Modelling how social network algorithms can influence opinion polarization

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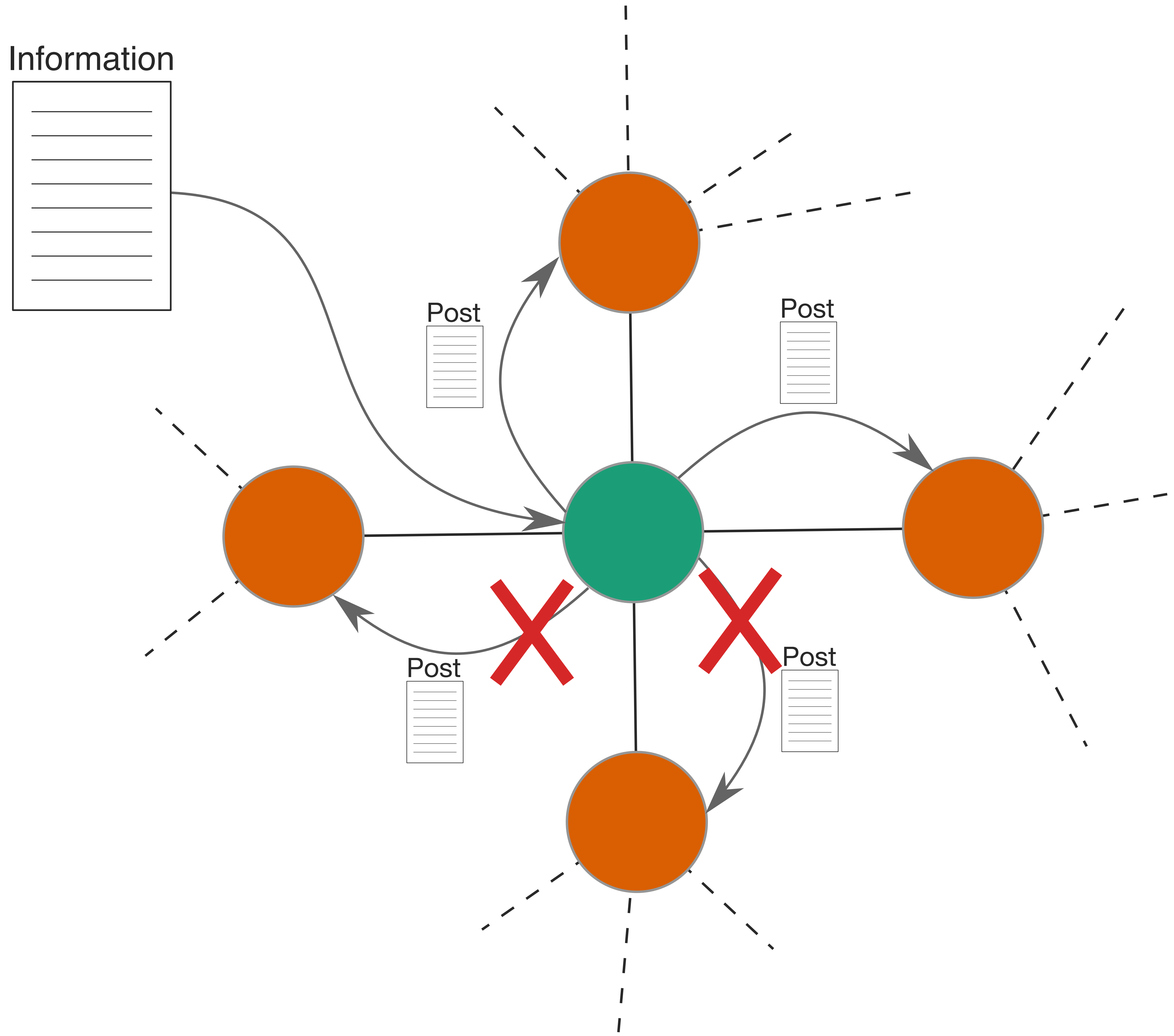
Introduction

- Many opinion models have been proposed based on different aspects of the interaction between people;

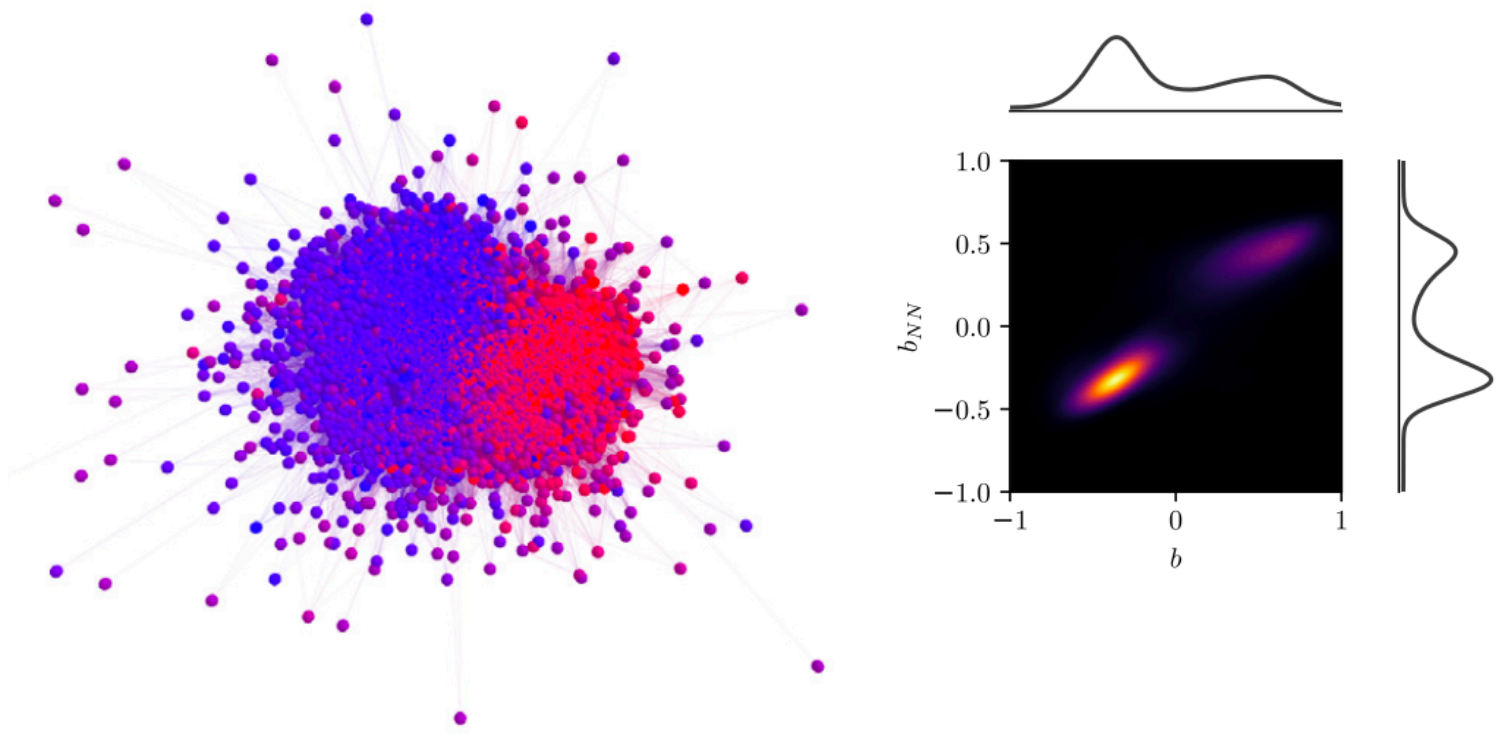
- Objective: propose a model to incorporate the information on the relationship between social network users and the social network;

- Our model simulates how the information from outside of the social network influences the opinions.



