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Social Depolarization: Blume–Capel Model

Miron Kaufman [1,*], Sanda Kaufman [2] and Hung T. Diep [3]

[1] Department of Physics, Cleveland State University, Cleveland, OH 44115, USA
[2] Levin School of Urban Affairs, Cleveland State University, Cleveland, OH 44115, USA; s.kaufman@csuohio.edu
[3] Laboratoire de Physique Théorique et Modélisation, Institut Sciences et Techniques, CY Cergy Paris Université, CNRS, UMR 8089, 2, Avenue Adolphe Chauvin, 95300 Pontoise, France; diep@cyu.fr
* Correspondence: m.kaufman@csuohio.edu

Abstract: This study belongs to an emerging area of research seeking ways to depolarize societies in the short run (around events such as elections) as well as in a sustainable fashion. We approach the depolarization process with a model of three homophilic groups (US Democrats, Republicans, and Independents interacting in the context of upcoming federal elections). We expand a previous polarization model, which assumed that each individual interacts with all other individuals in its group with mean-field interactions. We add a depolarization field, which is analogous to the Blume–Capel model's crystal field. There are currently numerous depolarization efforts around the world, some of which act in ways similar to this depolarization field. We find that for low values of the depolarization field, the system continues to be polarized. When the depolarization field is increased, the polarization decreases.

Keywords: political polarization; depolarization; anticipatory scenarios; agent-based models; opinion dynamics; statistical physics approaches for social dynamics

1. Introduction

For at least the past three decades, scholars have observed, defined [1], measured [2], and modeled social polarization, its drivers, its effects [3,4], and its trends around the world [5–8] (The references included here are illustrative of the numerous articles addressing the increasing polarization around the world.) Increasing polarization tendencies have been documented for the short run [9,10] and predicted in the long run [11] unless some event or intervention changes its course (for example, after long months of a deep split in the Israeli polity, accompanied by numerous weekly demonstrations, the sudden violent events of October 2023 played the role of a focusing event: differences were mostly set aside, and the entire society concentrated on mutual help and a unified response).

The problems generated by severe societal polarization are felt in many places and in many ways—and in particular, in a diminished ability to solve serious societal problems demanding consensus. Besides the numerous real consequences to which they can lead, decisions resulting from such fraught processes tend to be non-robust, further accentuating political divisions and acrimony, and causing the public to lose trust in the democratic process and possibly disengage.

For example, the two political parties in the US Congress—Democrats and Republicans—are deeply polarized. As a direct result, both the Senate and the House of Representatives have great difficulties in making necessary joint decisions about important policies, such as budget allocations. Each has extremely slim majorities: in the Senate, there are forty nine Republicans to forty eight Democrats and three Independents (caucusing with Democrats who in effect hold the majority); and in the House, there are 221 Republicans to 212 Democrats [12]. The resulting decision dynamics mostly lead to impasse. Many issues up for vote are very contentious, including, for example,

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nominations for necessary government positions, which remain unoccupied for extended time periods [13]. Most proposals are decided on party line, meaning that they pass by the slimmest of majorities, at one or two vote differences. As a result, some senators and representatives acquire more power than warranted by their constituencies or seniority, because their votes are commodities sought by both parties. They can exact favors for their states or districts, angering the public [14]. Yearly budget decisions are delayed to the last legal minute under threat of government closure [14]. The consequences of failure to vote for the budget can be far-ranging, extending beyond the US border. For example, in Fall 2023, the House of Representatives approved a bi-partisan 45-day stopgap spending bill to prevent government closure, which did not contain continued financial support for Ukraine. Moreover, despite relatively broad consensus on financially assisting Israel in its war which broke out on 7 October 2023, this aid could not be extended because the House of Representatives had first to vote for a Speaker—a party-line decision.

Polarization is especially notable and acute preceding elections in democratic countries, such as the United States [11,15]. For example, the latest yearly *Gallup* polls conducted over the past 20 years regarding 24 issues central to past and current debates found increasing gaps between Democrat and Republican views (some deeper than others) for all issues, amounting to severe political polarization [15]. These findings are consistent and buttressed by those of Refs. [10,16].

