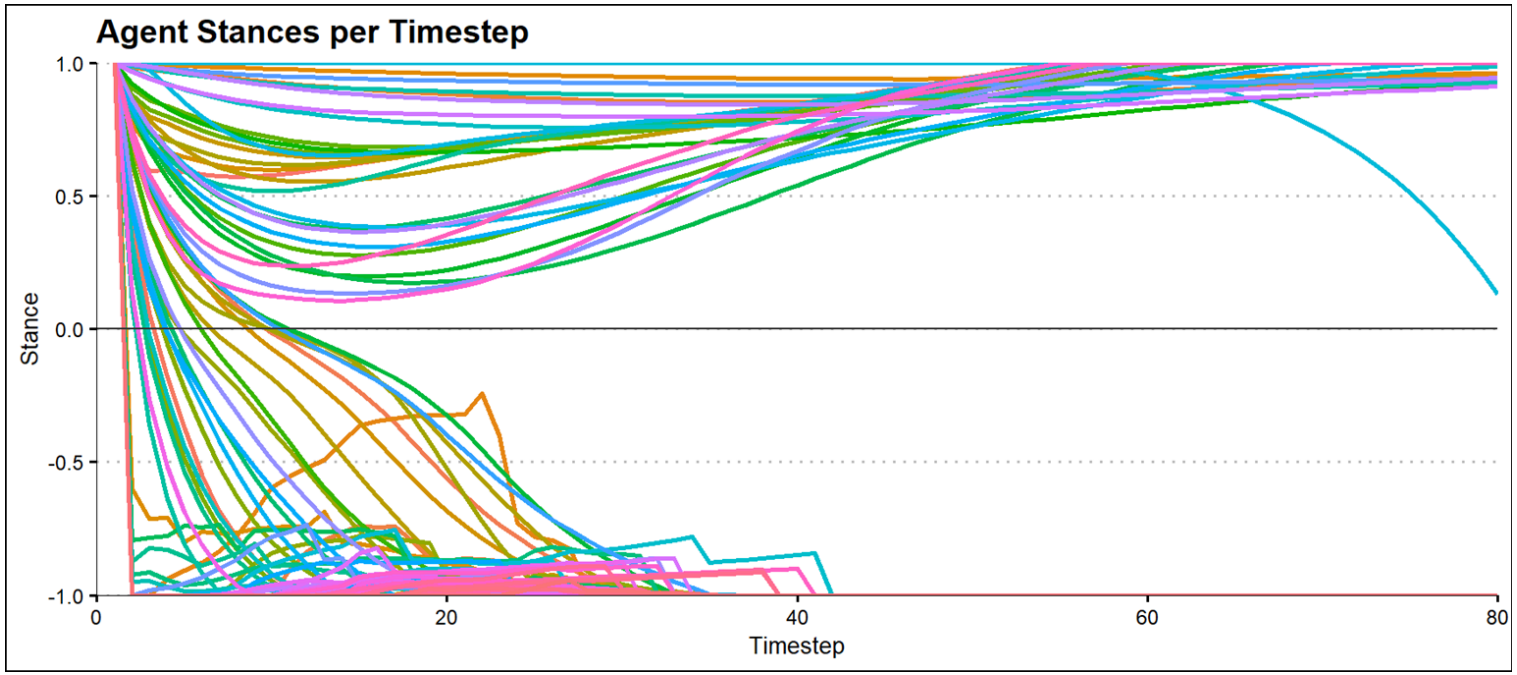
- Stance update[1]: $$y(t) = AWy(t-1) + (I - A)y(1)$$
- Influence update[2]: $$W = \lambda y_t y_t^{\intercal} + (1 - \lambda)W$$



1. Friedkin, N. E., and E. C. Johnsen. 1990. "Social influence and opinions". Journal of Mathematical Sociology
2. Macy, M. W., J. A. Kitts, A. Flache, and S. Benard. 2003. "Polarization in dynamic networks: A Hopfield model of emergent structure". Dynamic Social Network Modeling and Analysis

Methodology: Stable Polarized State

- Construct scale-free network
- Agent selection strategy
- Perturbation Strategy
- Run till stance convergence



