Modeling how social network algorithms can influence opinion polarization.

Information Sciences 588 (2022)

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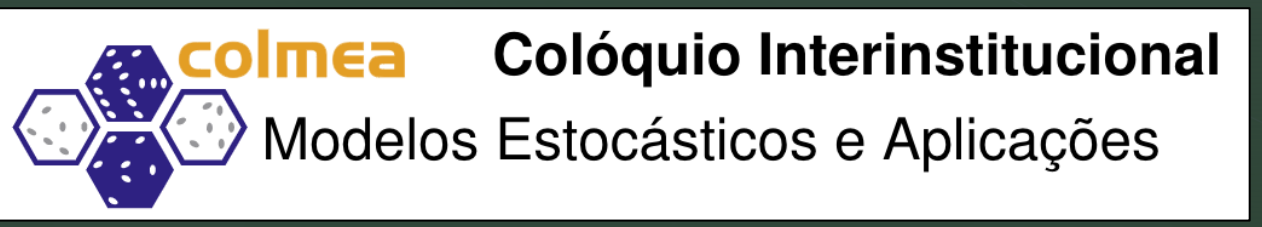

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Motivation: Democracy on the Digital Era

Delegation process

RESEARCH ARTICLE

Analyzing a networked social algorithm for collective selection of representative committees

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A networked voting rule for democratic representation

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Sense making process

Polarization inhibits the phase transition of Axelrod's model

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Robustness of cultural communities in an open-ended Axelrod's model

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Modelling how social network algorithms can influence opinion polarization

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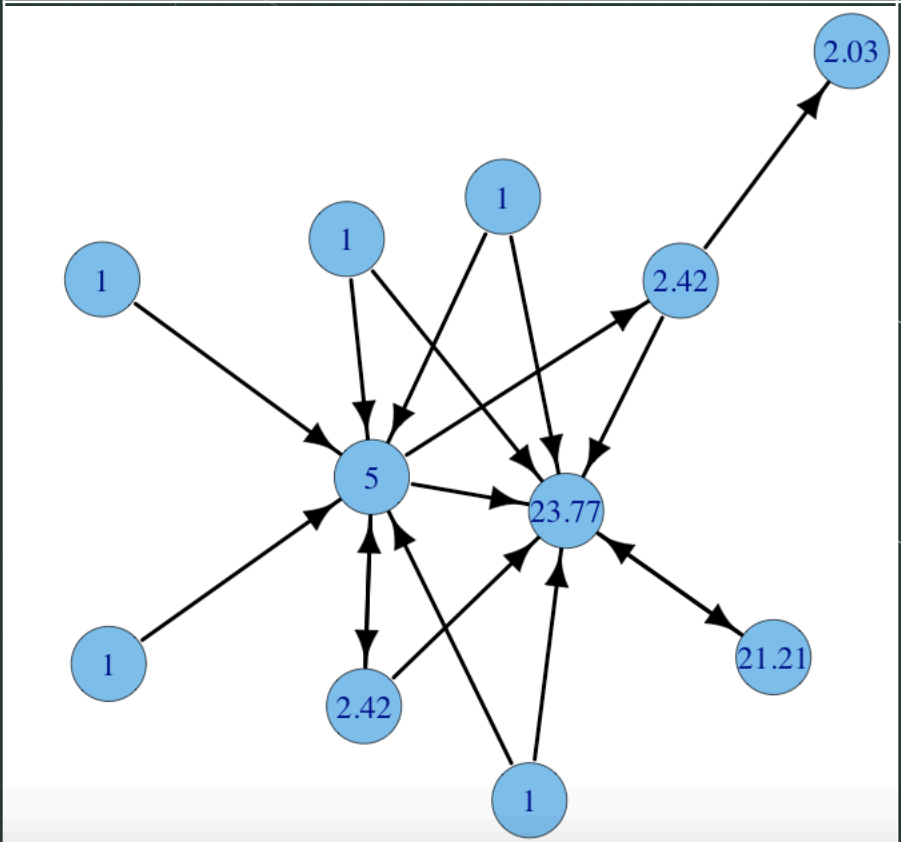
Delegation process



Collective Intelligence

↓

Self Organized Criticality

↓

Feedback loops

↓

Recommendations Systems

↓

Searching algorithms

Sense making process

- Polarization: an obstacle for the emergence of collective intelligence.
- Social networks takes advantage of outrage to capture users' attention.