Several factors have been viewed as causes, symptoms, and/or drivers for the observed increasing polarization among Americans. They include the widespread loss of mutual trust [17] and loss of trust in government, media, and science [18,19]. Media and science have aligned themselves with politics [20], further diminishing public trust. Lack of trust may be behind the seemingly distinct, nonoverlapping, and contradictory sets of data, facts, news, and opinions held by members of the two groups. Using an agent-based model (quite different than the model we propose), in Ref. [21], the authors have studied the role of communication in polarization.

Acute homophily [22] also contributes to polarization. It impels individuals to communicate almost exclusively with members of their own group who share their point of view, reinforcing the information disjunction. For example, people tend to evaluate information by the party affiliation of the source, more or rather than by its content, arguments, and evidence [23,24]. This way of evaluating information quality leads to the wholesale rejection of any statements coming from the opposing group. It also leads to the partition of society into groups whose members have non-intersecting perceptions of reality. In turn, this prevents the groups from solving problems, which necessitates finding agreement regarding specific policies and laws even while continuing to disagree on values. In Ref. [3], the authors examined several causes of polarization and proposed an additional category: bad-faith actors [4] fueling and reinforcing differences for their own purposes.

At times, such as currently in the US, a perfect storm is generated by deep value differences among opposing groups, combined with homophily (little or no direct intergroup communication) in the context of short political cycles which exacerbate both the differences and the homophily. In the face of the societal damage driven by polarization, scholars have been turning their attention to various theoretical and practical depolarization approaches, exploring tools at various scales, from local to country-wide [25–29]. Although research on depolarization is not recent (e.g., [30,31]), in Ref. [5], it is observed that, with a few exceptions [32–34], there are no corresponding definitions, measures, and models for depolarization.

As polarization reaches pernicious levels in some places including the US [24], efforts to counter it are emerging in research [3,5,35,36], media [17], and communities (see [35] for several examples of depolarizing initiatives at the community and organization levels). In the latter, one depolarizing strategy entails actively breaking homophily [37,38] to help individuals realize that even when they have very different values, they may share some interests that can be satisfied through joint decisions. In this paper, we contribute to these efforts by using sociophysics modeling to explore depolarization possibilities in the case of the US ahead of the 2024 elections. We ask what, if any, types of events or actions might work to counter the observed acute polarization trend, and how durable their effects can be.

Sociophysics methods [39] including statistical mechanics are particularly suitable to the study of polarization and depolarization because they are parsimonious ways to handle the complexity of social systems phenomena without requiring the use of extensive databases. For several examples of this approach, and how sociophysics can be applied specifically to the study of polarization, e.g., [11,40–42]. Together with agent-based models [43,44], sociophysics tools help construct anticipatory scenarios of polarization under different assumptions [45], circumventing some of the serious challenges to prediction posed by complexity [46].

Recently, we have proposed [11,42] a statistical mechanics model for exploring the dynamics of polarization in the US political system, between Democrat- and Republican-affiliated groups in the population, with consideration of a third group, Independents. The latter is now relatively large (representing a historic highest percent at about 41% of the American voter population [47] and therefore critical in determining election outcomes: neither of the two formal parties can win without attracting a considerable number of Independent voters. The model's results are qualitatively similar to poll outcomes in time, e.g., [16]. Using this model, we generated and explored [11,42] scenarios of whether leadership, also discussed by Ref. [35], and/or external events—for example, a massive natural disaster or a serious external threat, labeled a "focusing event"—might bring the groups closer to each other at least for some time. It was found [11,42] that although leadership and focusing events can help reduce polarization, their impact is rather temporary, consistent with conclusions in Ref. [5], who found in numerous case studies around the world that polarization reductions rarely last beyond about 10 years.

The voting public in the US is currently split down the middle between the two major parties and has been for at least the last 8 years [48], impairing the ability of governments at all levels to make necessary decisions on key topics such as the economy, the environment, energy, health care, immigration, and foreign relations, including financial assistance to other countries and global organizations. We ask here how we can overcome the current impasse resulting from the confluence of deep value differences, short political cycles that exacerbate them, novel technology effects, and homophily, which impedes direct communication across party lines. Perhaps the answers lie in the confluence of a multiplicity of conditions, which together push extremes toward each other (not necessarily to the middle).