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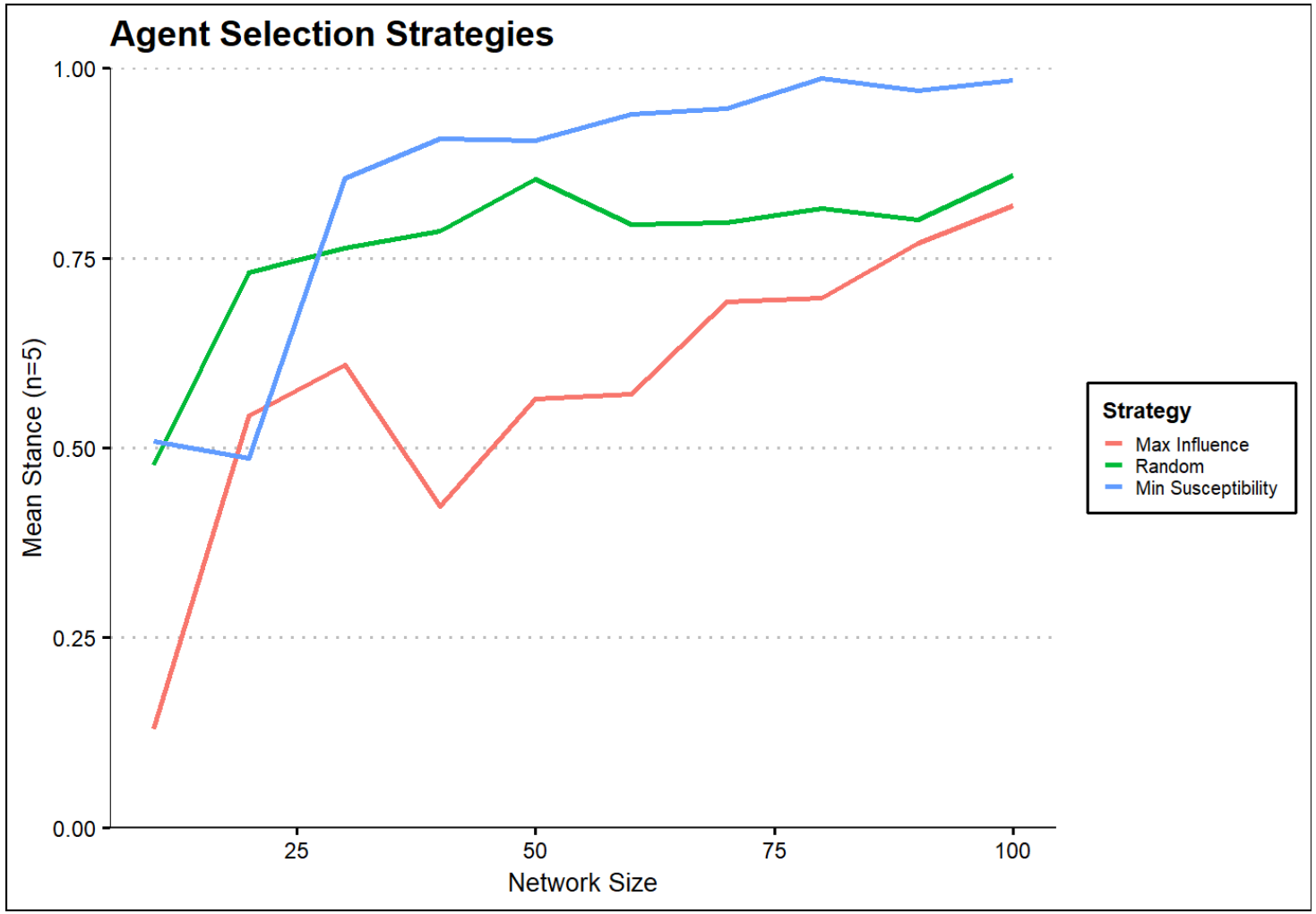