[Center for Humane Technology]

Polarization inhibits the phase transition of Axelrod's model

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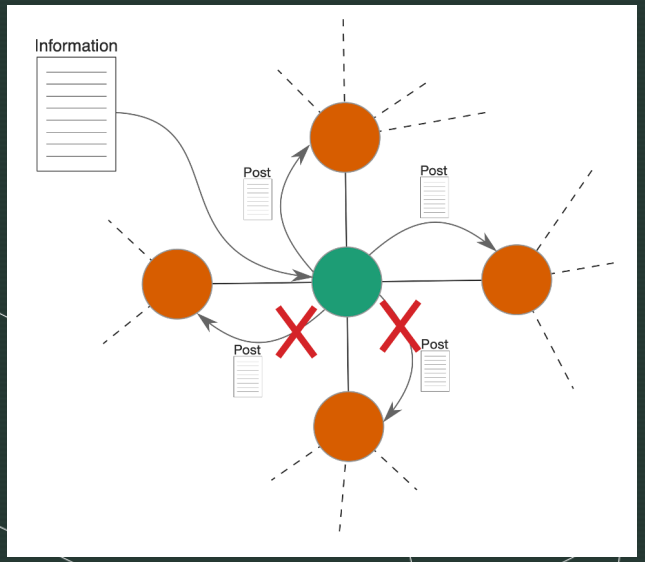
Model

Agents are distributed in a Network of friendship relations and their opinions are represented by a real number "b_i" in [-1,1]. The dynamics is comprehended by four processes:

- Transmission (related to individual's behavior)
- Distribution (related to the social network's algorithm)
- Attraction (or repulsion)
- Rewiring (change in friendship relationship)