We propose to use sociophysics modeling again to examine several conditions that together might depolarize the public effectively (especially important ahead of the 2024 national elections) by nudging opinion extremes toward each other to overcome homophily and enable idea exchanges in the short run, and even for longer durations. To this end, we expand the three-group polarization model of Refs. [11,42] by adding to it a depolarization field D similar to the Blume–Capel [49–51] crystal field. By design, increasing the value of D reduces the polarization of the system, as assessed by a measure proposed in Ref. [11]. We find that the depolarization field D has an additional, desirable effect: for each group, the distribution of individuals' stances, ranging from extreme left/liberal to extreme right/conservative, is a Gaussian normal distribution. This is consistent with empirical distributions captured through polling, such as by the Pew Research Center [16] for example. The challenge remains to identify actions that together have an effect similar to the D field. A three-state model with agents belonging to a single group was considered in Ref. [52]. By contrast, our model considers three groups (two homophilic) and the stance of each individual is a continuous variable.

The balance of this article begins with the description of our model in Section 2, followed by numerical results in Section 3. We offer our final remarks and plans for future work in Section 4.

2. Method: A Dynamic Mean-Field Model

We approach the study of depolarization in the context of US political contests. They are waged among three major US political groups historically providing candidates for president, congress, as well as state and local positions: Democrats and Republicans (which are currently highly polarized [48]), and Independents. The latter tend to lean toward, and reinforce, the number of Democrat or Republican voters in specific elections. Especially now, when they constitute a relatively large group of voters compared to the other two [47], Independents are viewed as a deciding factor in elections. For this reason, both Democrats and Republicans attempt to attract them to their respective positions.

Our three-group model represents the interactions in time of voters affiliated with the two parties—Democrats and Republicans—and with the nonaffiliated Independents. The model allows the testing of various interventions, which might contribute to depolarization by bringing extreme positions closer to the center.

We assume that in each of the three political groups, each individual has preferences with respect to several key political issues [11,34]. These individual preferences range between extremely left-leaning and extremely right-leaning, but more or less aligned with the positions taken by their respective parties. Democratic party- and Republican party-affiliated individuals actively interact with each other mostly within their own group, enhancing internal cohesion. Nevertheless, they also keep an eye on the stances of the members of the other groups.

Within any of the Democrat and Republican groups, everyone interacts with everyone, on a complete Erdös–Renyi network. The Independents, not being formally organized into a bloc or identifiable, interact with other Independents in a much weaker fashion or not at all. In what follows, we label Democrats as group 1, Republicans as group 2, and Independents as group 3.

In each group, each individual has a stance s that reflects their preferences regarding single issues under current political debate—economics, health care, defense, immigration, climate change—or a package of such issues. The stance s varies between −1 and +1, where −1 corresponds to the Democrats' extreme progressive/left position, +1 corresponds to the republicans' extreme conservative/right position, and 0 corresponds to the middle-of-the-road position.

The Democrats and the Republicans are homophilic, meaning that individuals in a given group prefer to communicate with other individuals from the same group through intra-group couplings J, and little or not at all with anyone from the other group. Thus, the magnitude of the couplings J quantifies the cohesiveness of each group. The other groups' mean stances influence the stances of individuals in the group under consideration through inter-group couplings K. The groups' leaderships act on individuals' stances through the fields H and D. The temperature T represents the effects of the context on the individual stances. For example, at the moment, different states of the economy or politics might impinge on the degree of polarization and on the extent to which leaders or other factors can reduce it.

We use the Boltzmann probability weight to compute the probability distributions for individual stances in each group. The underlying assumption in this study is that statistical physics models describe social systems at a scale that includes a large number of individuals. The Boltzmann distribution function maximizes entropy (disorder) for a given energy function. Quantitative properties of large-scale phenomena exhibit regularities that are not sensitive to short-scale details.

We compute the average stance of each group using this Boltzmann probability distribution $\exp(-E/T)$, where E is the energy. The negative energy associated with an individual in group 1 is:

$$-E_1 = (J_1 s_1 + K_{12} s_2 + K_{13} s_3 + H_1) s - D_1 s^2 \,,$$

where s denotes the stance of that individual and s_1, s_2, and s_3 denote the mean stances of groups 1, 2, and 3, respectively. The fields H_1 and D_1 represent the action of the leaders on individuals of group 1. For $H_1 > 0$, the mean stance is pushed towards positive values, while for $H_1 < 0$, the mean stance is pushed to negative values.