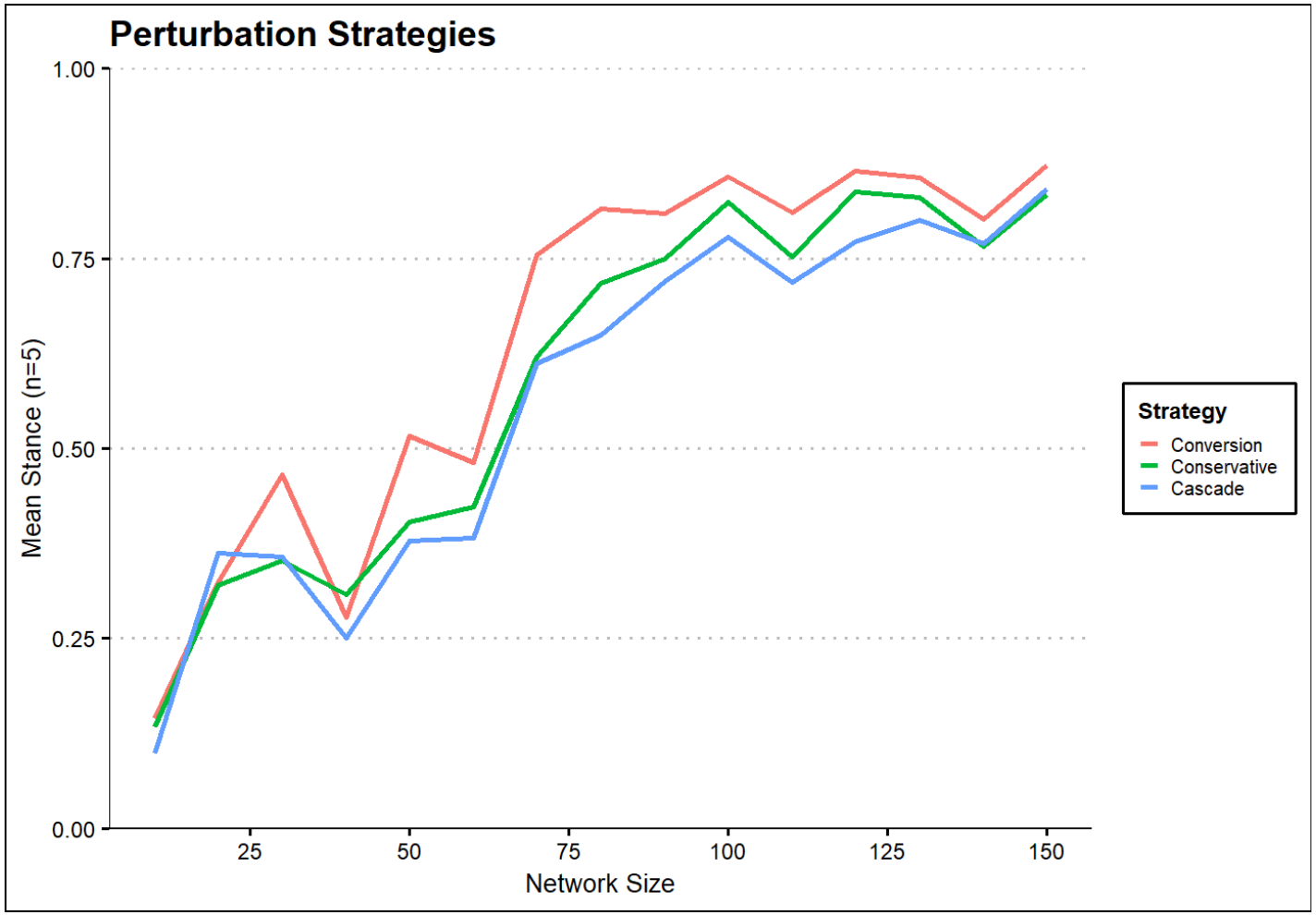
Perturbation Strategies

