How to stop the emergence of political segregation in cooperative networks

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Overview

- The "problem" of cooperation and the factors that promote it
- Prior work on how networks promote cooperation
- Negative externalities of social networks
- New large-scale experimental results
- Discussion

Background

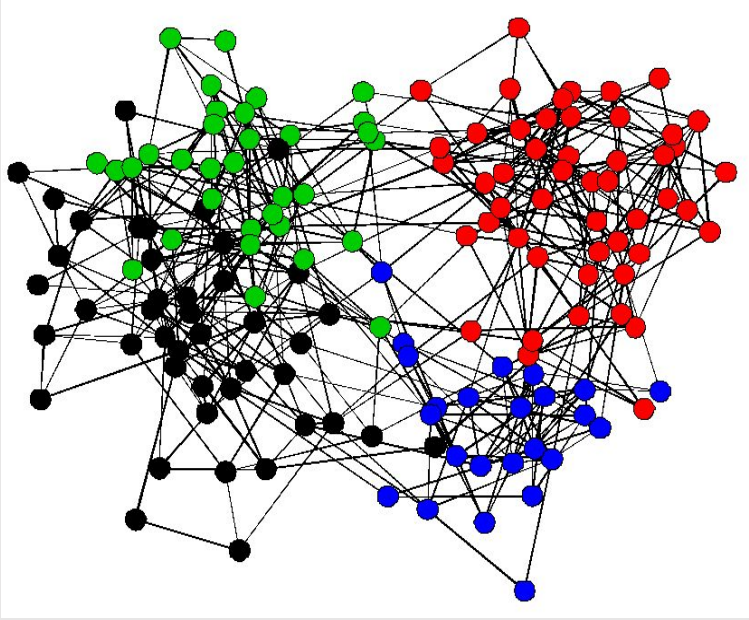
- Cooperation – one agent pays a cost for another to receive a benefit (Rand and Nowak 2013)
- Evolution rewards selfish behaviors, so the prevalence of cooperation among humans (other animals, genes, chromosomes, etc) is perplexing (e.g., Nowak 2006)
- Aside from being an interesting theoretical/evolutionary puzzle, the practical implications are to identify (social) factors associated with cooperation

Five mechanisms that promote cooperation

- "Natural selection opposes the evolution of cooperation unless specific mechanisms are at work" (Rand and Nowak 2013)
- 1) Structured Populations – agents interact with those near them, and hence cooperators can form clusters (Nowak and May 1992)
  - Geographic (Hauert and Doebeli 2004) and **network** (Ohtsuki et al 2006) structures promote cooperation
- 2) Reputations – third parties observe behavior and condition their behavior accordingly (e.g., Feinberg et al. 2012)
- 3) Direct Reciprocity; 4) Multi-level selection; 5) Kin selection

Networks and Cooperation

- Random Network < Lattice Structure (Nakamura, Matsuda & Iwasa 1997)
- Lattice < Clustered Network (Assenza et al 2008)



Networks and Cooperation

- ***Dynamic networks***, in particular, promote the evolution of cooperation (Fehl et al 2011; Melamed et al. 2018; Pacheco and Nowak 2006; Rand et al 2011; Rezaei et al 2012; Wang et al 2012)
  - Cooperators punish defectors by shedding their ties (Wang, Suri and Watts 2012)
  - When reputational information is available, defectors are avoided when seeking new ties (Gallo and Yan 2015; Roberts 2015)
  - Network dynamics result in endogenous clusters of cooperators (Melamed, Harrell and Simpson 2018)

Networks and Inequality

- Past work assumes people sort on prosocial reputations
  - Evidence for this is mixed at best, e.g., Simpson et al 2014, c.f., Schwyck et al. 2022
- Social Identity Theory provides reasons why individuals would select others with similar social identities
  - Higher baseline trust for ingroup members than outgroup members
  - Promotes cooperation as well (Balliet, Wu, and De Dreu 2014)

- If individual decisions in dynamic networks show a preference for ingroup members, the aggregate result should be the segregation of social ties between categories
- Further, if there are group-level differences in access to rewards those differences will increase due to rewards being concentrated in intragroup ties

Negative externalities of dynamic networks

- Past work* demonstrates how reputations for prosociality and a social category combine to shape the coevolution of network structure and cooperation
- Large web-based experiment (N = 646)
- Participants from two universities played iterated PD games on a dynamic network
- Manipulated whether university affiliation was salient during the study
- Key results:
  - Net of participant reputations for cooperation, participants cooperated with ingroup members at higher rates
  - Net of participant reputations, participants were more likely to select ingroup members to form new ties
  - **Segregation of ties between groups emerged in all conditions where social identities were known**

*Melamed, David et al. 2020. "Homophily and Segregation in Cooperative Networks." *AJS* 125(4): 1084-1127.

Negative externalities of dynamic networks

- Dynamic networks increase cooperation, but they also increase segregation (2020) and between group inequality (2022*)
- Can we sustain cooperation while minimizing segregation and inequality?
- SIT claims intragroup cooperation is high because there is higher baseline trust for fellow ingroup members
- Can we develop a reputation system that conveys this information?

*Melamed, David et al. 2022. "Inequality and Cooperation in Social Networks." *Scientific Reports* 12: 6789.

Types of reputations

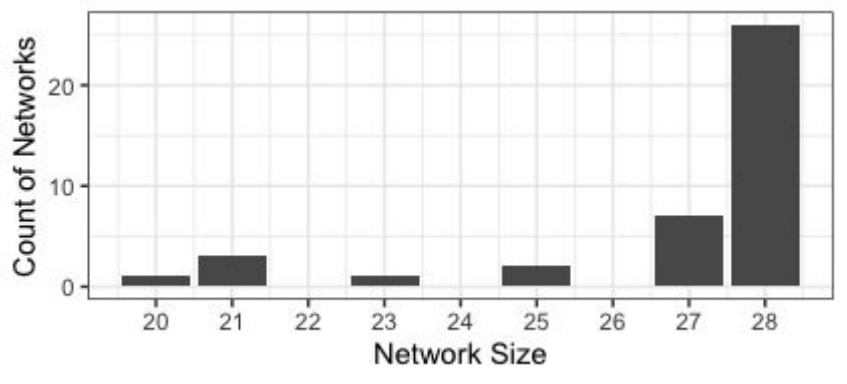
- Recent theory/evidence suggests that concerns for reputations are global, occurring for both ingroup and outgroup members (Romano et al. 2017a&b)
- Distinguishing reputations for treatment of ingroup and outgroup members may minimize ingroup favoritism in heterogeneous settings
- That is, reputation concern may mitigate some of the observed effects of identity on cooperation and segregation we found previously

- **Shared identity can serve as a heuristic, but actual reputations undermine the need for such heuristics**

Hypotheses

- Replication of past work under traditional reputational system
  - Salient social identity will increase ingroup cooperation
  - Salient social identity will promote preferential attachment to ingroup members
  - By extension, network segregation will emerge
- Predictions with reputation system that parses treatment of ingroup and outgroup members
  - Salient social identity will be unrelated to cooperation
  - Tie selection will be driven by reputations rather than group membership
  - By extension, networks will not result in aggregate segregation

The Experiment*



- Breadboard enables participants to interact via iterated games where who plays with whom is defined by an underlying network topology
- 1,073 US participants from Prolific interacted on 40 networks via an iterated PD for 18 rounds
- Decisions to C/D with each alter to whom they were tied
- Network updates occurred every 4 rounds
- Experimentally manipulated the type of reputation information in the networks

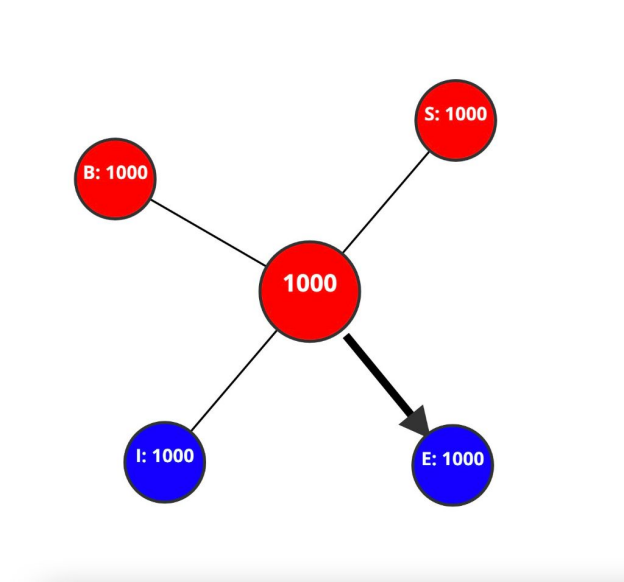
*Simpson, Montgomery and Melamed. 2023. "Reputations for Treatment of Outgroup Members can Prevent the Emergence of Political Segregation in Cooperative Networks." *Nature Communications* 14:7721.