When positive, the field D_1 favors depolarization through $D_1 s^2$, whose effect is to push stances s toward the center: $s \sim 0$; while when D_1 is negative, it favors polarization: $|s| \sim 1$. The crystal field D_1, which in our context controls depolarization, was used in Refs. [49–51] to study the thermodynamics of UO_2 and He^3–He^4 mixtures. In our implementation, the stance s is a continuous variable, whereas in the original model [49–51], the spin $s = -1, 0, 1$. For $D >> 0$, the mean stance approaches zero after a few time iterations, while for $D << 0$, the mean stance $|s|$ approaches unity after a few time iterations.

To write the mean-field theory for our model, we introduce the Langevin–Blume–Capel function:

$$LBC(h,d) = \frac{\int_{-1}^{1} s e^{hs-ds^2} ds}{\int_{-1}^{1} e^{hs-ds^2} ds}, \tag{1}$$

where h and d stand for H/T and D/T, respectively.

We employ a numerical adaptative integration with a tolerance of 0.001 to evaluate this function. The average stance s at time $t + 1$ is assumed to be determined by preferences of the group at an earlier time t. This lag represents the time it takes to change individuals' stances. The time t is expressed in units of the lag time. Thus, for each of the three groups, respectively:

$$\begin{aligned} s_{1,t+1} &= LBC(h_1 + j_1 s_{1,t} + k_{12} s_{2,t} + k_{13} s_{3,t}, d_1), \\ s_{2,t+1} &= LBC(h_2 + j_2 s_{2,t} + k_{21} s_{1,t} + k_{23} s_{3,t}, d_2), \\ s_{3,t+1} &= LBC(h_3 + j_3 s_{3,t} + k_{31} s_{1,t} + k_{32} s_{3,t}, d_3), \end{aligned} \tag{2}$$

where h_1 stands for H_1/T, k_{12} stands for K_{12}/T, d_1 stands for D_1/T, etc. The inter-group interaction parameters K_{12} and K_{21} are not necessarily equal, as members of one group may feel cooperative toward another group, who might not reciprocate. The model includes fifteen parameters: three js, six ks, three hs, and three ds.

We use here the polarization measure defined in Ref. [11] as the distance at any point in time between the mean stances of groups 1 and 2:

$$P = (s_2 - s_1)/2, \tag{3}$$

This definition is consistent with Pew polls, e.g., [10,16] reporting distributions of stances among Republicans and Democrats.

It is defined so that $-1 \leq P \leq 1$. The unpolarized case $P = 0$ corresponds to equal stances $s_1 = s_2$. Polarization is extreme when $P = 1$, corresponding to the Republicans' stance $s_2 = 1$ (most conservative/right) and the Democrats' stance $s_1 = -1$ (most progressive/left) or when $P = -1$, corresponding to the Republicans' stance $s_2 = -1$ and the Democrats' stance $s_1 = 1$.

The distribution of individuals of group 1 among the stances s at time t is:

$$\begin{aligned} \rho_1(s,t) &= \frac{e^{(j_1 s_{1t} + k_{12} s_{2t} + k_{13} s_{3t} + h_1)s - d_1 s^2}}{\int_{-1}^{1} e^{(j_1 s_{1t} + k_{12} s_{2t} + k_{13} s_{3t} + h_1)s - d_1 s^2} ds}, \\ \rho_2(s,t) &= \frac{e^{(j_2 s_{2t} + k_{21} s_{1t} + k_{23} s_{3t} + h_2)s - d_2 s^2}}{\int_{-1}^{1} e^{(j_2 s_{2t} + k_{21} s_{1t} + k_{23} s_{3t} + h_2)s - d_2 s^2} ds}, \\ \rho_3(s,t) &= \frac{e^{(j_3 s_{3t} + k_{32} s_{2t} + k_{31} s_{1t} + h_3)s - d_3 s^2}}{\int_{-1}^{1} e^{(j_3 s_{3t} + k_{32} s_{2t} + k_{31} s_{1t} + h_3)s - d_3 s^2} ds}. \end{aligned} \tag{4}$$

$\rho_1(s,t)ds$ gives the fraction of all individuals in group 1 who have a stance in the interval $(s, s + ds)$ at time t. Similarly, ρ_2 and ρ_3 are the distribution functions for groups 2 and 3, respectively.