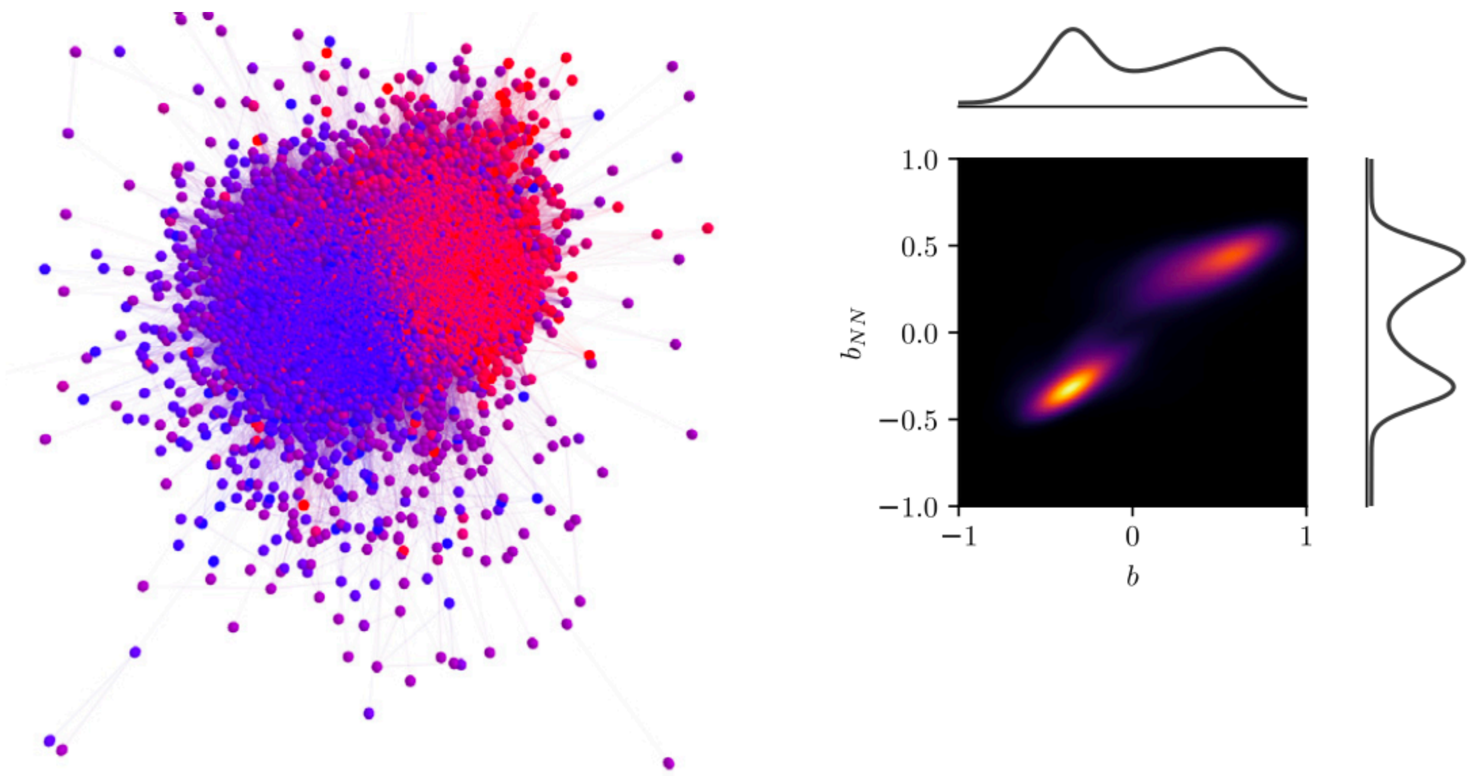
Motivation

Gun control



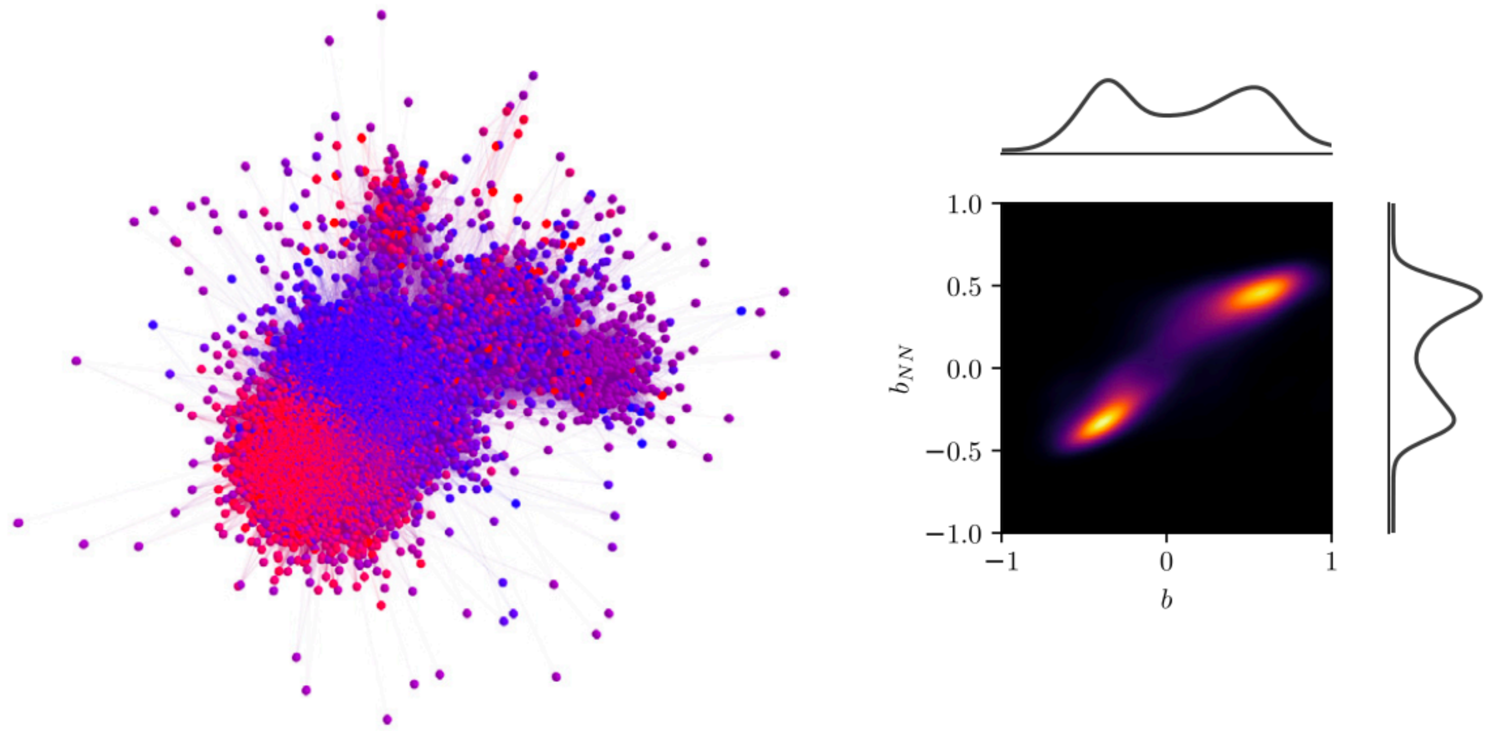
3963 nodes and 1,053,275 edges

Abortion



7401 nodes and 2,330,276 edges

Obamacare



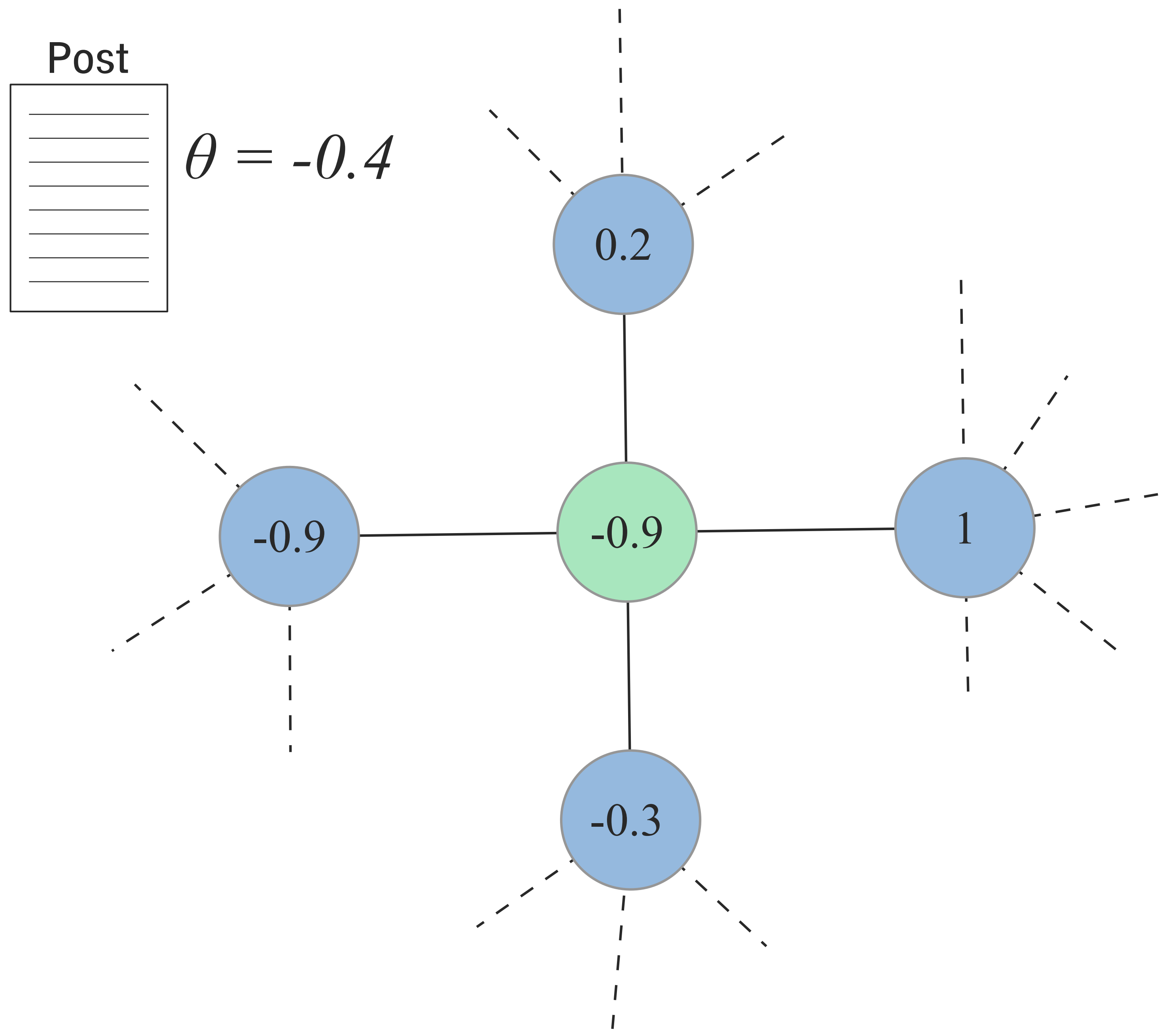
8703 nodes and 3,797,871 edges

Twitter networks: examples of polarization in the United States

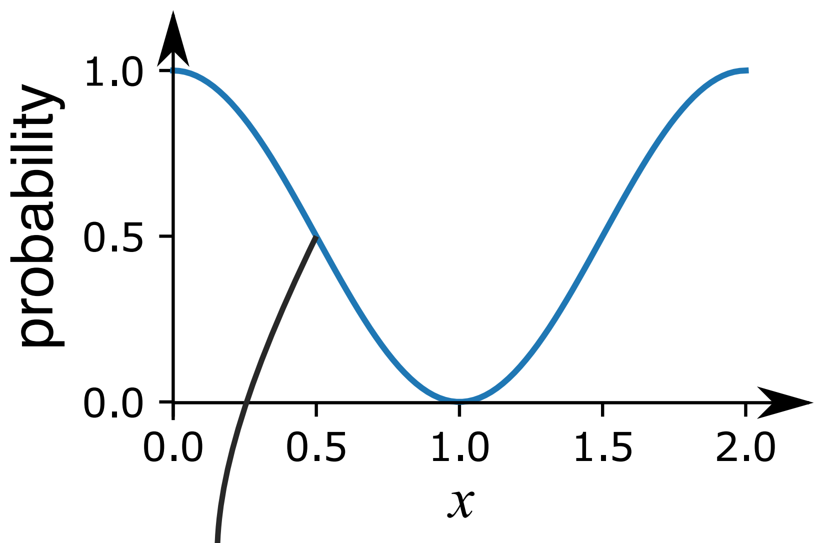
K. Garimella, G. De Francisci Morales, A. Gionis, M. Mathioudakis, Political