- Conservative: $y(i,t) = \begin{cases} \mu_y & \Sigma_j^N w(j,i) \leq \theta \\ -1 & \Sigma_j^N w(j,i) > \theta \end{cases}$
- Conversion: $y(i,t) = \mu_y^g + w_i^g * (-1 - \mu_y^g)$
- Cascade: $y(i,t) = \mu_y^l + w_i^l * (-1 - \mu_y^l)$

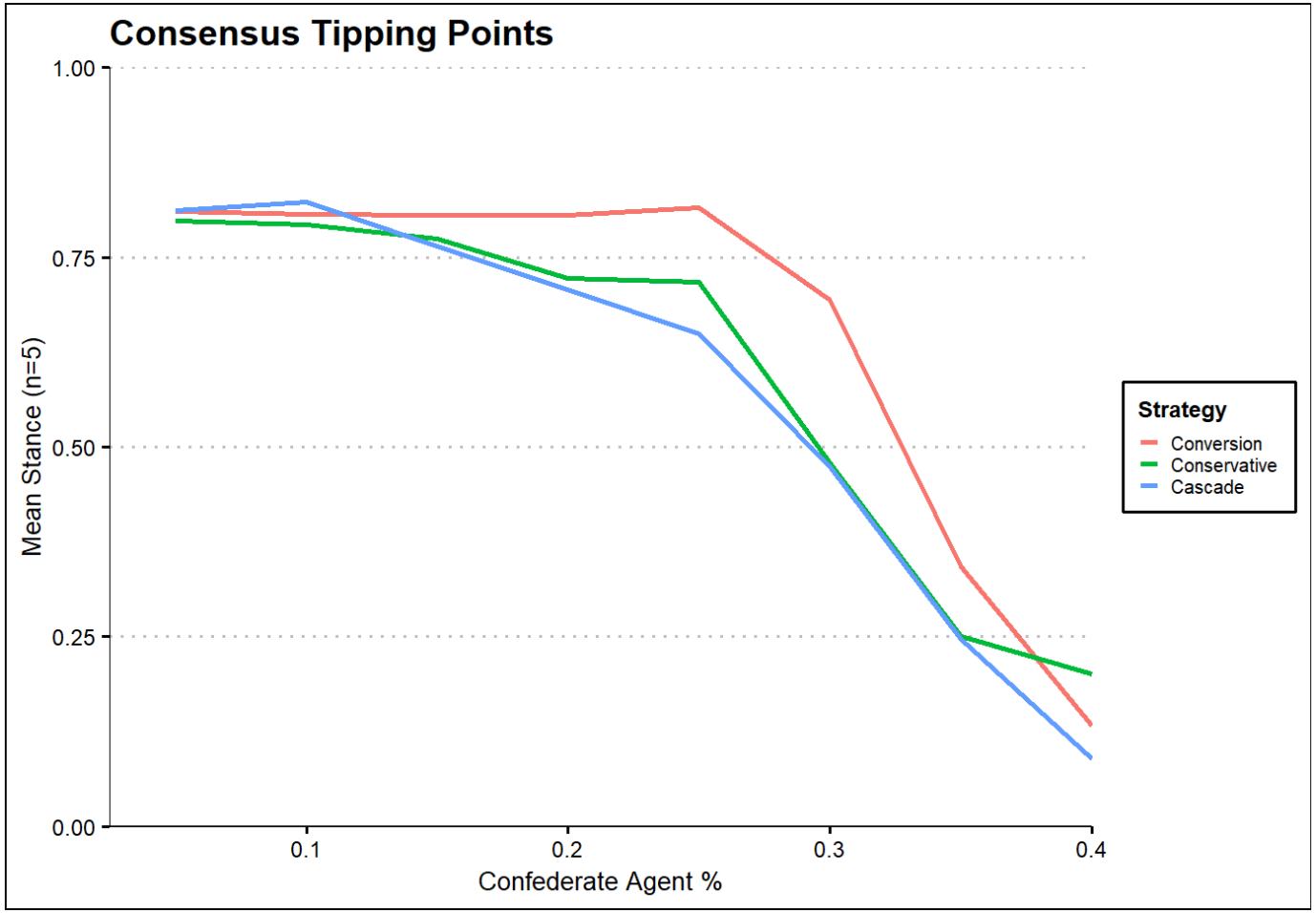
Influential agents are better confederates