3. Numerical Results and Discussion

To assess the influence of the depolarization field D on the three groups' stances, we generate four scenarios for which we use the same J and K values (these values were selected based on a qualitative analysis to replicate 2017 poll results [10,16] on Democrats' and Republicans' increasingly polarized stances) as in our previous article [11]. The field values are consistent with following assumptions. Individuals in group 1 are more cohesive than individuals in group 2: $j_1 > j_2$. Individuals in group 3 have no cohesion $j_3 = 0$. They exert no influence on the other two groups: $k_{13} = k_{23} = 0$. Individuals in group 3 are contrarian to group 1, which is in power: $k_{31} < 0$. They are not influenced by group 2 individuals: $k_{32} = 0$. Thus, all results that follow are obtained: $j_1 = 5$, $j_2 = 3$, $j_3 = 0$, $k_{12} = -4$, $k_{21} = -5$, $k_{31} = -3$, $k_{13} = 0$, $k_{23} = 0$, $k_{32} = 0$, $h_1 = 0$, $h_2 = 0$, and $h_3 = 0$. We also fix $d_3 = 5$ for all cases discussed below.

In the scenario shown in Figure 1a, we set $d_1 = d_2 = 0$, meaning no depolarization action (this was the case for all scenarios we studied in Ref. [11], where d_3 was also 0). As a result, the system polarizes over time. Starting at $t = 0$ with s_1 and s_2 quite close to 0, in time the distance between the Democrats' and Republicans' mean stances increases. This can also be seen in Figure 1b, where the polarization measure increases from 0 to about 0.8. In Figure 1c (where $t = 5$), we show the stance distributions for the three groups. Since the value of d_3 is positive, the distribution of stances for group 3 (Independents) is Gaussian. In contrast, the Democrats' and the Republicans' distributions $\rho(s,t)$ depend monotonically on the stance since $d_2 = d_2 = 0$.

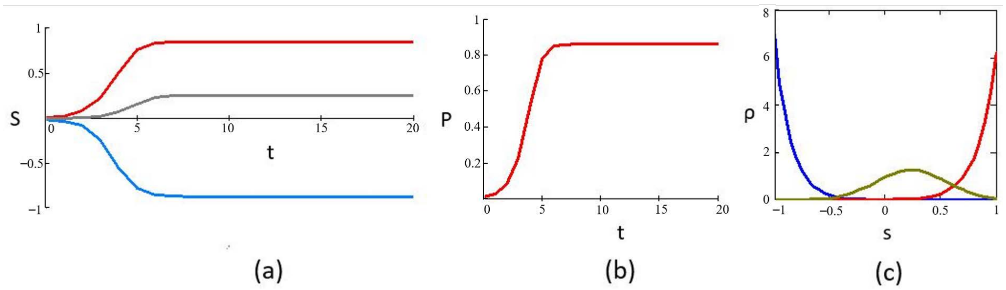

Figure 1. (**a**) Mean group stances versus time, (**b**) polarization time, and (**c**) stance distributions for groups 1 (blue line), 2 (red), and 3 (green) at $t = 5$ with the parameters $j_1 = 5$, $j_2 = 3$, $j_3 = 0$, $k_{12} = -4$, $k_{21} = -5$, $k_{31} = -3$, $k_{13} = 0$, $k_{23} = 0$, $k_{32} = 0$, $d_1 = 0$, $d_2 = 0$, $d_3 = 5$, $h_1 = 0$, $h_2 = 0$, and $h_3 = 0$. See text for details.

In the scenario of Figure 2a, we set the intervention $d_1 = d_2 = 3$. Consequently, the system polarization diminishes over time. Starting at $t = 0$ with $s_1 = -1$ and $s_2 = 1$, over time the distance between the mean stances diminishes. Figure 2b also reflects this effect: polarization P decreases from 1 to about 0.6. In Figure 2c, for $t = 5$, we show that since the d values are all positive, the distributions for the three groups are all Gaussian.