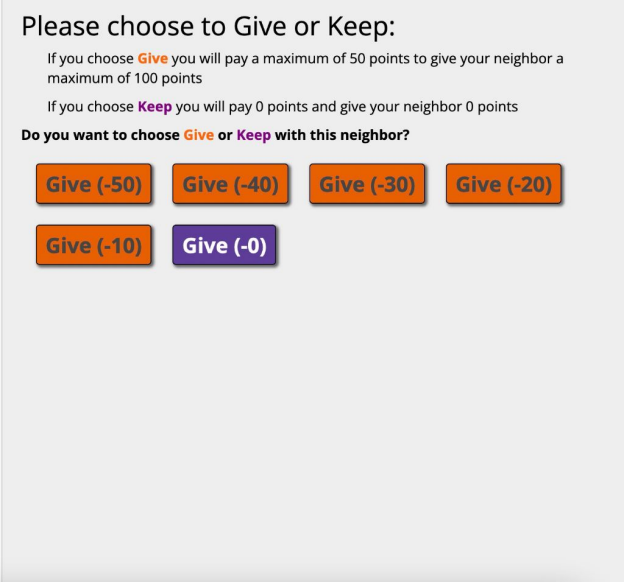
Between Networks Manipulation

- 1) Control condition – reputations solely based on total given in the past; no distinguishing information between participants otherwise
- 2) Undifferentiated - Politics were salient (dem/repub) and reputations were based on total given in the past
- 3) Parochial - Politics were salient and reputations were based solely on treatment of ingroup members
- 4) Inter/Intra group reputations - Politics were salient and reputations were separated by treatment of ingroup members and treatment of outgroup members

The Experiment

- Given an endowment of 1,000 MUs ($1 for every 1,000 at the end of the study)
- Could pay up to 50 MUs in 10 MU increments to their alters
- MUs given are doubled





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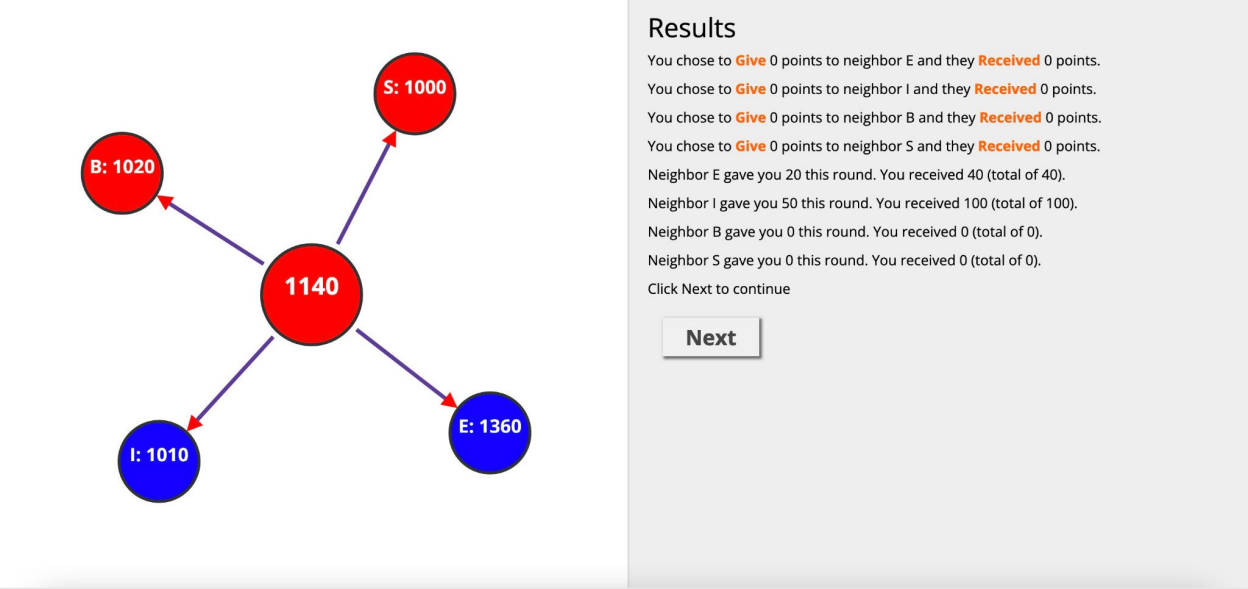

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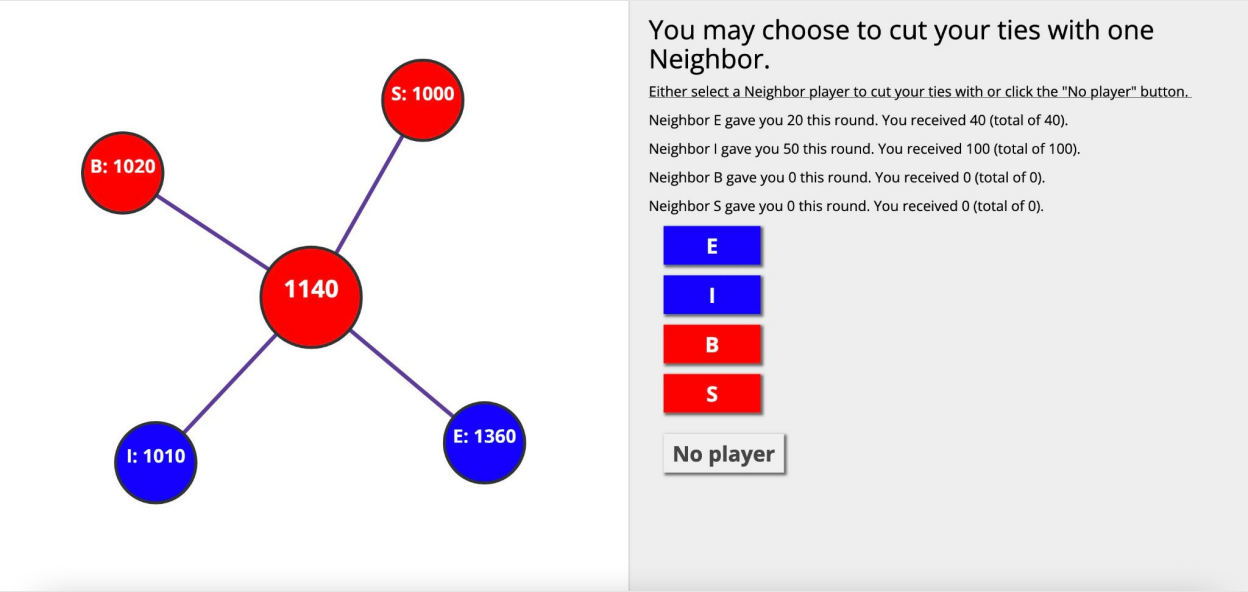