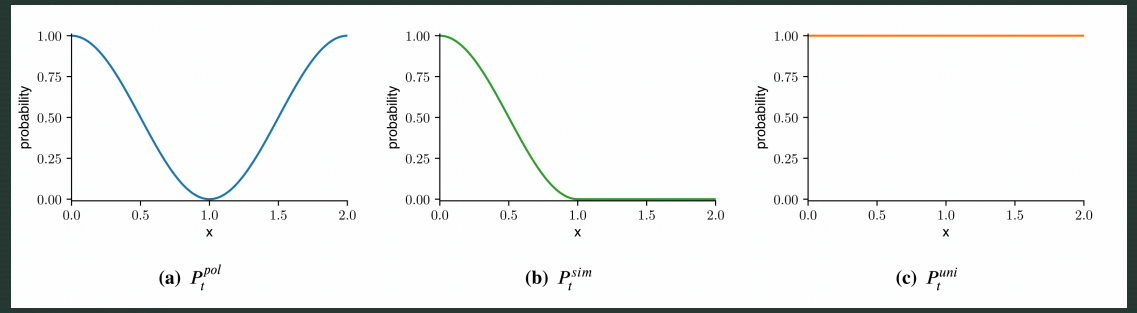


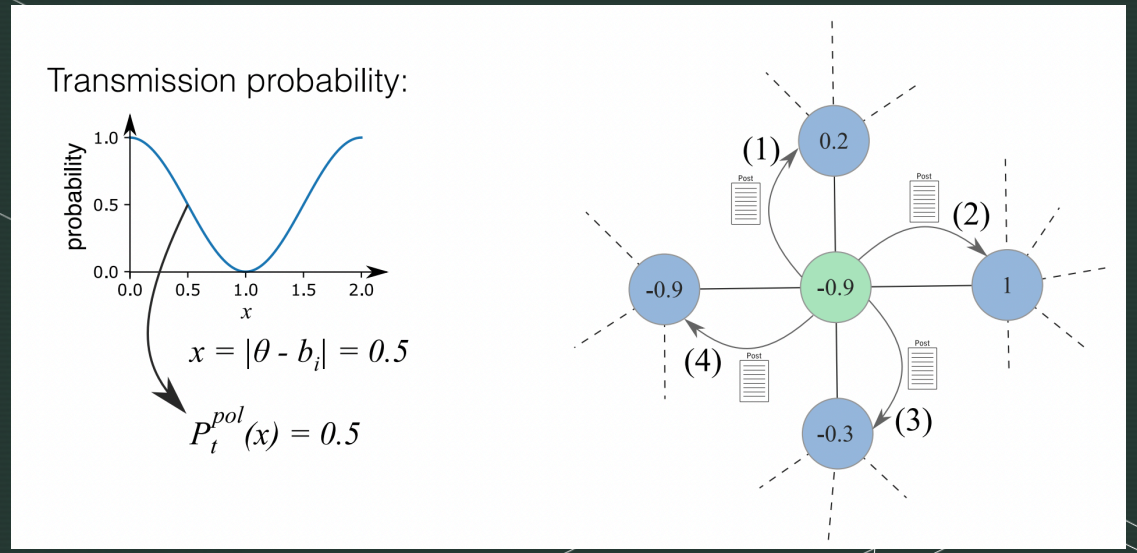
Transmission

Describe Agent's behavior:

A post will be shared depending on the relative distance between the agent's opinion b_i and the post position θ.

We consider tree different kind of users.



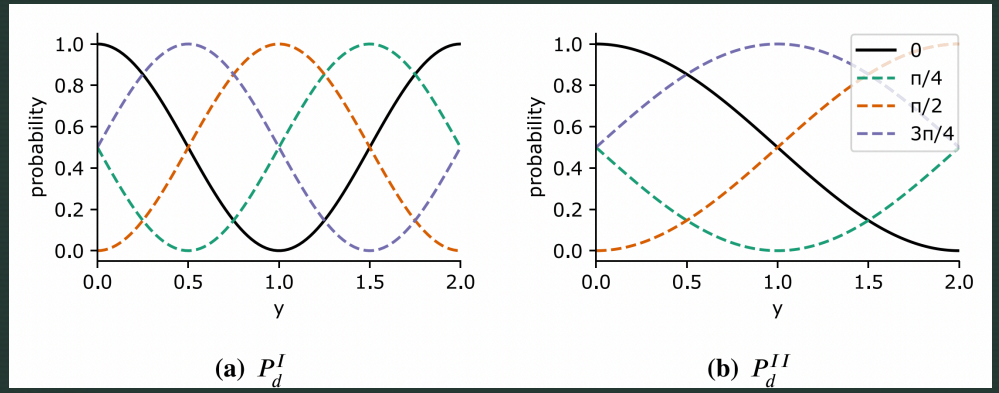


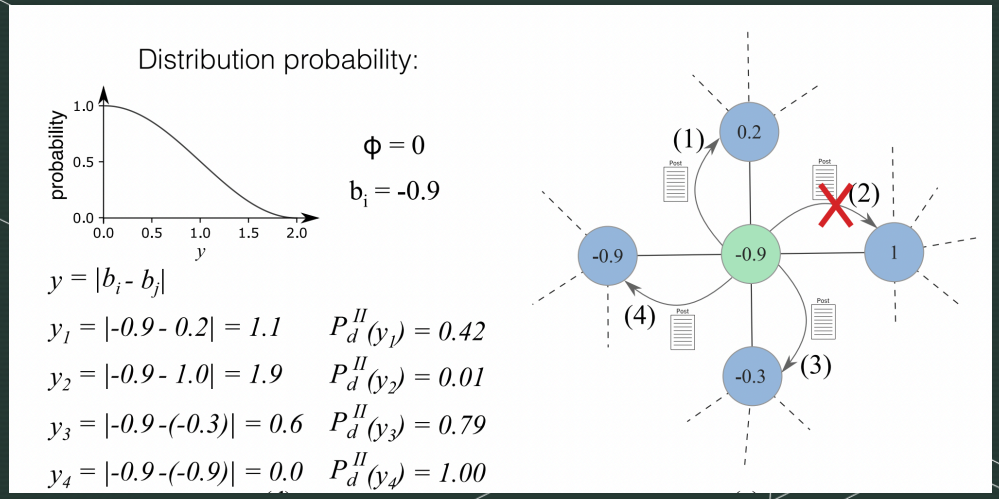
Distribution

Describe the Algorithm behavior:

The social network's algorithm decide to which friends to distribute the post, based on the relative distance between the agent's opinions ($|b_i - b_j|$).

We consider two different algorithms.