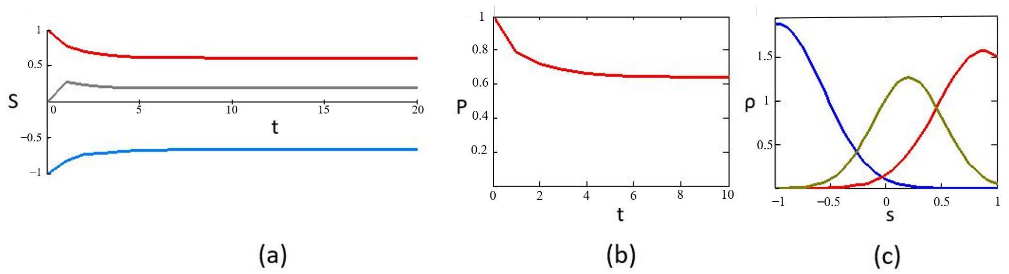

Figure 2. (**a**) Mean group stances versus time, (**b**) polarization versus time, and (**c**) stance distributions for groups 1 (blue line), 2 (red), and 3 (green) at $t = 5$ with the parameters $j_1 = 5$, $j_2 = 3$, $j_3 = 0$, $k_{12} = -4$, $k_{21} = -5$, $k_{31} = -3$, $k_{13} = 0$, $k_{23} = 0$, $k_{32} = 0$, $d_1 = 3$, $d_2 = 3$, $d_3 = 5$, $h_1 = 0$, $h_2 = 0$, and $h_3 = 0$. See text for details.

In the scenario of Figure 3a, we further increase the depolarization fields $d_1 = d_2 = 5$. The system depolarizes over time. Starting at $t = 0$ with $s_1 = -1$ and $s_2 = 1$, over time the distance between the mean stances diminishes. This is also shown in Figure 3b, where the polarization decreases from 1 at $t = 0$ to about 0 at $t = 20$. In Figure 3c, we show the stance distributions for the three groups. Since the ds are positive, the distributions are all Gaussian.

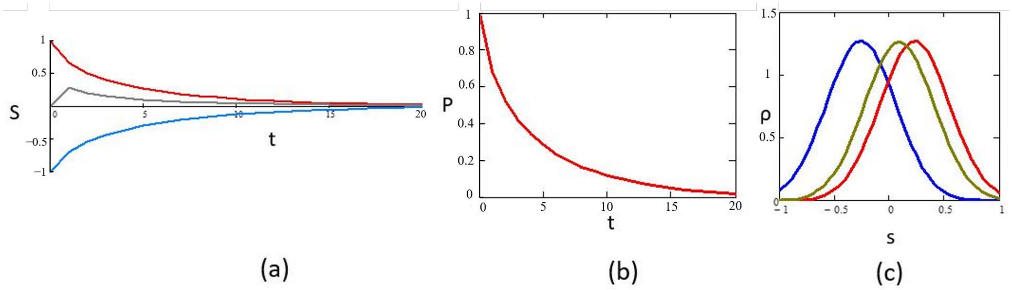

Figure 3. (**a**) Mean group stances versus time, (**b**) polarization versus time, and (**c**) stances distributions for groups 1 (blue line), 2 (red), and 3 (green) at $t = 5$ with the parameters $j_1 = 5$, $j_2 = 3$, $j_3 = 0$, $k_{12} = -4$, $k_{21} = -5$, $k_{31} = -3$, $k_{13} = 0$, $k_{23} = 0$, $k_{32} = 0$, $d_1 = 5$, $d_2 = 5$, $d_3 = 5$, $h_1 = 0$, $h_2 = 0$, and $h_3 = 0$. See text for details.

Finally, we consider a fourth scenario, which in Ref. [11] exhibited time oscillations of the three stances: $j_1 = 5$, $j_2 = 3$, $j_3 = 0$, $k_{12} = 4$, $k_{21} = -5$, $k_{31} = -3$, $k_{13} = 0$, $k_{23} = 0$, $k_{32} = 0$, $h_1 = 0$, $h_2 = 0$, and $h_3 = 0$. Again, we add depolarization fields: $d_1 = d_2 = 3$ and $d_3 = 5$. Now in Figure 4a, the three groups' stances exhibit damped oscillations over time. The system depolarizes in time and the polarization P also exhibits damped oscillations (Figure 4b). The distributions of stances for the three groups, shown in Figure 4c ($t = 5$), are Gaussian because the depolarization field values are positive for each group.