discourse on social media: Echo chambers, gatekeepers, and the price of bipartisanship, in: Proceedings of the 2018 World Wide Web Conference, 2018, pp. 913–922.

M. Cinelli, G.D.F. Morales, A. Galeazzi, W. Quattrociocchi, M. Starnini, The echo chamber effect on social media, Proceedings of the National Academy of Sciences 118 (2021).

Model: Post transmission

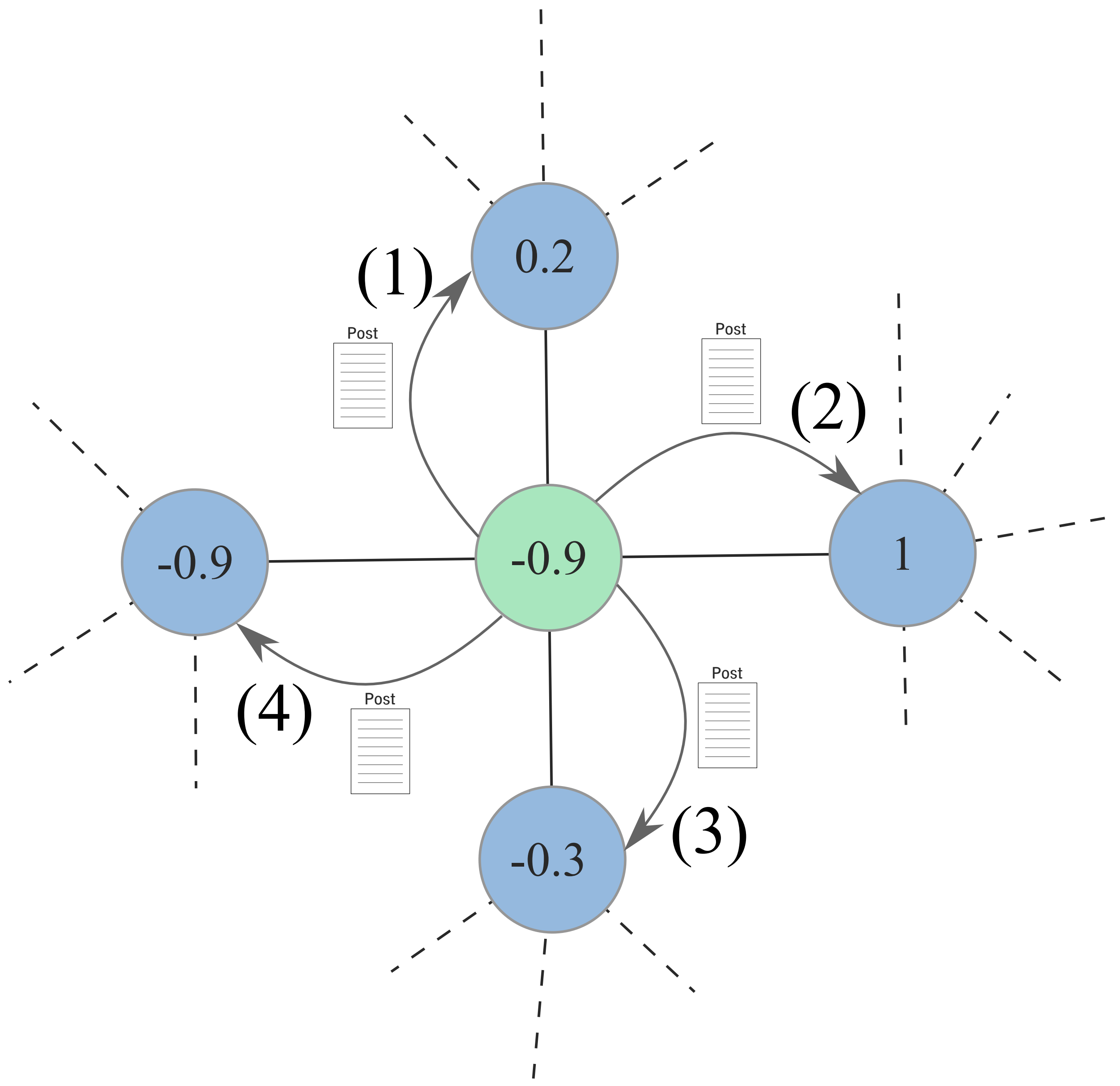


Transmission probability:



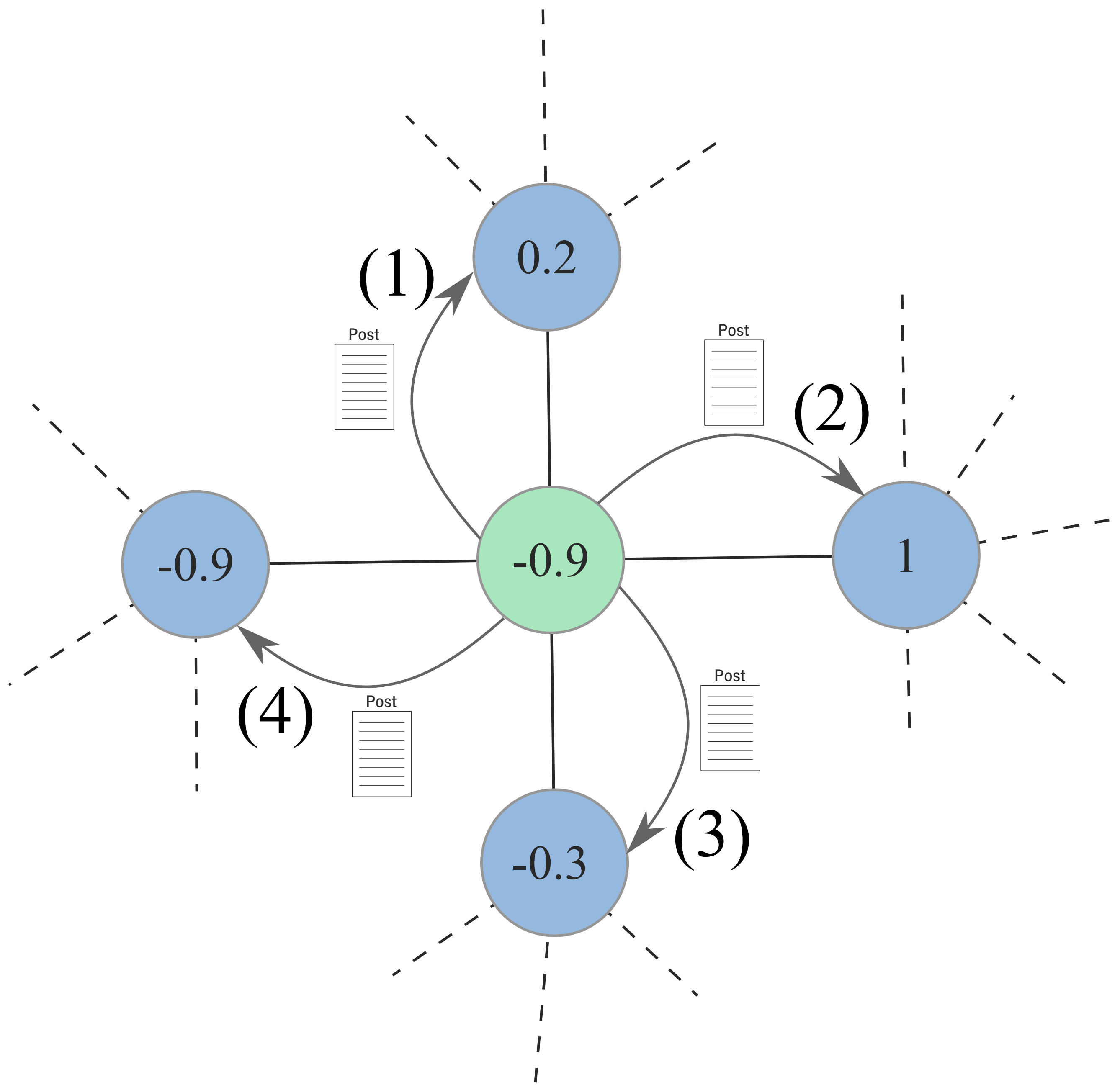
$x = |\theta - b_i| = 0.5$

$P_t^{pol}(x) = 0.5$

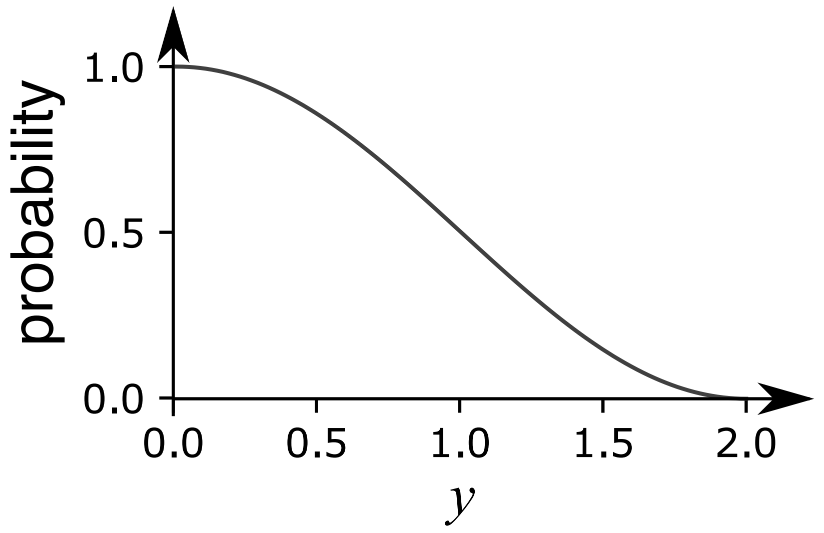


We tested four different user behaviors.

Model: Post reception



Reception probability:



$\phi = 0$

$b_i = -0.9$

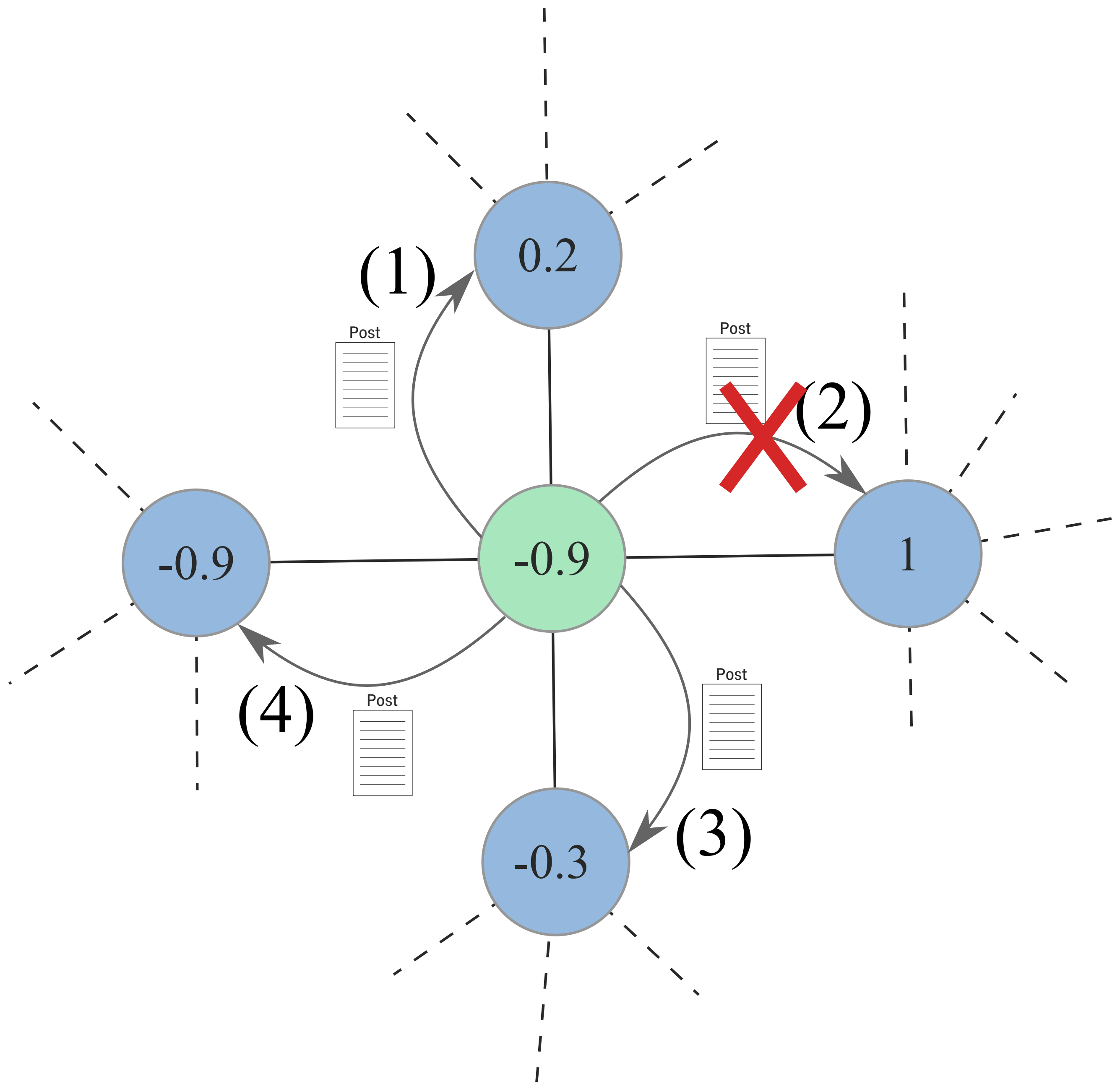
$y = |b_i - b_j|$

$y_1 = |-0.9 - 0.2| = 1.1 \quad P_d^{II}(y_1) = 0.42$

$y_2 = |-0.9 - 1.0| = 1.9 \quad P_d^{II}(y_2) = 0.01$

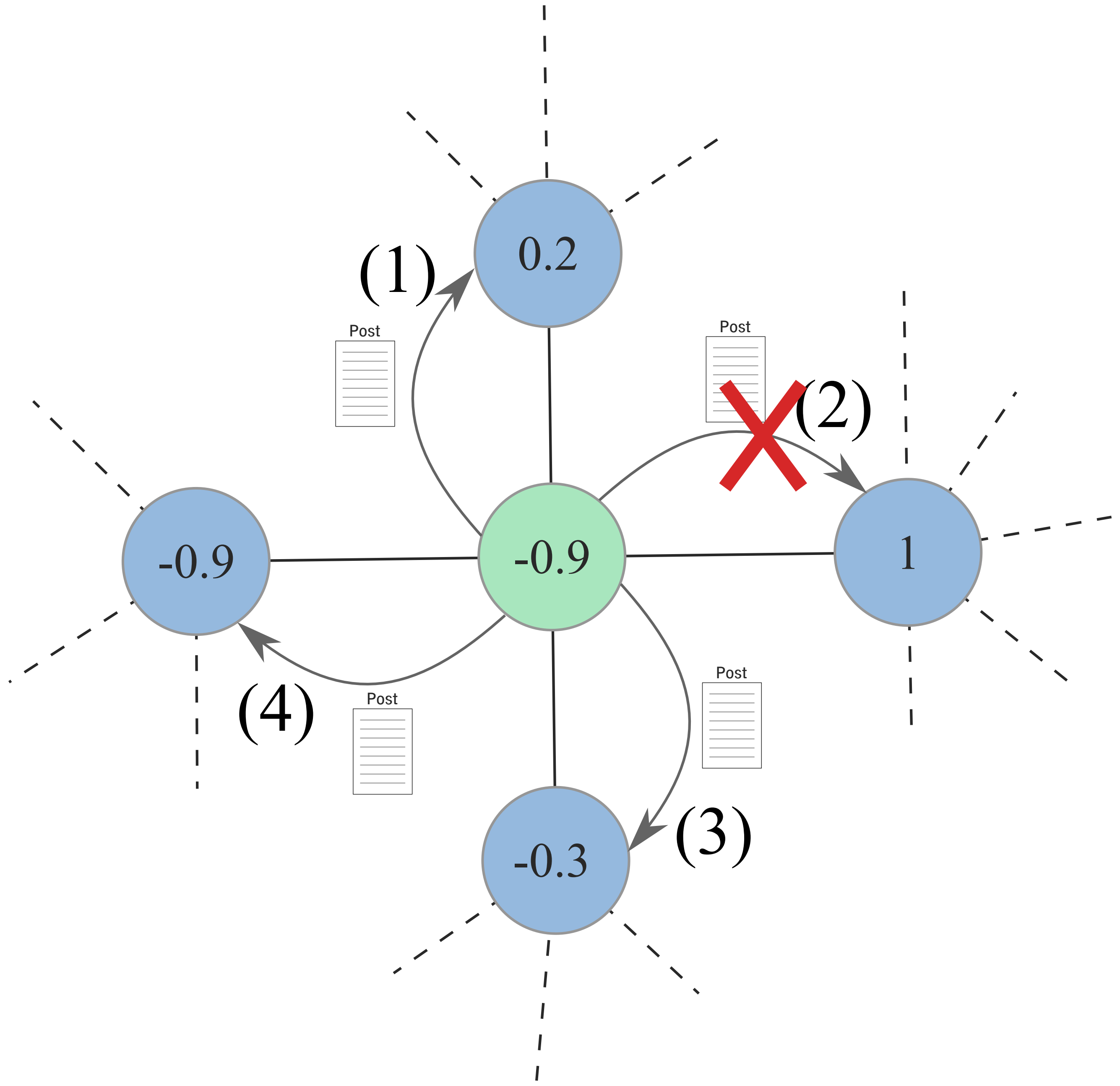
$y_3 = |-0.9 -(-0.3)| = 0.6 \quad P_d^{II}(y_3) = 0.79$

$y_4 = |-0.9 -(-0.9)| = 0.0 \quad P_d^{II}(y_4) = 1.00$



This step simulates the social network algorithm.
We tested several possibilities of algorithms.