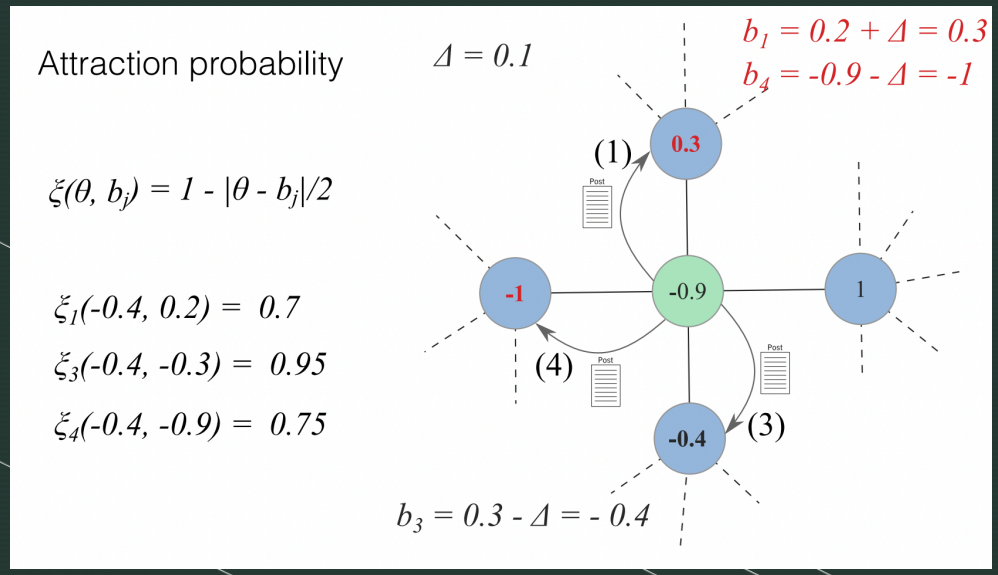
Attraction

Describe the effect of the received post on the agent's opinion:

The agent's opinion approach to the post value θ by a small amount Δ with a probability:

$$\xi(\theta, b_j) = 1 - |\theta - b_j|/2$$

otherwise, the agent's opinion departures from θ by the same amount Δ.

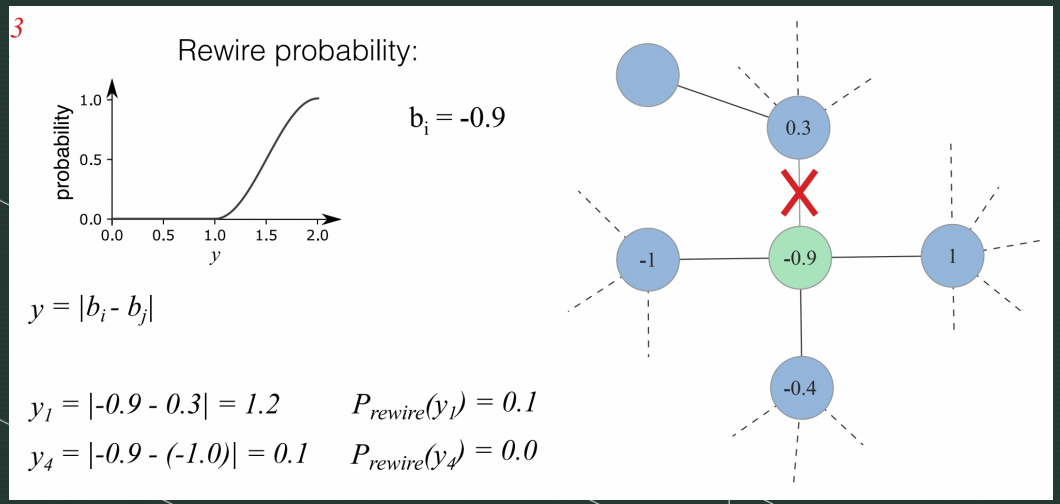


Rewiring

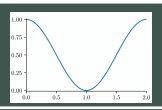
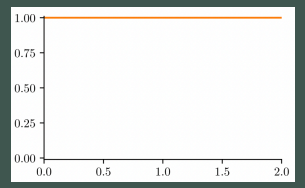
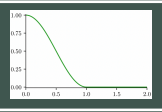
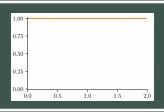
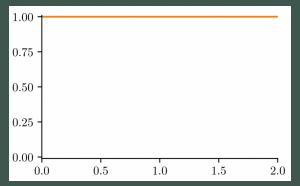
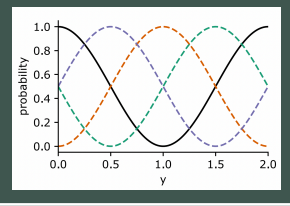
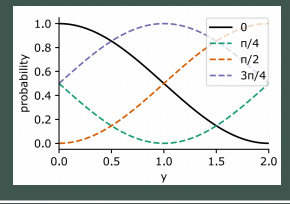
Describe the situation when the receiving agent decide to unfriend the transmitting agent.