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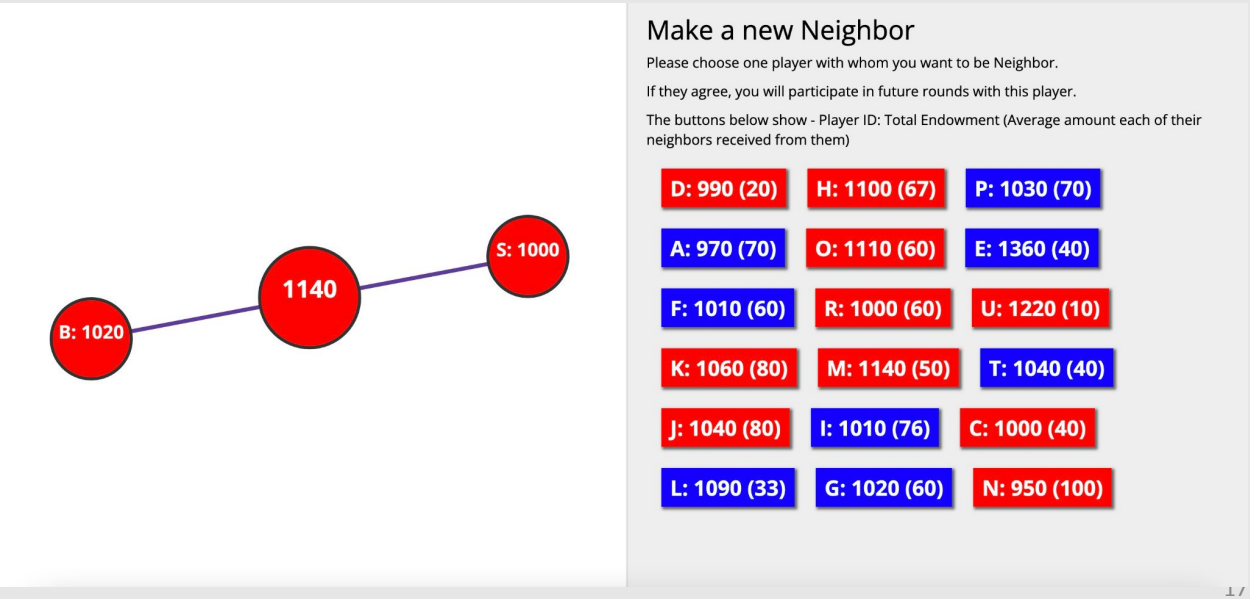


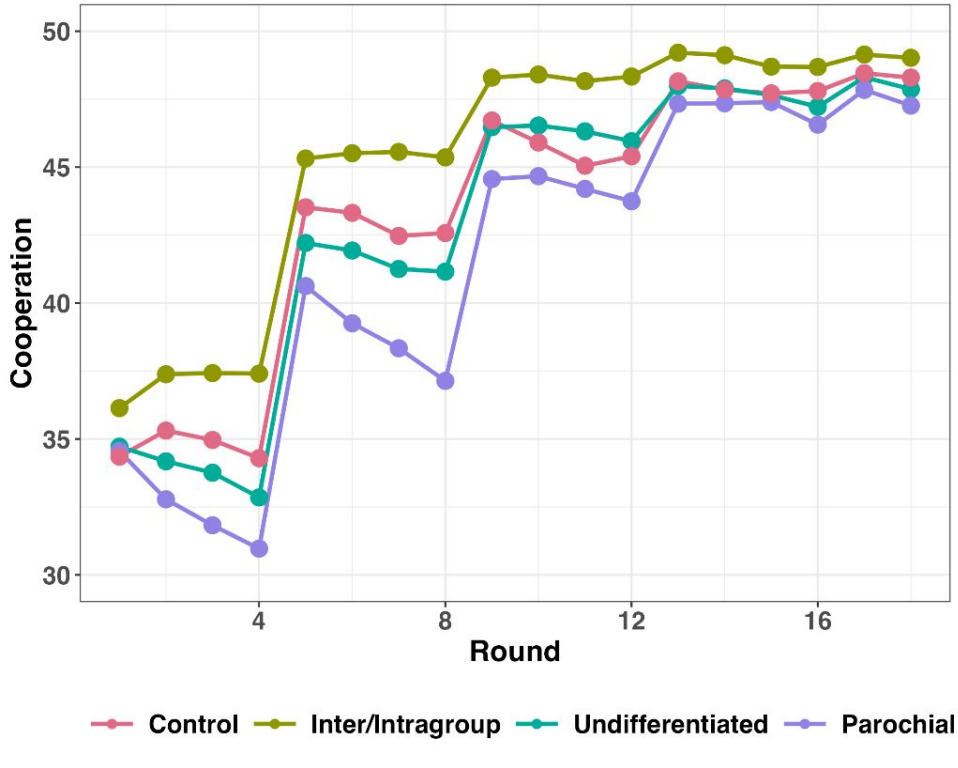
https://osf.io/xkamd/

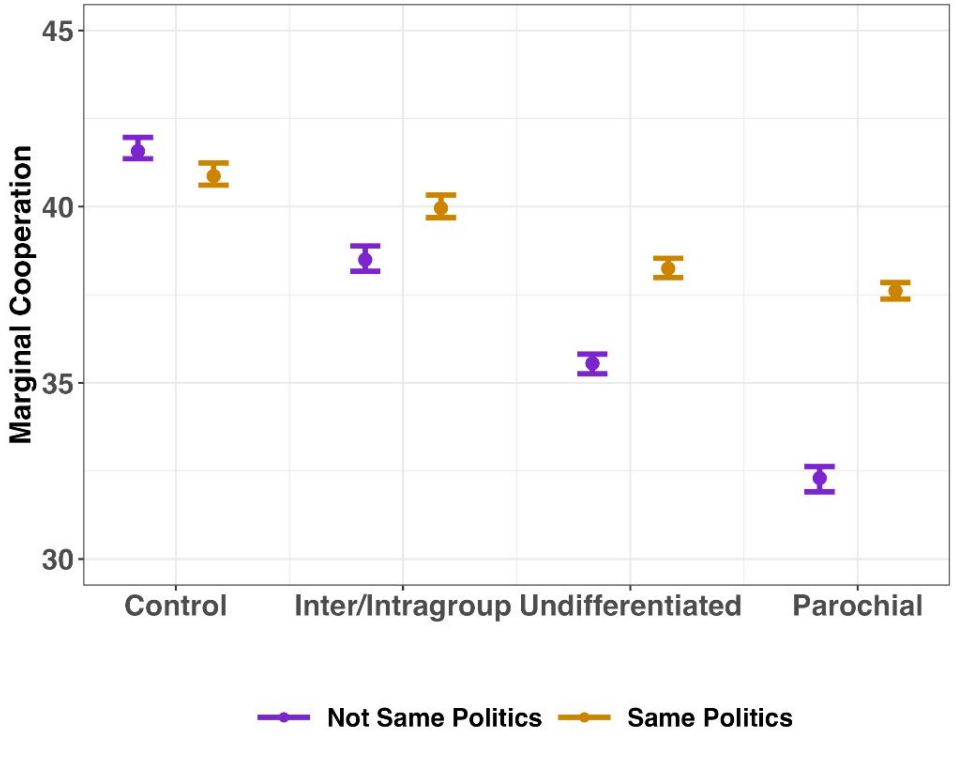
Analytic Strategy

- Cooperation – decisions per alter are nested in rounds, rounds nested in participants, and participants nested in networks
- Other outcomes have a similar dependence structure
- Parametric models can address nesting due to time and multiple decisions per round, but not network dependencies
- Network dependence induces "anticonservative variance estimation"*
- Estimated generalized mixed effects models adjusting for multiple alters per round, and serial correlation via an autoregressive (1) term
- Significance was determined with nonparametric permutation tests* (1,000 permutations)
- Confidence intervals about model margins were bootstrapped (90% of relevant data with replacement)