Optimal confederates target local ego-networks



Minority stance 'tipping points' around 25%



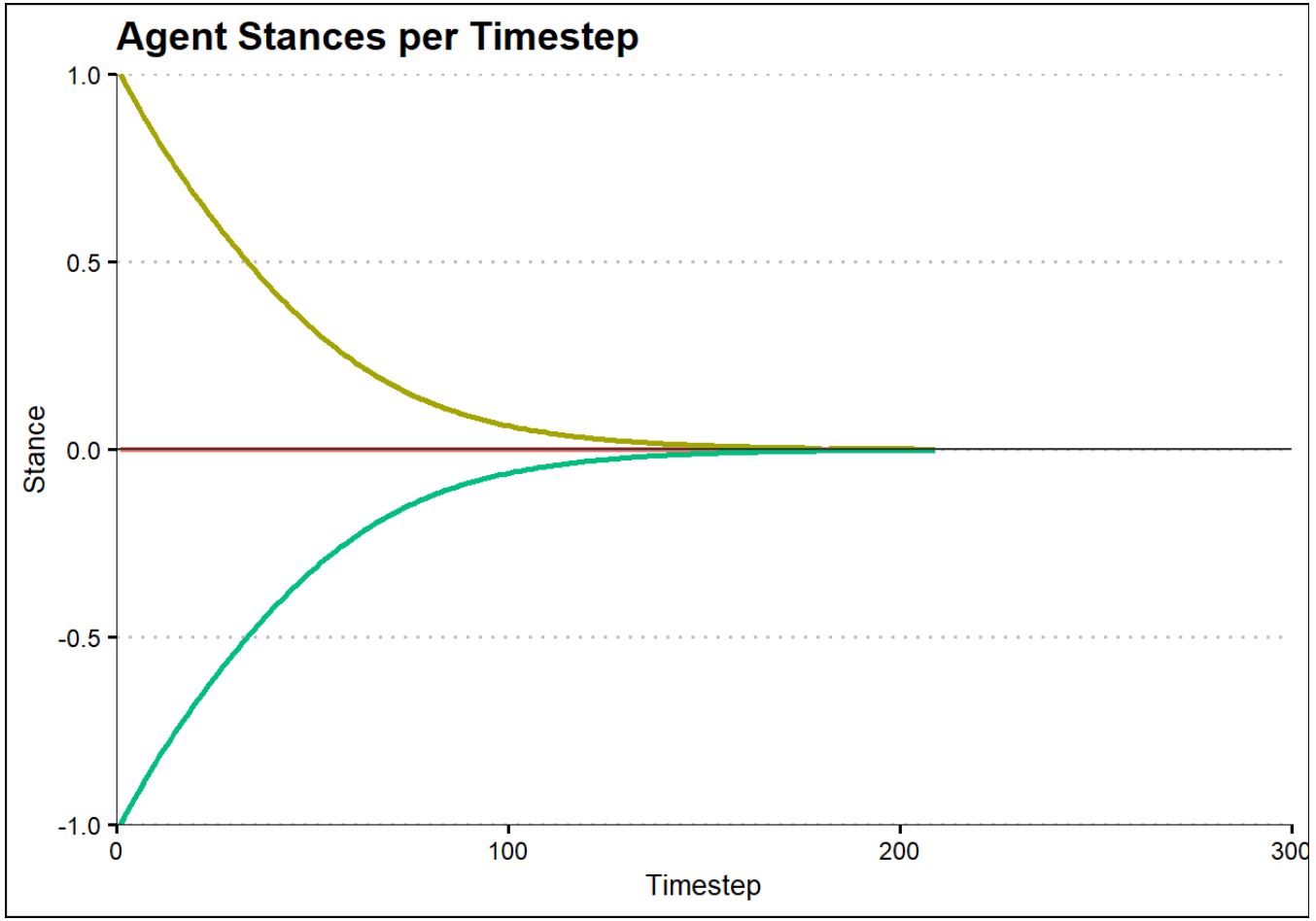
Limitation in Validation

- We cannot intentionally perturb real social networks
- Stance determination requires data collection + prediction
- Similarity of scale-free networks to real networks
- Confederates can only control their stance (cannot ‘friend’ others)
- Stance & influence update rates are:
  - instantaneous (temporal / ‘lagging’ relations are not modeled)
  - constant (vs GLIE based RL policies)
- Single topic, continuous stances

Future Work

- Formalize wisdom of crowds & tipping points as 2 extremes of conditional probability spectrum parameterized by social influence
  - Wisdom of crowds -> independence
  - Tipping points -> conditional independence via influence network
- Explore impact of lagging social influence effects on stance
- Do dynamics change when confederate agents saturate environment?
  - Higher suspicion, lower trust, lower susceptibility
  - “Lemons market”