Model: Atraction



Attraction probability

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

$$\xi_1(-0.4,\ 0.2) = \ 0.7$$

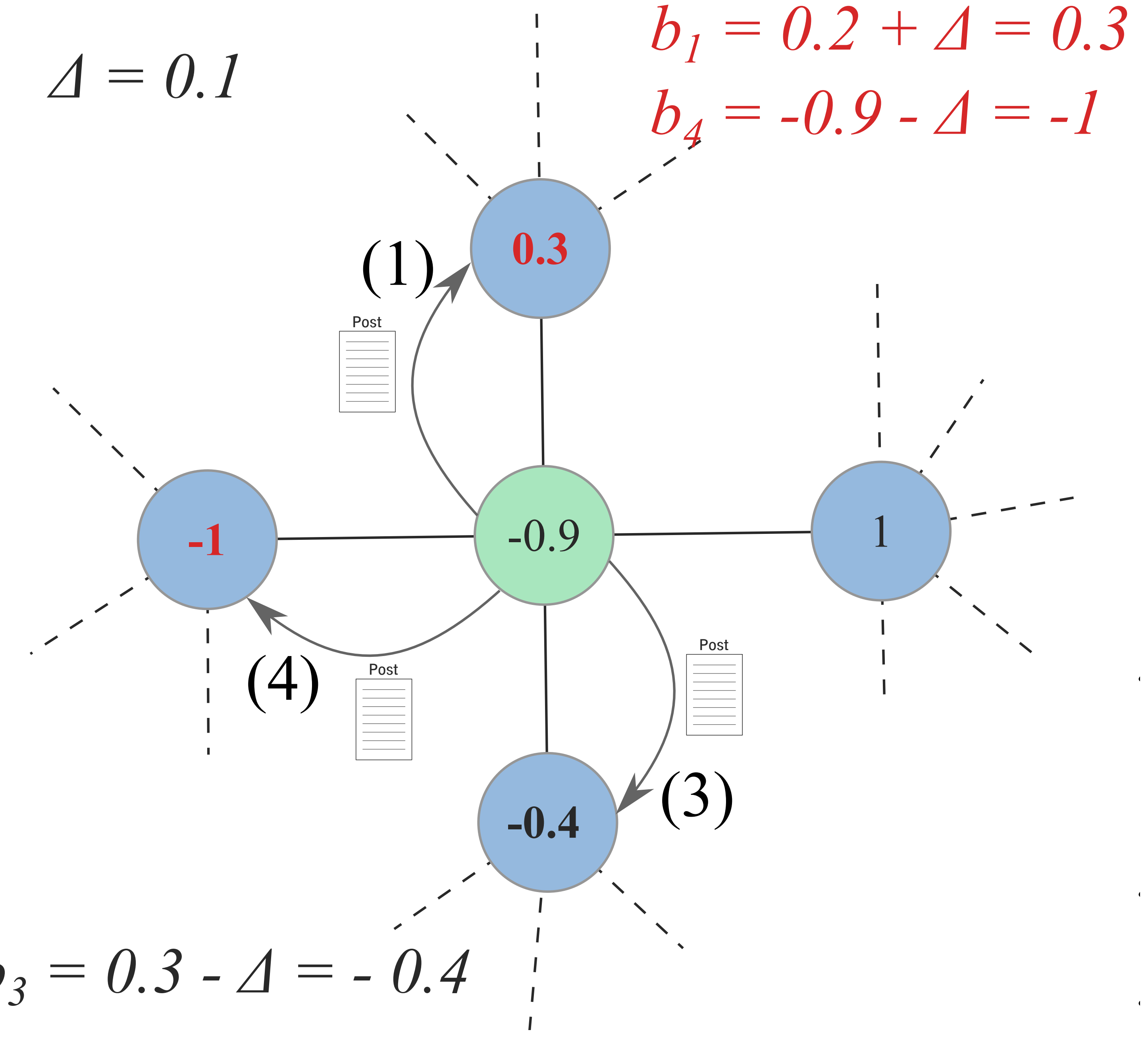
$$\xi_3(-0.4,\ -0.3) = \ 0.95$$

$$\xi_4(-0.4,\ -0.9) = \ 0.75$$

$\Delta = 0.1$

$b_1 = 0.2 + \Delta = 0.3$

$b_4 = -0.9 - \Delta = -1$



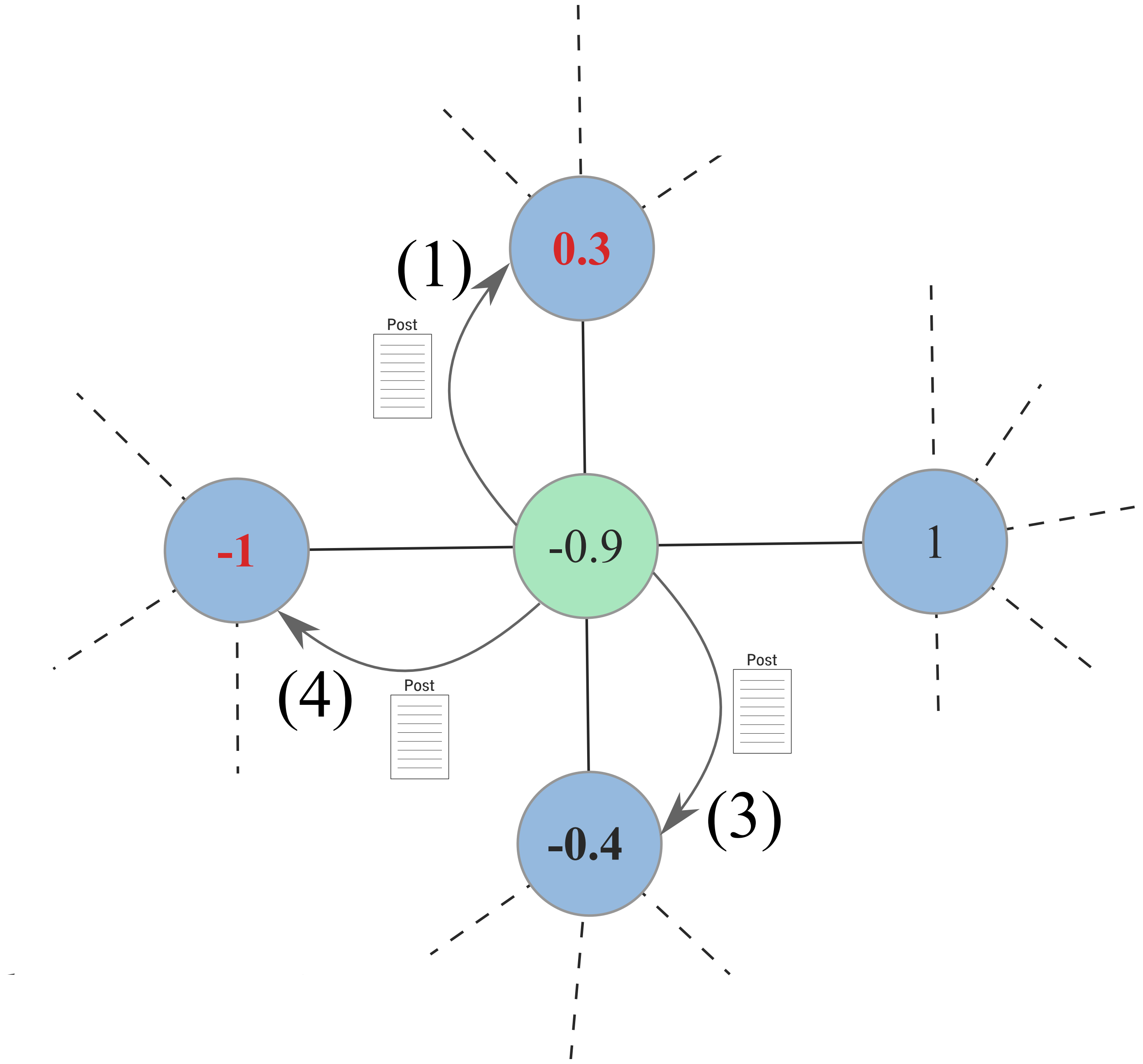
$b_3 = 0.3 - \Delta = -\ 0.4$

People update their opinions on topics after interacting or in a discussion and can become more polarized doing so.

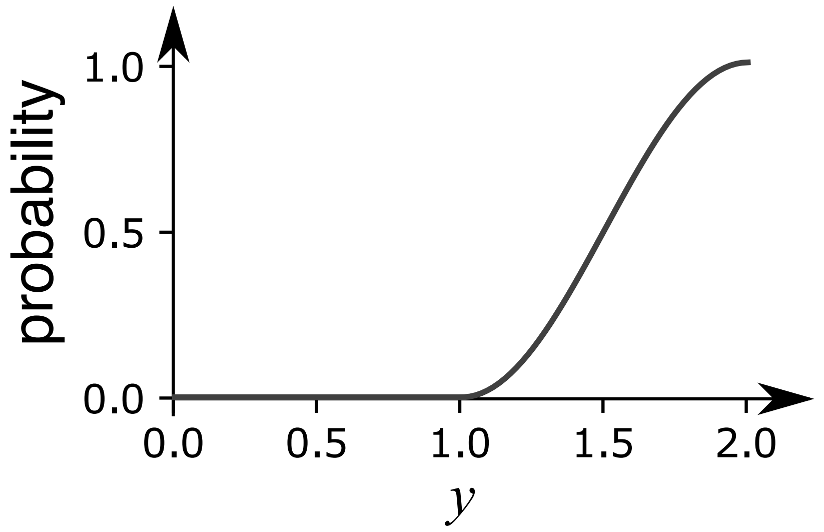
D.J. Isenberg, Group polarization. A critical review and meta-analysis, Journal of Personality and Social Psychology 50 (1986) 1141–1151.

S. Moscovici, M. Zavalloni, The group as a polarizer of attitudes, Journal of Personality and Social Psychology 12 (1969) 125–135.

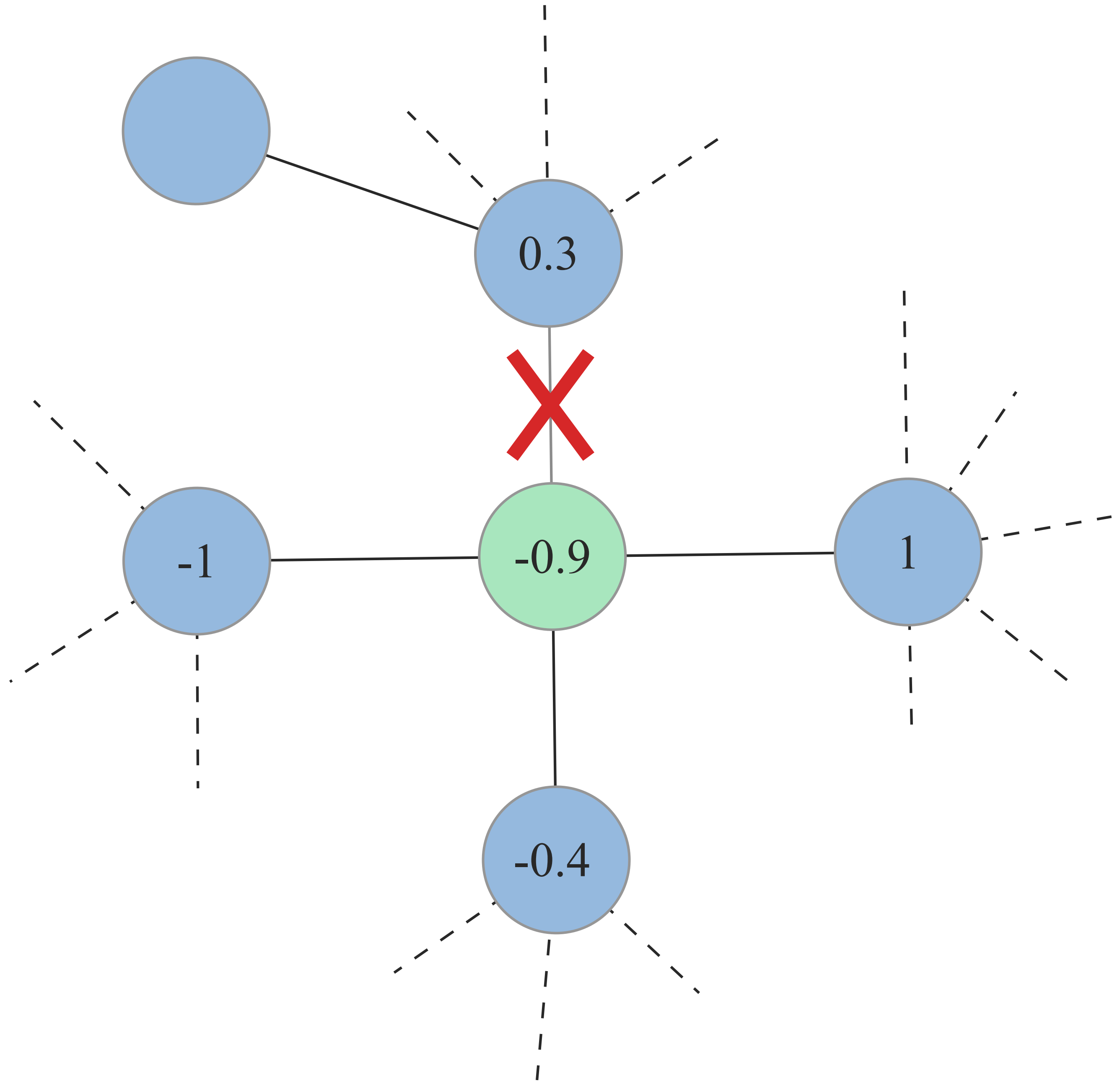
Model: Rewiring



Rewire probability:



$b_i = -0.9$



$y = |b_i - b_j|$

$y_1 = |-0.9 - 0.3| = 1.2 \qquad P_{rewire}(y_1) = 0.1$

$y_4 = |-0.9 - (-1.0)| = 0.1 \qquad P_{rewire}(y_4) = 0.0$

Twitter users are less likely to unfollow friends who have acknowledged them.