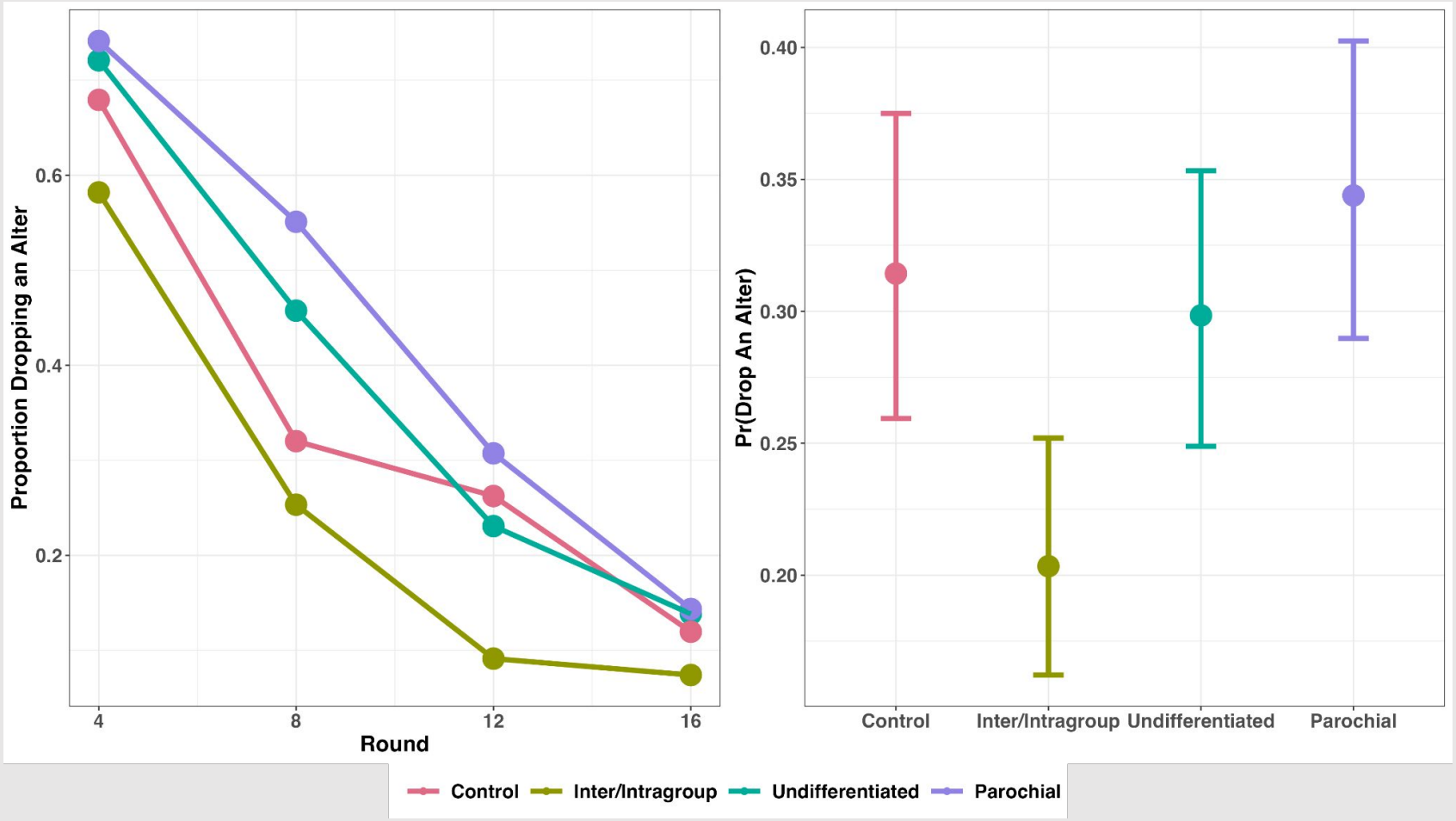
*Lee, Youjin and Elizabeth Ogburn. 2020. "Network Dependence Can Lead to Spurious Associations and Invalid Inference." *JASA* 116(535): 1060-74

Cooperation



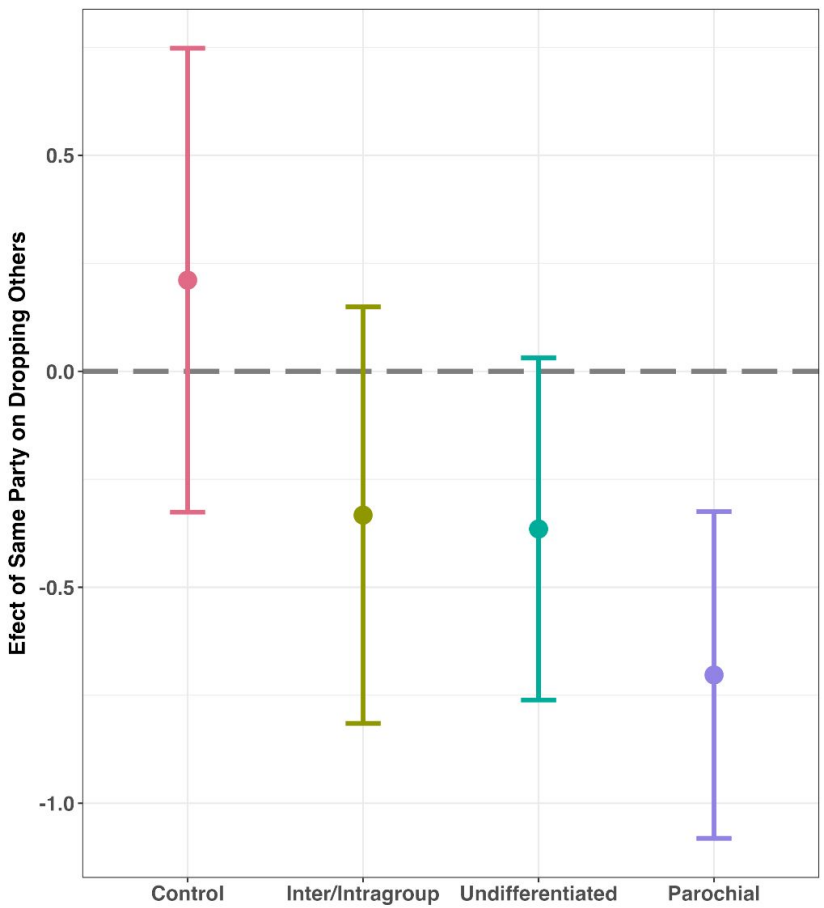


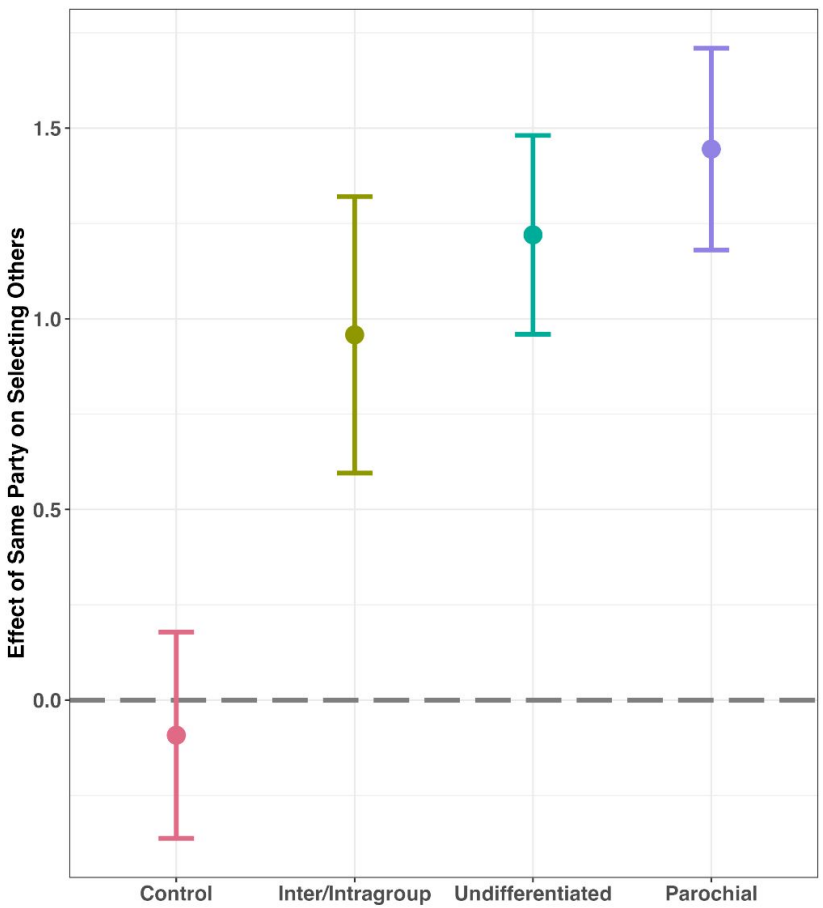
Network Dynamics



In terms of network change, we observe the least change in the Inter/Intra group condition