When a receiving agent experience a repulsive interaction, it considers to unfriend the transmitting agent. In this case a new friendship relation is created as a substitution.

The rewiring probability depends on the relative distance between the agent's opinions ($|b_i-b_j|$).



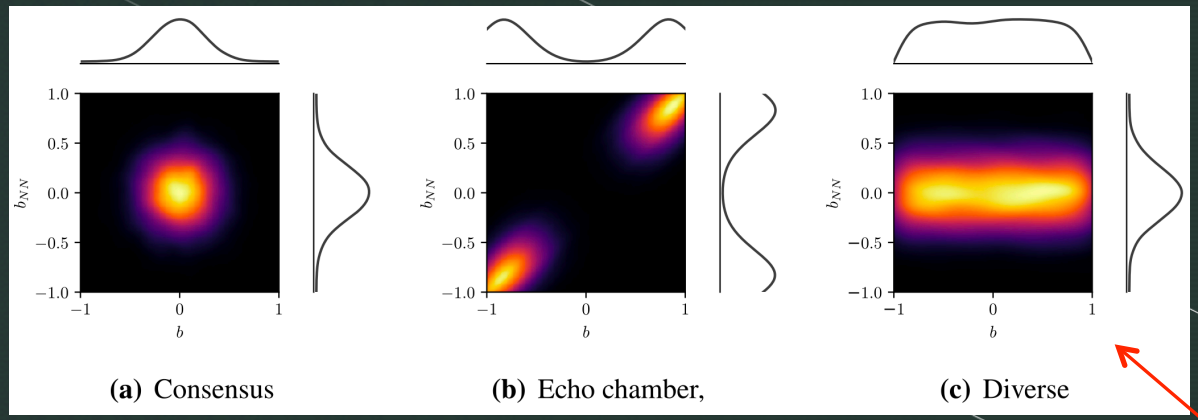
Transmission vs Distribution

Transmission prob.	Distribution prob.	Opinions' distribution
		Bi-modal
		Uni-modal
		Uniform
	 $0 \leqslant \phi < \pi/2$	Uni-modal
	$\pi/2 \leqslant \phi < \pi$	Bi-modal
	 $\pi/4 \leqslant \phi < 3\pi/4$	Uni-modal
	otherwise	Bi-modal

Analysis of opinions' distribution and social structure

Density map of the individuals' opinion "b" against the average opinion of its neighbors, b_{NN}