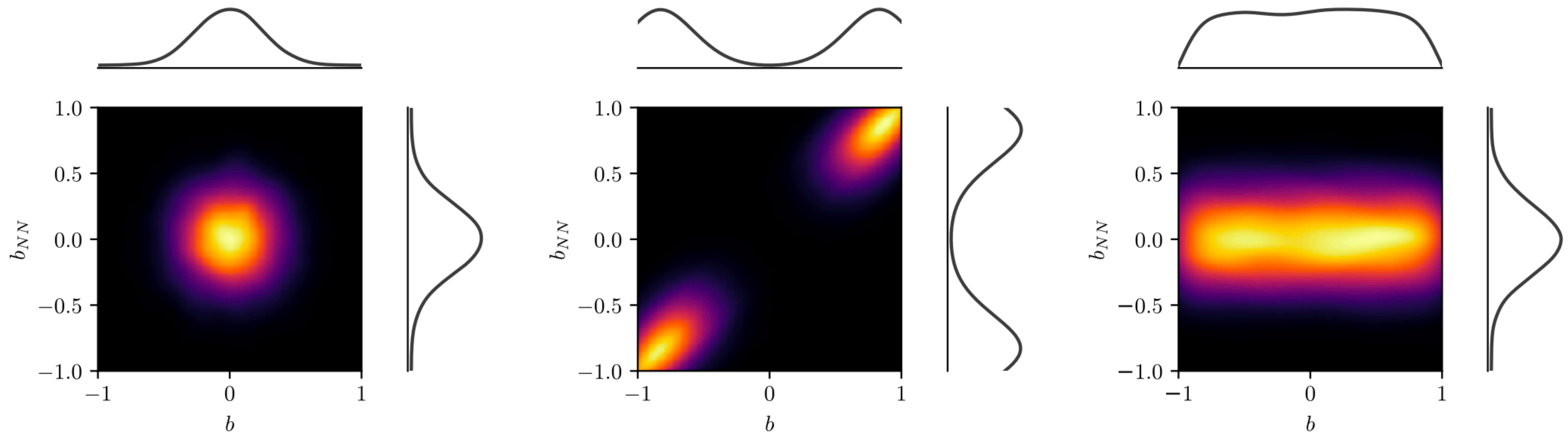
H. Kwak, S. Moon, W. Lee, More of a receiver than a giver: why do people unfollow in twitter?, in: Sixth International AAAI Conference on Weblogs and Social Media, 2012

Model

Post
θ = -0.4
(a)
Transmission probability:
probability
x
x = |θ - b_i| = 0.5
P_t^pol(x) = 0.5
(b)
Post
(1)
(2)
(3)
(4)
(c)
Reception probability:
probability
y
ϕ = 0
b_i = -0.9
y = |b_i - b_j|
y_1 = |-0.9 - 0.2| = 1.1 P_d^II(y_1) = 0.42
y_2 = |-0.9 - 1.0| = 1.9 P_d^II(y_2) = 0.01
y_3 = |-0.9 -(-0.3)| = 0.6 P_d^II(y_3) = 0.79
y_4 = |-0.9 -(-0.9)| = 0.0 P_d^II(y_4) = 1.00
(d)
(e)
Attraction probability
ξ(θ, b_j) = 1 - |θ - b_j|/2
ξ_1(-0.4, 0.2) = 0.7
ξ_3(-0.4, -0.3) = 0.95
ξ_4(-0.4, -0.9) = 0.75
(f)
Δ = 0.1
b_1 = 0.2 + Δ = 0.3
b_4 = -0.9 - Δ = -1
b_3 = 0.3 - Δ = - 0.4
(g)
Rewire probability:
probability
y
b_i = -0.9
y = |b_i - b_j|
y_1 = |-0.9 - 0.3| = 1.2 P_rewire(y_1) = 0.1
y_4 = |-0.9 - (-1.0)| = 0.1 P_rewire(y_4) = 0.0
(h)
(i)

Results analyses

Bimodality coefficient



(a) Consensus **(b)** Echo chamber, **(c)** Diverse

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

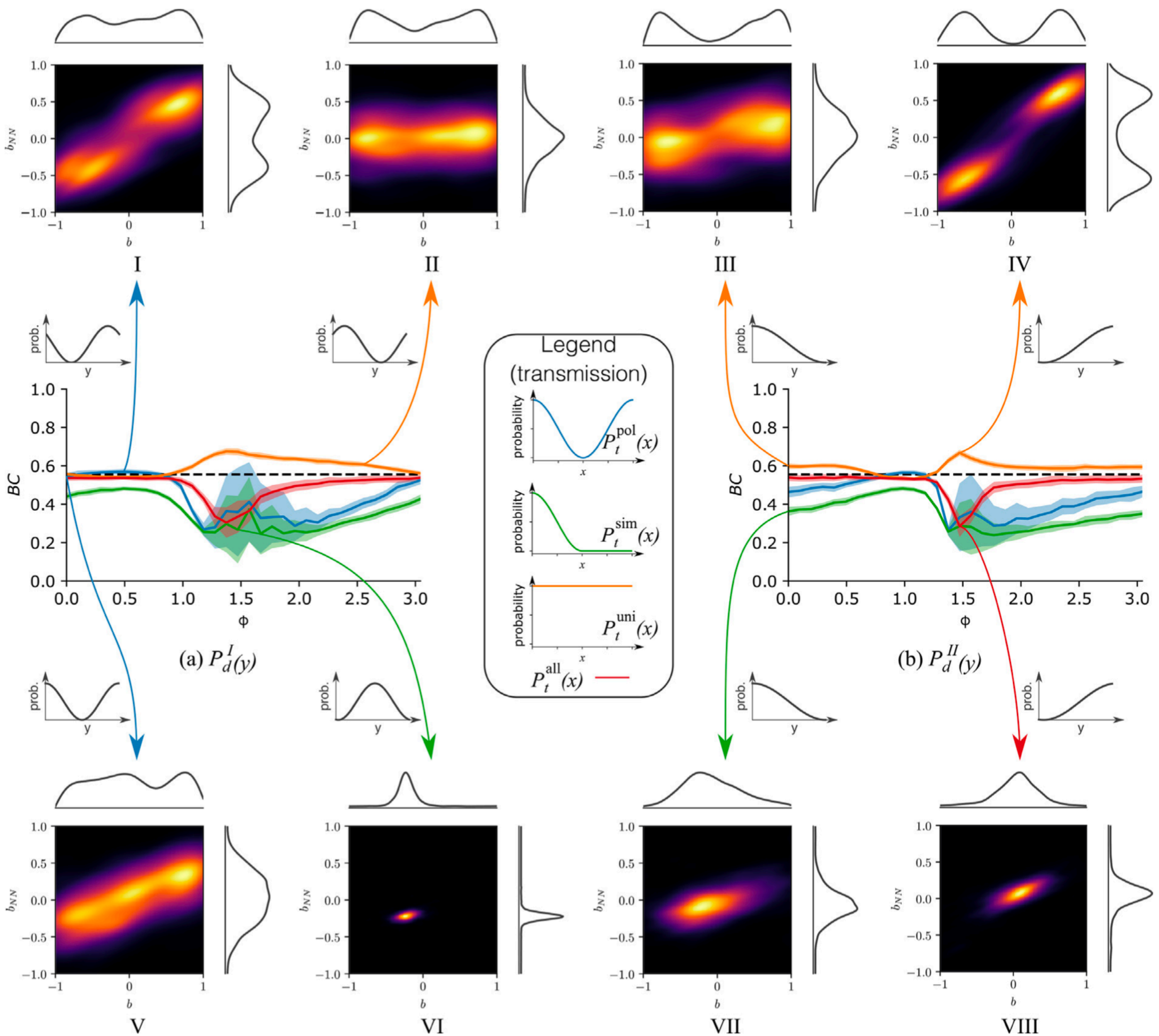
where n is the number of samples, and g and k are the skewness and kurtosis of the analyzed distribution, respectively.