Network Dynamics

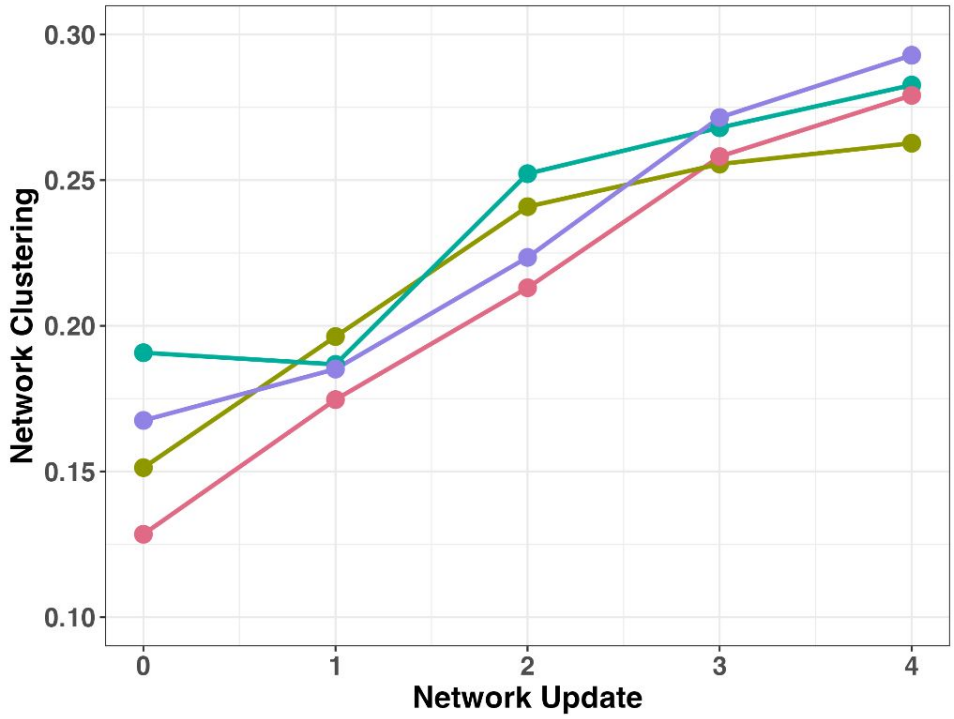


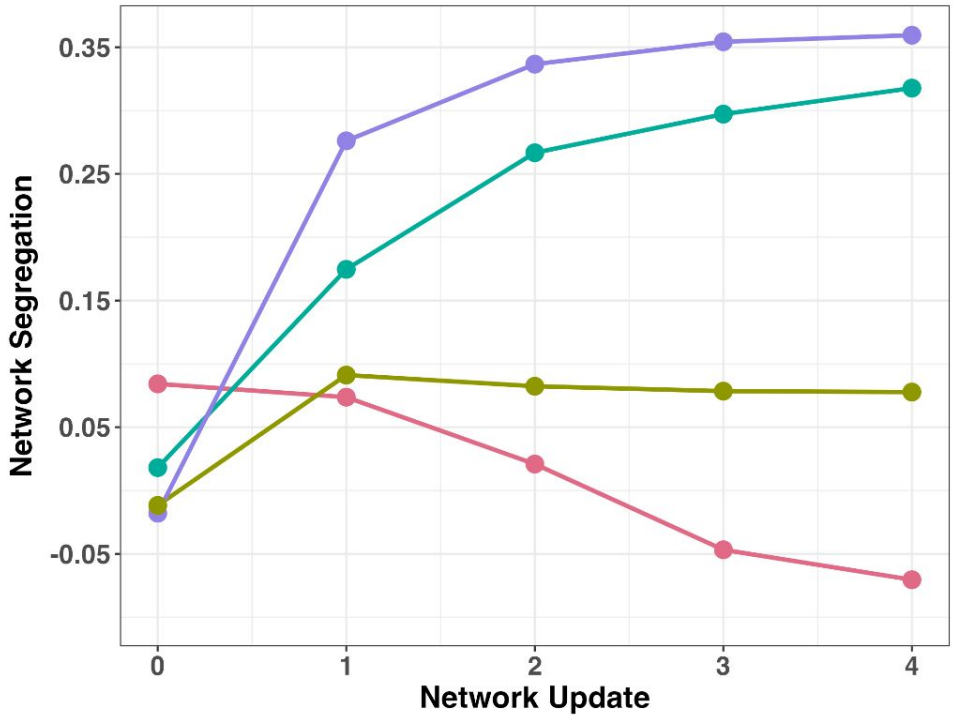


Less turnover in the Inter/Intra group reputation condition

And weaker effects of homophily when there is network change

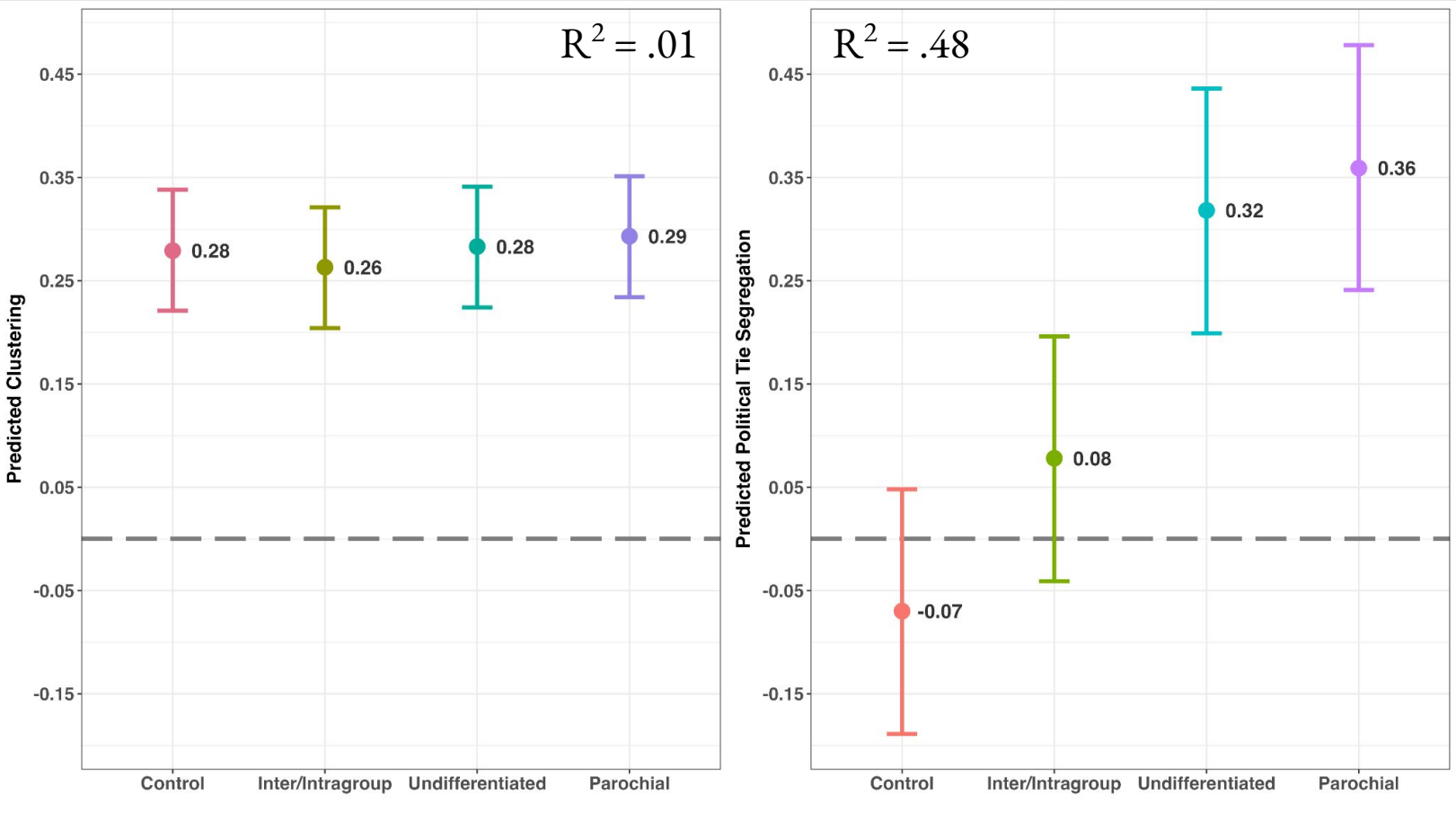
Emergence of clustering and segregation





Control Inter/Intragroup Undifferentiated Parochial

Emergence of clustering and segregation

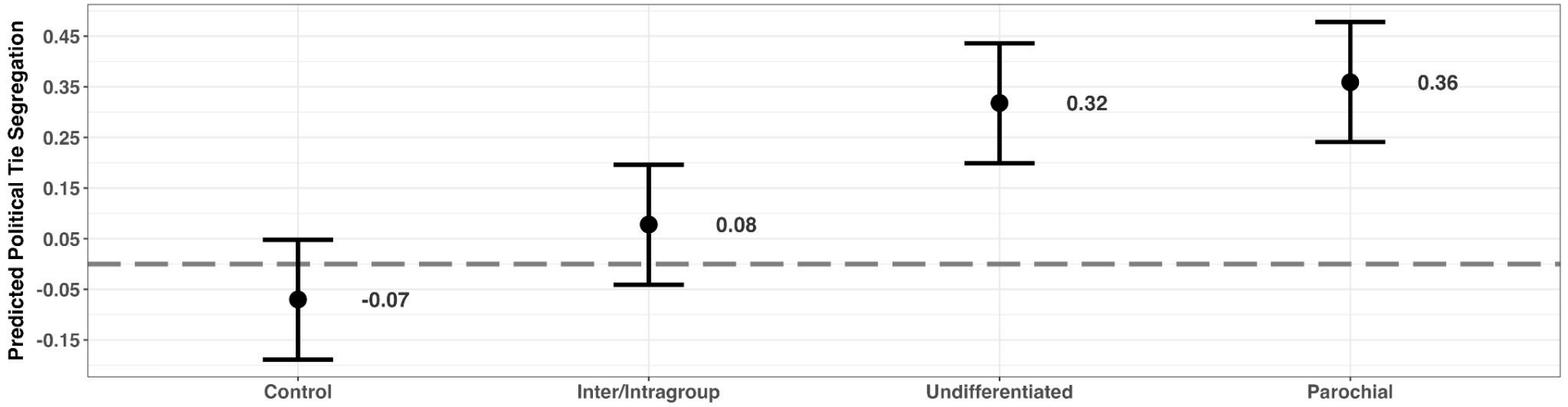


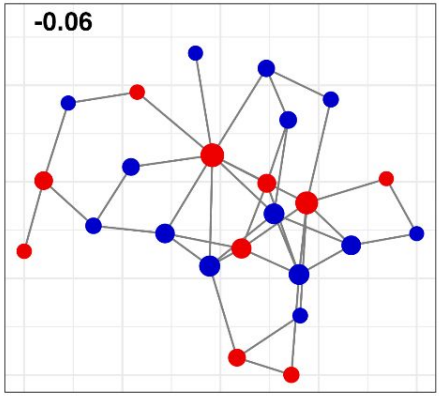
OLS regressions predicting clustering and segregation at the end of the study (each network is a single case, N = 40)

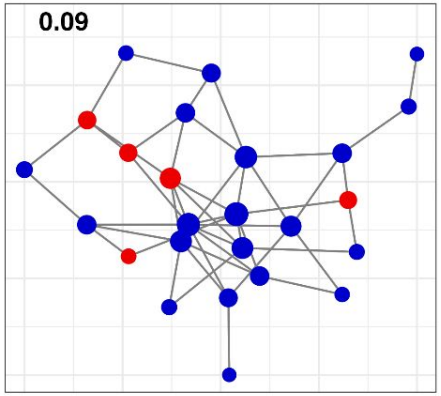
In all networks, we see the emergence of clustering

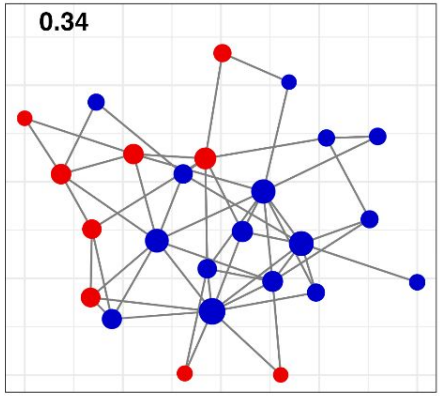
Parochial and Undifferentiated reputation systems result in the emergence of political segregation

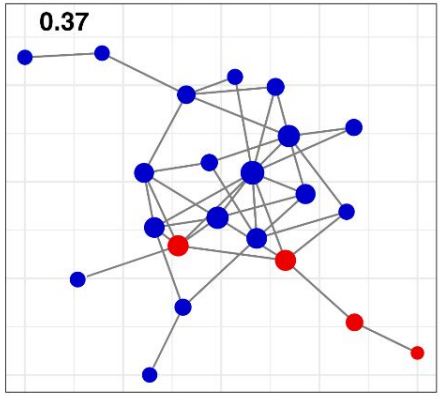
Marginal Segregation and Representative Networks











Political Identity • Democrat • Republican

Endowment • 2000 • 4000 • 6000 • 8000 • 10000 • 12000

Robustness

We tested for network dependence* and replicated our results on the subset of data that does not show significant network dependence on cooperation