Social structure



*

Opinions' distribution

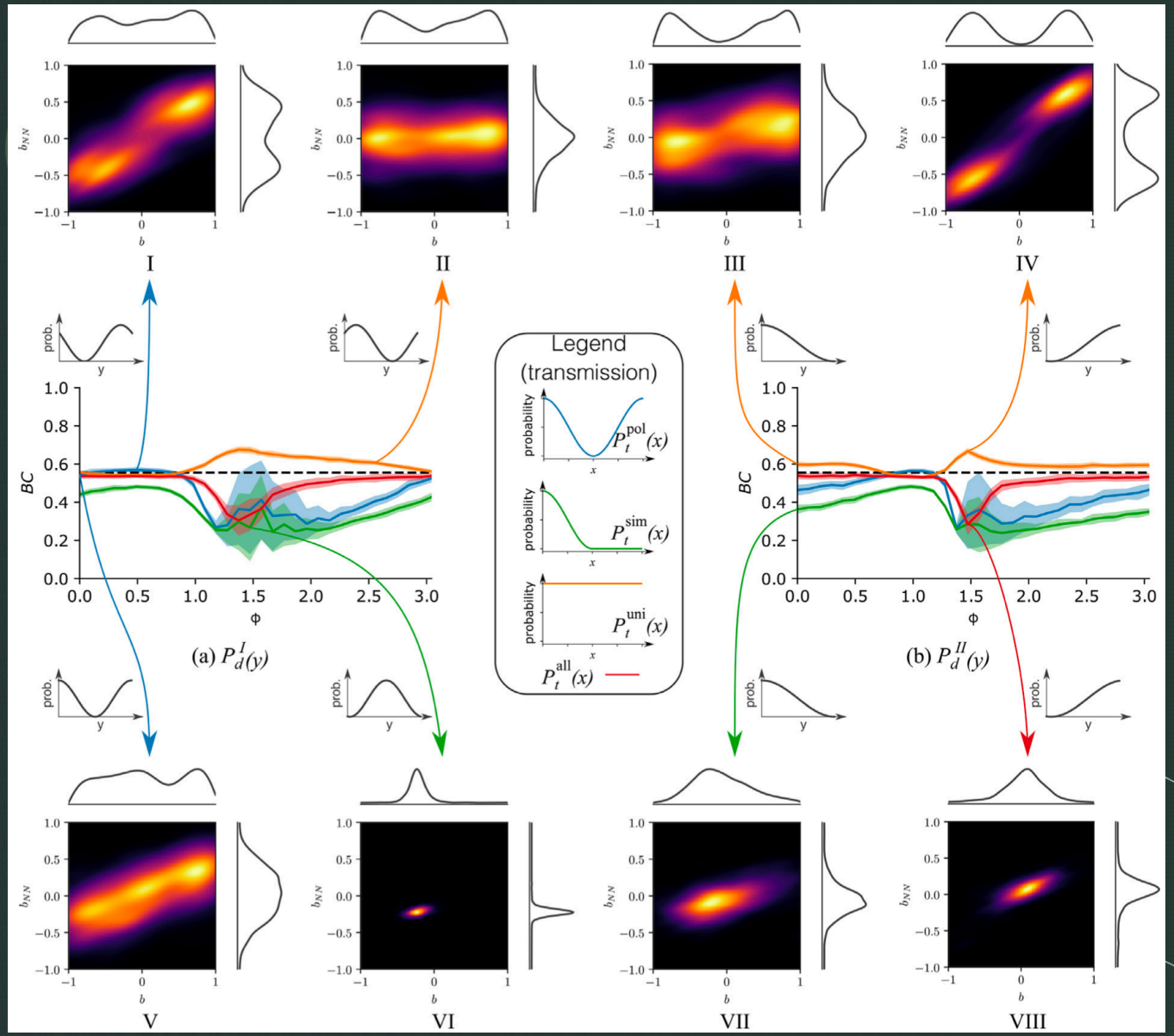
Initial configuration

To quantify opinion's polarization, we use the bimodality coefficient:

$$BC = \frac{g^2 + 1}{k + \frac{3(n-1)^2}{(n-2)(n-3)}},$$

where n is the number of samples, and g and k are the skewness and kurtosis of the analyzed distribution, respectively.

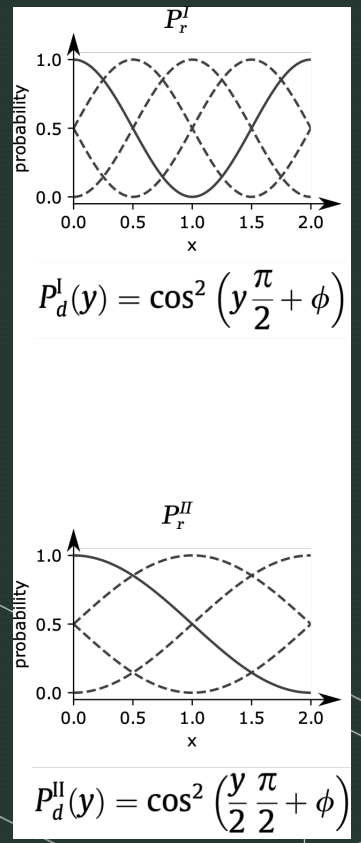
* Bipartite mutualistic network not shown



Empirically BC_{critic} = 5/9

Higher values -> bi-modal

Lower values -> uni-modal



we considered that the dynamic reached the steady state when there were no significant variations of BC along time.

