Emergence of opinion polarization in weighted contact structures

H. Pérez-Martínez[1,2], F. J. Bauzá[2,3], D. Soriano-Paños[2,4], J. Gómez-Gardeñes[1,2] and L. M. Floría[1,2]
[1]Department of Condensed Matter Physics, University of Zaragoza, 50009 Zaragoza (Spain).
[2]GOTHAM lab, Institute for Biocomputation and Physics of Complex Systems (BIFI), University of Zaragoza, 50018 Zaragoza (Spain).
[3]Department of Theoretical Physics, University of Zaragoza, 50009 Zaragoza (Spain).
[4]Institute Gulbenkian of Science (IGC), 2780-156 Oeiras (Portugal).

Opinion polarization has become widespread in modern societies. Its emergence is usually linked to the advent of social networks, as the dynamical aspect of online interactions and the homophily in social contacts can generate echo chambers that isolate people from opposing perspectives. However, recent studies suggest that echo chambers in online interactions might be less common than previously thought, and in general, real-world relationships are not solely dependent on ones opinion about certain issues, but also on friendship, kinship, professional ties and the like, usually featuring cross-cutting interactions with disagreeing peers: the effect these relationships have over ones opinion lies on the importance assigned to the others' points of view.

To take these facts into account, we adapt an opinion model previously applied to temporal graphs [1] to weighted graphs with static contact patterns. In our model, agents always interact with the same set of neighbors, being influenced by their opinions and giving more importance to like-minded individuals by changing the weights of the links.

Mathematically, the opinion change of an agent i is governed by the equation:

$$\dot{x}_i = -x_i + K \sum_{j=1}^{N} A_{ij} w_{ij} \tanh(x_j) \ , \tag{1}$$

where the influence that each neighbor has over the agent's opinion is weighted by w_{ij} following:

$$w_{ij} = \frac{\left(|x_i - x_j| + \delta\right)^{-\beta}}{\sum_{l=1}^{N} A_{il} \left(|x_i - x_l| + \delta\right)^{-\beta}} \ . \tag{2}$$

It depends on the parameter β, and the higher it is, the stronger the homophily effect become.

We find that polarization is indeed possible under this formalism in a wide parameter range and network structures (see Figure 1a, right panel). Moreover, in these polarized configurations agents can follow a broad range of opinions between the most extreme ones, similar to what occurs in reality. Depending on the parameters, the agents environment can vary from high heterogeneity, meaning that the agents have multiple cross-cutting relationships with disagreeing neighbors, to low heterogeneity, in which agents tend to interact with many like-minded neighbors reproducing a scenario of very high homophily. In general, highly heterogeneous environments give rise to less polarized configurations, in which agents usually take milder points of view.

In addition, the polarized configurations obtained over a certain range of parameters mimic those obtained in surveys about typically polarized issues like LGTBQ+ rights or other partisan topics (see Figure 1a, left panel). Comparing our distributions with those obtained in the 2016 American National Election Studies (ANES) Survey [2], we infer some optimal combination of parameters that give rise to the most similar opinion distributions, which allows us to classify multiple issues by their degree of polarization based on the inferred optimal parameters (see Figure 1b).

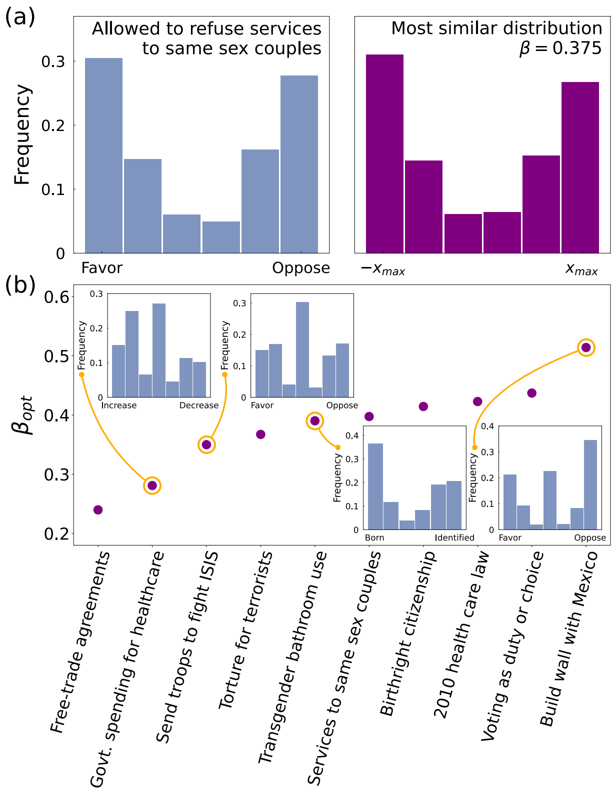

Fig. 1. **Comparison with real-world data.** (a) Left: Frequency of responses regarding the question: 'Do you think business owners who provide wedding-related services should be allowed to refuse services to same-sex couples if same-sex marriage violates their religious beliefs?', obtained from the ANES survey of 2016 (codes V161227 and V161227a, aggregated in V161227x). Right: most similar opinion distribution obtained in our simulations. (b) β_{opt} estimated for multiple polarized issues of the ANES 2016 survey. Inset figures show some of their distributions. An ErdsRnyi graph with $\langle k \rangle = 10$ and $N = 10^4$ nodes is used to generate the results of the figure.

[1] F. Baumann, P. Lorenz-Spreen, I. M. Sokolov, and M. Starnini, Phys. Rev. Let., *Modeling Echo Chambers and Polarization Dynamics in Social Networks*, **124**, 048301 (2020).

[2] The American National Election Studies (www.electionstudies.org). These materials are based on work supported by the National Science Foundation under grant numbers SES 1444721, 2014-2017, the University of Michigan, and Stanford University.