Results are not moderated by participant sex, whether the participant is a republican or democrat, nor whether the participant is politically extreme (==1 or ==6)

*Lee, Youjin and Elizabeth Ogburn. 2020. "Network Dependence Can Lead to Spurious Associations and Invalid Inference." *JASA* 116(535): 1060-74

Summary of results

We replicate past work, illustrating that social differentiation often leads to the emergence of segregation

Higher ingroup cooperation and preferential attachment to ingroup members

Results in the emergence of clustering and segregation

When reputations replace ingroup heuristics, we can reduce effects of ingroup favoritism and eliminate the emergence of political segregation

Discussion

Participants were after money

- Unclear how this works when interactions are zero sum (instead of mutually beneficial) or when the outcome is symbolic (as many political outcomes are)

Intergroup ties may cascade

- Reputation diffusion as a mechanism for heterogeneous triadic closure

Signals of Trustworthiness may increase Intergroup ties

Next steps

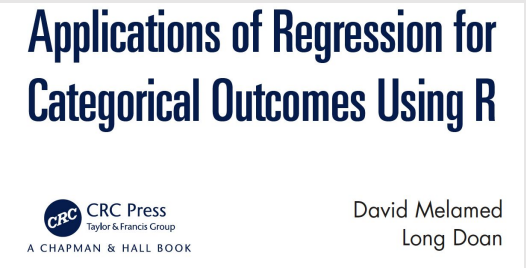
Are our results robust to situations with between-group competition?