Echo-chambers bistability

Stochastic Block Model (without rewiring)

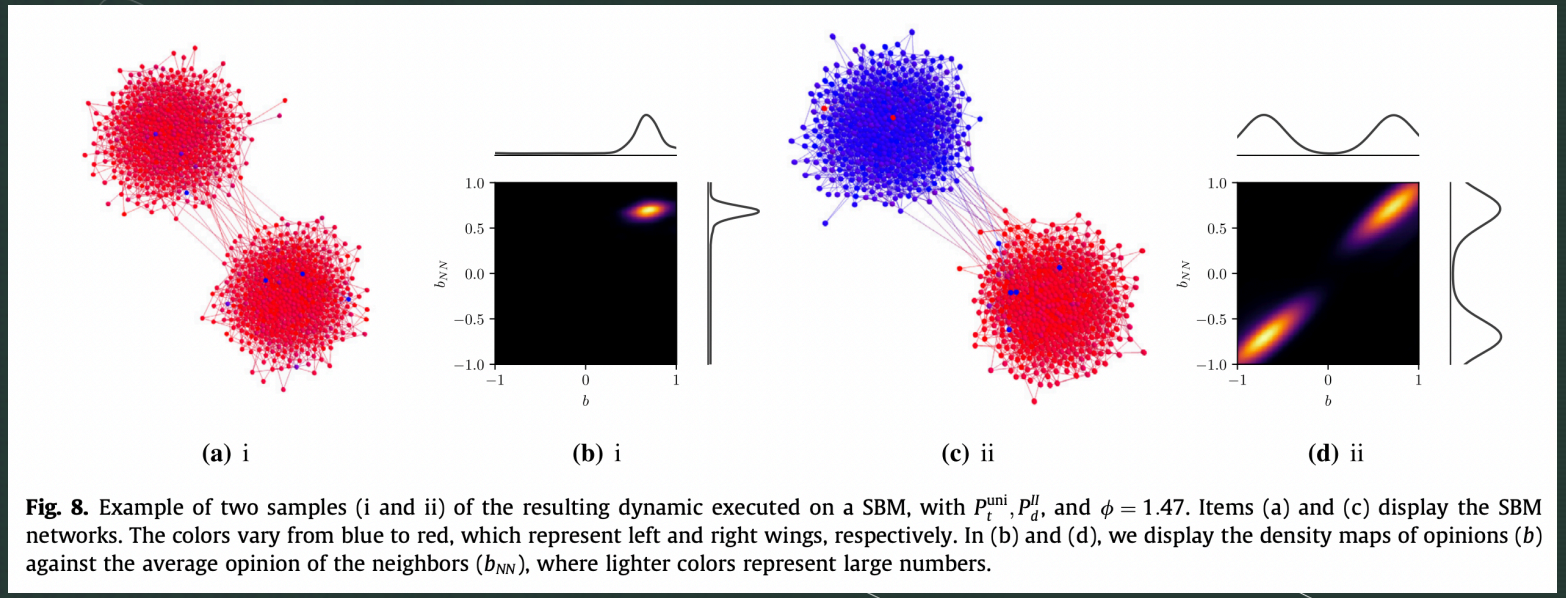
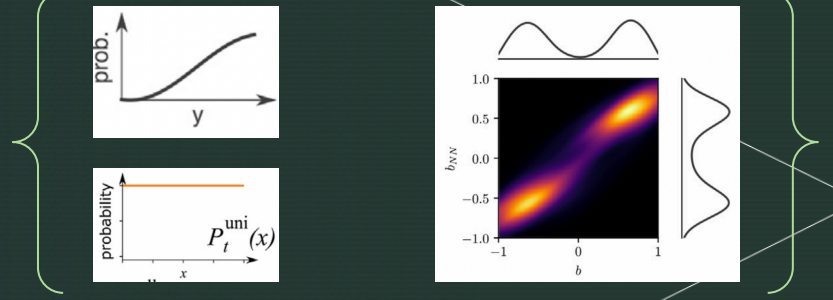


Fig. 8. Example of two samples (i and ii) of the resulting dynamic executed on a SBM, with $P_t^{\text{uni}}, P_d^{II}$, and $\phi = 1.47$. Items (a) and (c) display the SBM networks. The colors vary from blue to red, which represent left and right wings, respectively. In (b) and (d), we display the density maps of opinions (b) against the average opinion of the neighbors (b_{NN}), where lighter colors represent large numbers.