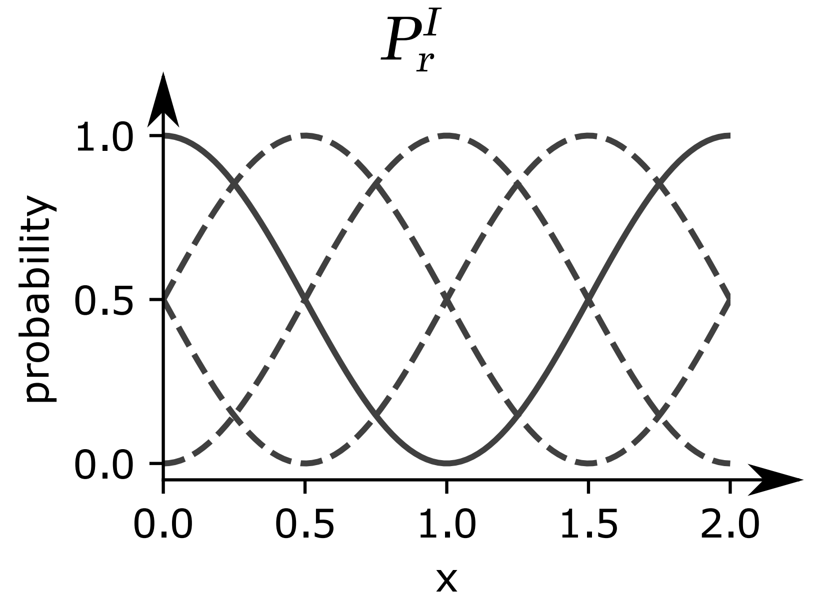
A BC_{critic} = 5/9 was empirically found. For values higher and lower than BC_{critic}, it tends to be bi-modal and uni-modal, respectively.

W. Cota, S.C. Ferreira, R. Pastor-Satorras, M. Starnini, Quantifying echo chamber effects in information spreading over political communication networks, EPJ Data Science 8 (2019) 35.

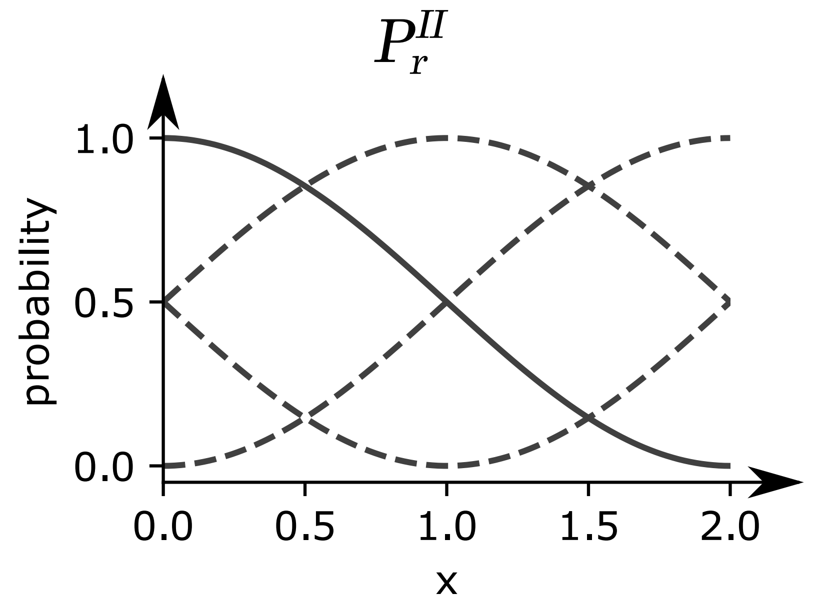
R. Pfister, K.A. Schwarz, M. Janczyk, R. Dale, J. Freeman, Good things peak in pairs: a note on the bimodality coefficient, Frontiers in Psychology 4 (2013) 700.

Results: Analysis of the dynamics





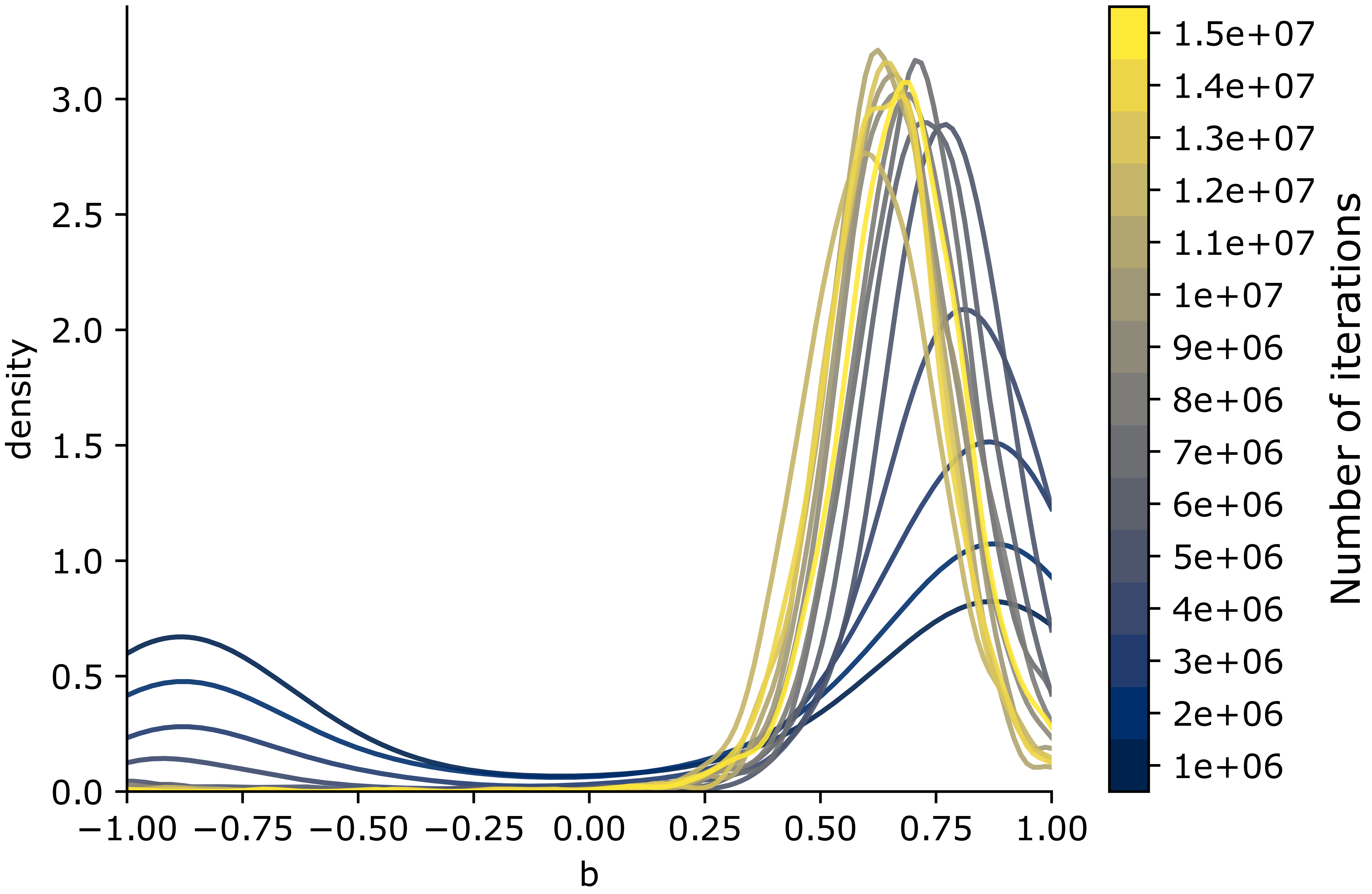
$$P_d^{\mathrm{I}}(y) = \cos^2\left(y\frac{\pi}{2} + \phi\right)$$



$$P_d^{\mathrm{II}}(y) = \cos^2\left(\frac{y}{2}\frac{\pi}{2} + \phi\right)$$

Temporal analysis

- Example of dynamics without rewiring;
- In this case, the dynamics goes from bimodal to unimodal, with consensus close to an extreme opinion.



Main conclusions

- This model was found to be flexible and can give rise to a wide range of outcomes representing different scenarios;
- In some cases, there is the polarization of opinions but without the formation of echo chambers (mainly when rewiring is not considered);
- If the users do not care about the information they post, the algorithm (post reception) can lead to polarization and the formation of echo chambers.

For more information

Our paper is published in:

de Arruda, H. F., Cardoso, F. M., de Arruda, G. F., Hernández, A. R., Costa, L. da F., & Moreno, Y. (2022). **Modelling how social network algorithms can influence opinion polarization**. Information Sciences, 588, 265-278.

The source code can be found in:

https://github.com/hfarruda/OpinionPolarization

SCAN ME

Thank you!

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