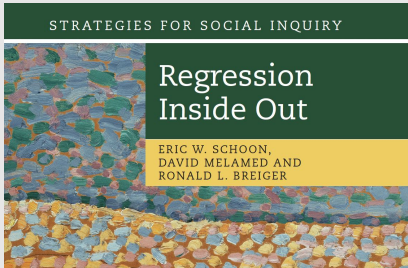
How network position and social differences shape the formation of reputations when there is no monitoring system, i.e., when reputations are also emergent

Translational impact - can we develop reputation systems for online interactions that yield similar results

Broader Research Agenda

- Interested in emergence of sociological outcomes (cooperation, stratification) in complex systems
  - E.g., How do individual decisions in networks aggregate to shape collective outcomes, such as segregation?
  - How do status hierarchies evolve in task discussion groups?
- Methods research
  - Applied Statistics in R::mixed model functions
  - Regression Inside Out
- Largely use experimental and observational data
  - Large-scale experiments, traditional lab studies, representative samples (e.g., AmeriSpeak), social media data, simulations, and more recently applying natural language processing/ML methods to qualitative data





Thanks (melamed.9@osu.edu)

Descriptive Statistics

- Self identified Repubicans were 33% of participants.
- Average age was 37.9 (sd = 12.6)
- 50.2% Female at birth
- Race: 79% white, 5% black, 8% Asian, 6% Latino, 2% Other

Five mechanisms that promote cooperation

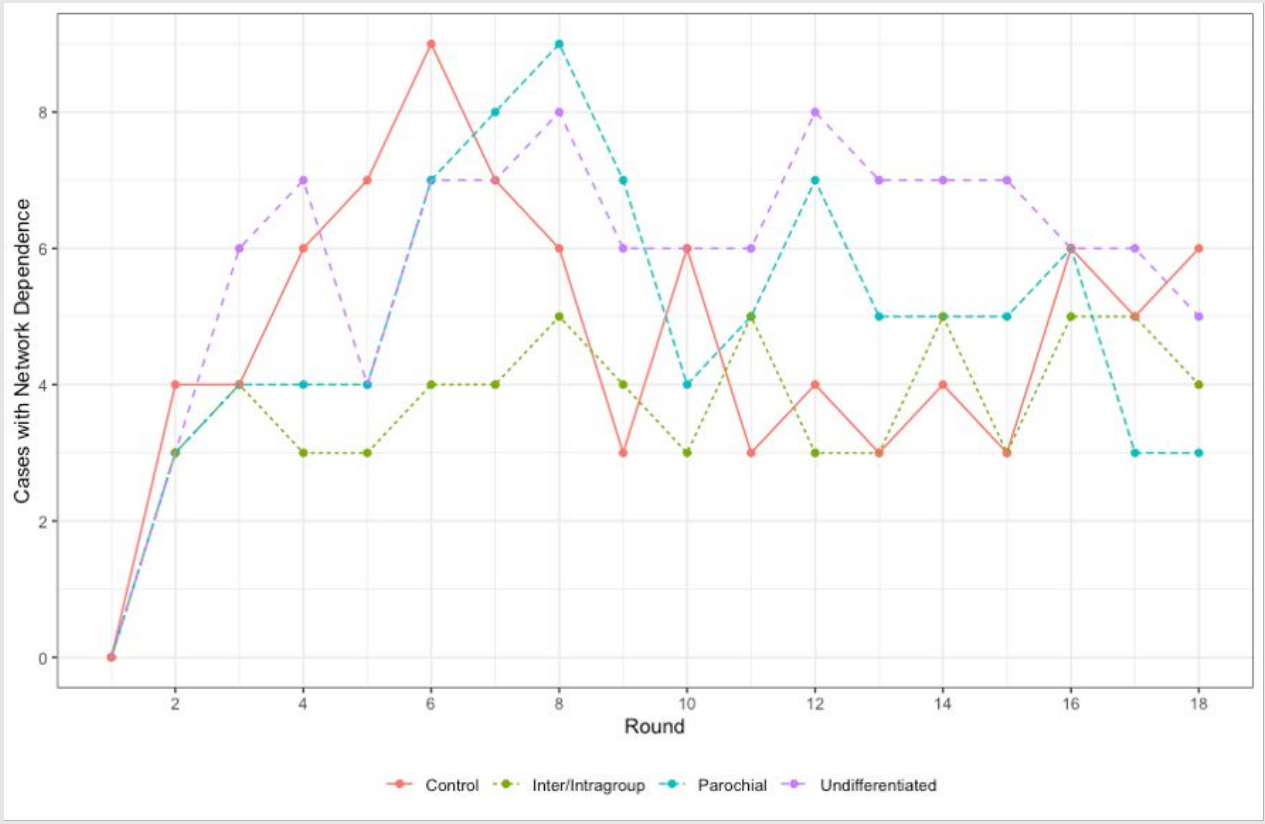
- 4) Multilevel selection – competition between groups promotes cooperation within groups (wilson 1975; bowles and gintis 2011)
  - "There can be no doubt that a tribe including many members who were always ready to sacrifice themselves for the common good would be victorious over other tribes; and this would be natural selection." (Darwin 1871)
- 5) kin selection (inclusive fitness) – cooperation is more likely as relatedness increases (hamilton 1964)

Cooperation in rounds 1-8. Variance components excluded for brevity. N = 31,442 Models 1 & 2; N = 26,053 Model 3

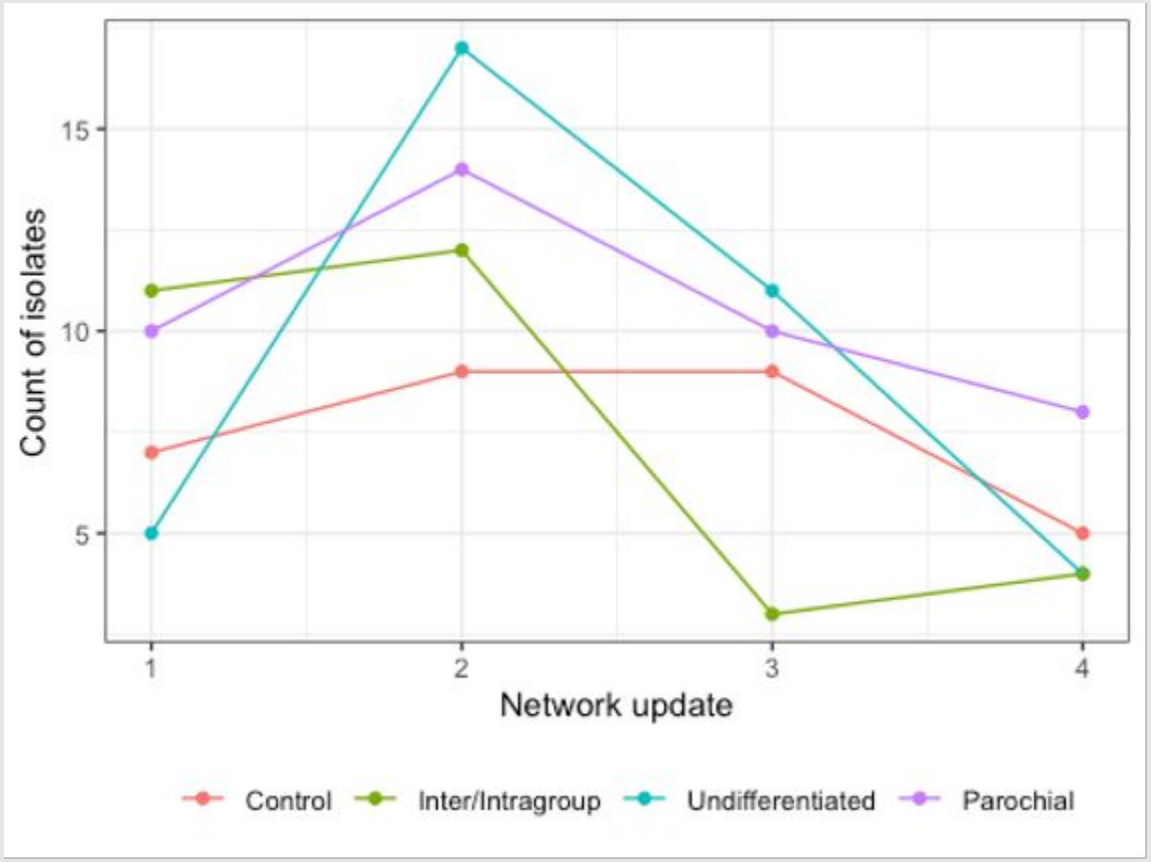
	Model 1	Model 2	Model 3
Parochial Reputations[1] (P)	-5.771 (.999)	-9.389*** (<.001)	-5.764 (.999)
Inter/Intragroup Reputations[1] (I)	-1.712*** (<.001)	-3.076*** (<.001)	-1.442 (.251)
Undifferentiated Reputations[1] (C)	-4.012 (.999)	-6.093*** (<.001)	-3.592 (.999)
Homophily (H)	2.482*** (<.001)	-.735 (.072)	-.456 (.161)
P H		5.980*** (<.001)	3.171*** (<.001)
I H		2.112*** (<.001)	1.088* (.063)
C H		3.351*** (<.001)	1.643** (.009)
Intercept	39.801 (.999)	41.807*** (<.001)	20.243 (.999)
Direct Reciprocity			.534*** (<.001)