ER network
with rewiring



Comparison with real data: Twitter (US)

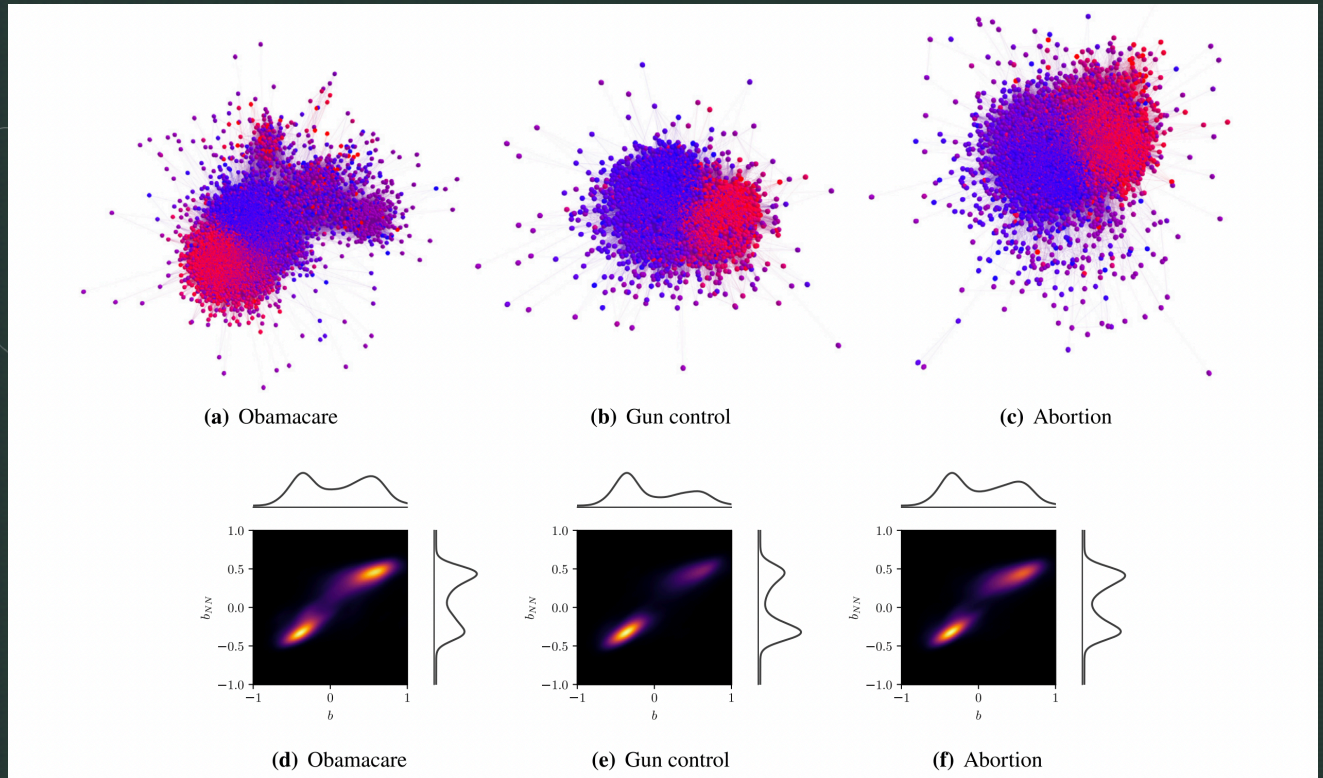


Fig. 9. Real data visualizations. The three first panels display the Twitter network visualizations, in which the colors vary from blue to red. More specifically, blue and red represent left and right wings, respectively. The second line shows the respective density maps of opinions (b) against the average opinion of the neighbors (b_{NN}), in which lighter colors represent large numbers.

Table 1
Measures of bimodality coefficient, BC, and balance, β, obtained from real Twitter networks.

Subject	BC	β
Obamacare	0.60	0.80
Gun control	0.67	0.70
Abortion	0.60	0.91

Conclusions

- The model reproduce a wide range of social phenomena, such as, polarization, echo-chambers, diverse and focalized consensus…
- The distribution's probability (the algorithm) appears to have stronger effects on the final opinions' distribution.
- Real data from Twitter (US) shows a polarized distribution of opinions with echo-chambers formation, this configuration is very similar to one of the scenarios observed in our model.

Thanks