Recovery from Stable Polarized State



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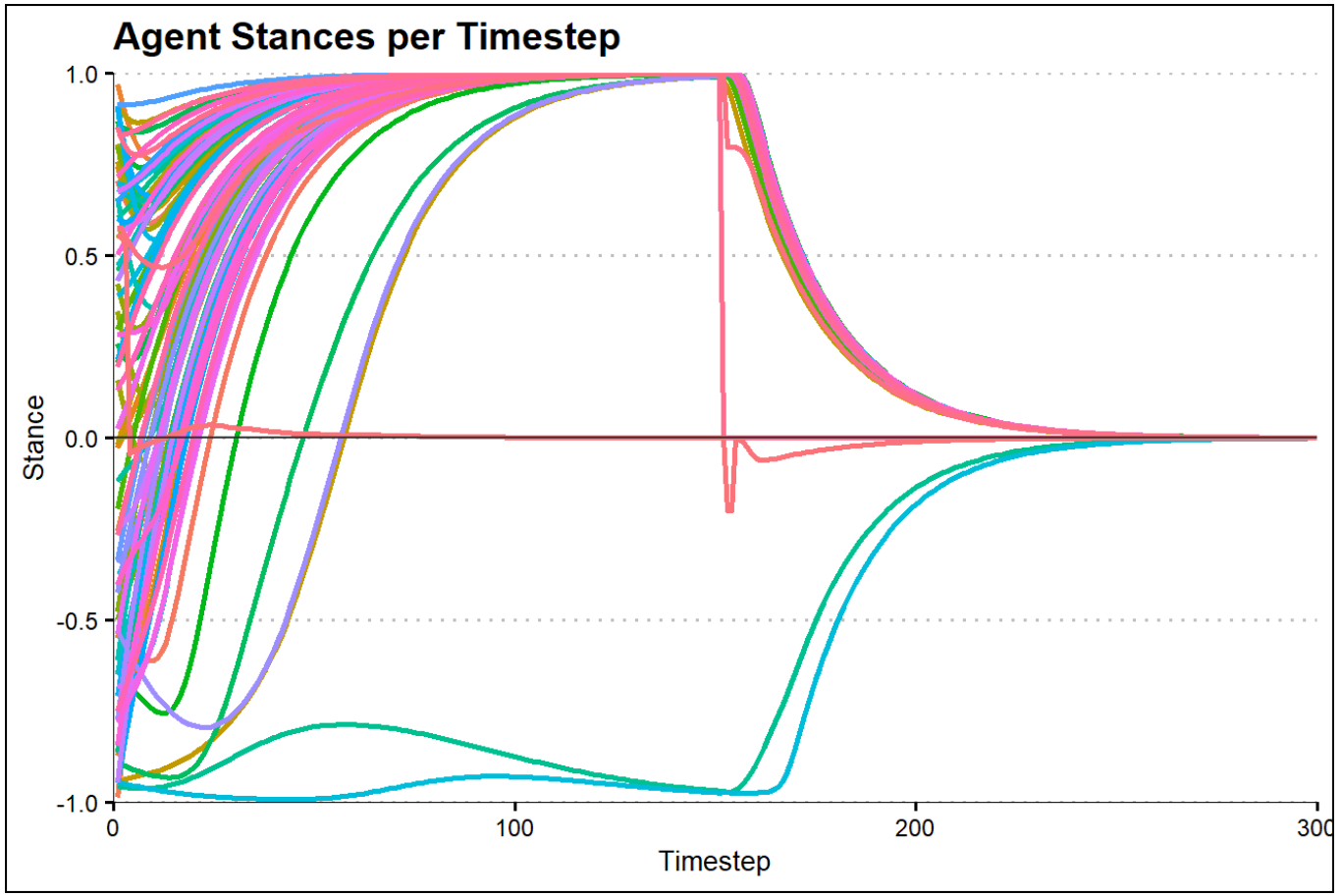

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- Journal of Information Systems 28(4):394–412. Will, M., J. Groeneveld, K. Frank, and B. Muller. 2020, Feb.. “Combining social network analysis and agent-based modellingto explore dynamics of human interaction: A review”. Socio-Environmental Systems Modelling 2:16325.