Network Dependence

Count of network-rounds with significant network dependence on cooperation. Results derive from computing the association between neighbors' cooperation, i.e., the spatial correlation, and comparing it to a null distribution derived from permuting cooperation within network-rounds.



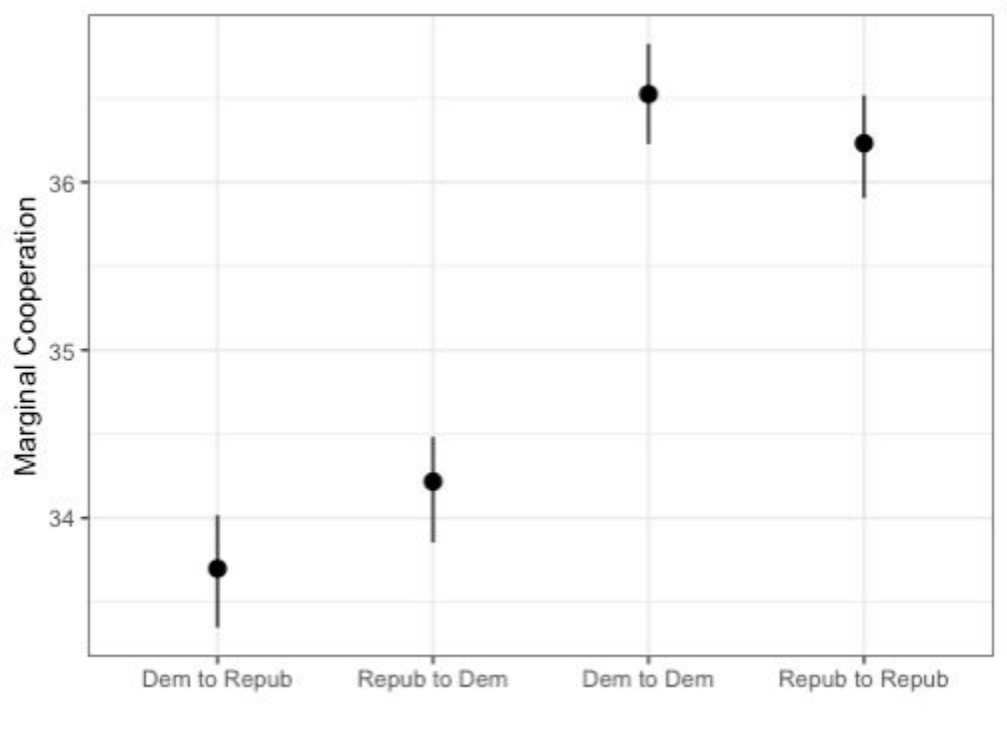
Network isolated by condition



Sensitivity Analyses

Robust to participant sex, political party, and political extremism

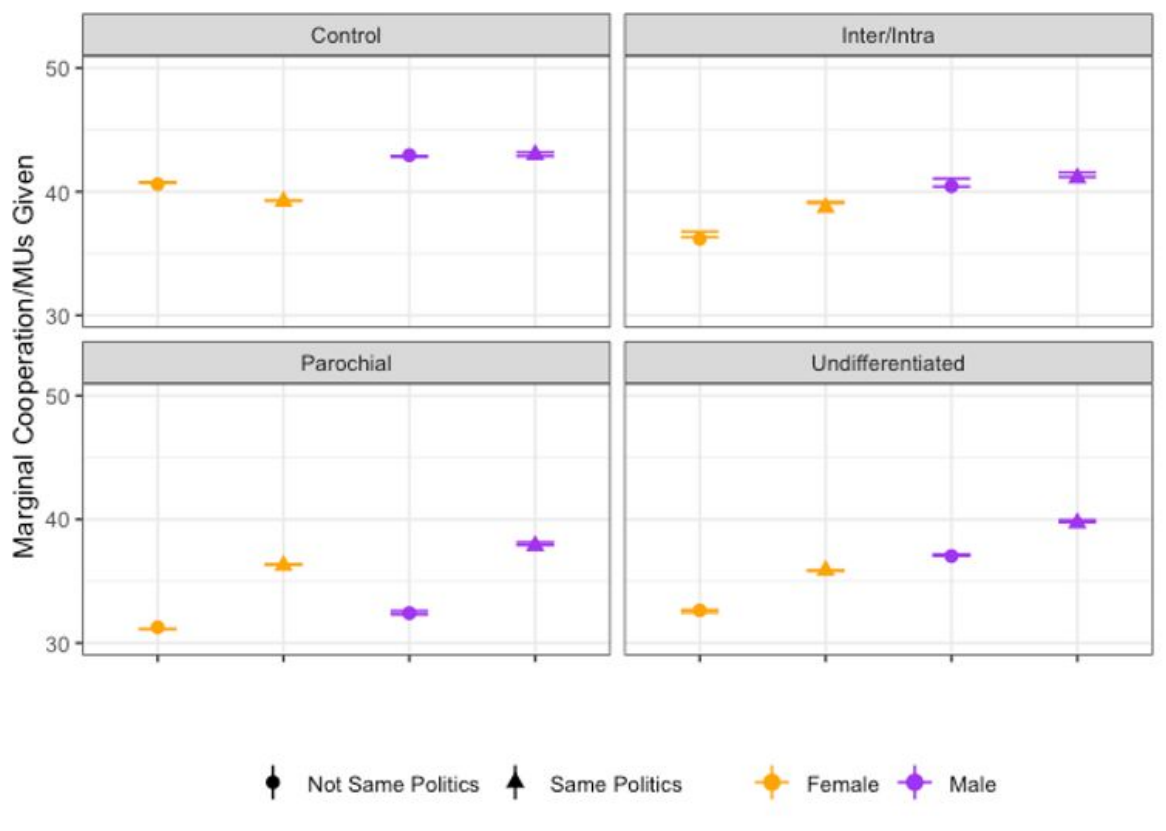
Political Party:



Sensitivity Analyses

Robust to participant sex, political party, and political extremism

Sex: Females give slightly less overall, otherwise patterns are similar



Sensitivity Analyses

Robust to participant sex, political party, and political extremism

Extremists or "Strong Identifiers": Little effect

Overview of scholarship

Status Processes:

1. Substance - whether group moderators can offset status generalization from race
2. Methods - developing a computational pipeline to automate coding the status significance of task group discussions

Regression Inside Out:

1. Decompose general linear models to show how each case contributes to the overall model coefficients
2. Visualization techniques that illustrate cases and variables in the same space

Applied Statistics:

1. Tools for the GLM in R
2. Developing tools for multilevel or mixed effects models in R