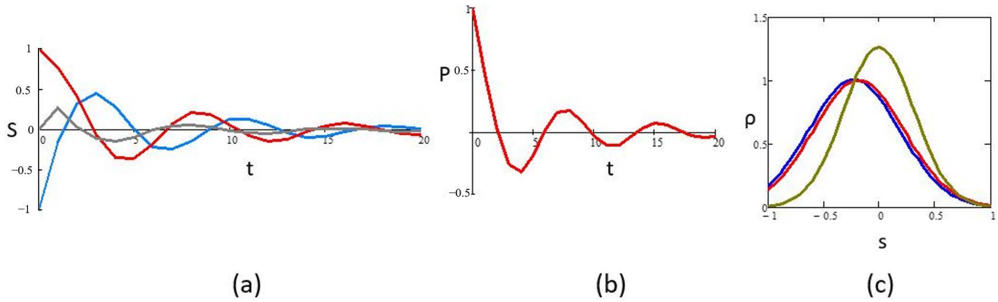

Figure 4. (**a**) Mean group stances versus time, (**b**) polarization versus time, and (**c**) stances distributions for groups 1 (blue line), 2 (red), and 3 (green) at $t = 5$ with the parameters $j_1 = 5$, $j_2 = 3$, $j_3 = 0$, $k_{12} = 4$, $k_{21} = -5$, $k_{31} = -3$, $k_{13} = 0$, $k_{23} = 0$, $k_{32} = 0$, $d_1 = 3$, $d_2 = 3$, $d_3 = 5$, $h_1 = 0$, $h_2 = 0$, and $h_3 = 0$.

The increase in value of the depolarization fields of groups 1 and 2 reduces polarization over time. In the oscillatory case, which occurs when k_{12} and k_{21} have different signs, the depolarization field dampens those oscillations.

We have shown through these scenarios that when a positive depolarization field is added to the three-group system, the distribution of stances becomes Gaussian. It means that it is maximized at a stance within the interval $(-1, 1)$, signifying a non-extreme stance. When the groups' stances are non-extreme, there exists the possibility of breaking out of the extreme polarization.

4. Concluding Remarks

Using the case of the US political system where three polarized groups—Democrats, Republicans, and Independents—interact, we explored scenarios of depolarization under the effect of intervention. We found that when a depolarization field D is added, the polarization decreases over time. If the D field is sufficiently strong, the polarization decreases to zero.

In practice, the field D can result from the actions of the groups' leaderships and/or from events that can refocus all groups on concerted actions in the face of some external threats. Examples of both have occurred in the past in the United States, such as during World War II, the Vietnam War, after the 9/11 attack on the World Trade Center in New York City, and elsewhere. The field D can also be the result of numerous local grassroots initiatives (also proposed in Ref. [17] as an antidote to polarization) currently occurring in the United States. They may add up to country-wide depolarization. Several examples can be found in Ref. [36]. These initiatives are akin to massively parallel intervention—a multiplicity of independent, locally driven actions—proposed in Refs. [3,53]—which together, when reaching a critical mass, can have a depolarizing effect among the political groups, at least in the short run. Sustaining depolarization in the longer run remains a challenge. As Ref. [5] observed in cases around the world, in general, repolarization tends to resume after about 10 years. Since in our model, the extent of depolarization depended on the strength of the intervention, we plan to explore further what factors might extend the duration of depolarized states.

This model includes, besides the single site field D, a field H. While D promotes compromise stance $s \sim 0$, the H field fosters extreme positions: $|s| \sim 1$. This could be the result of social influencers and/or media activities. We plan to further explore the group dynamics in the 15-dimensional parameter space, including the role of the H field. For example, we intend to elucidate the influence of the D field on the chaotic dynamics that we observed in the three-group model with competing K interactions. We also plan to study the model with intra-group short-range interactions by means of Monte-Carlo simulations. We will extend our study to account for different levels of randomness by varying the temperature.

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References

1. Baldassarri, D.; Gelman, A. Partisans without constraint: Political polarization and trends in American public opinion. *Am. J. Sociol.* **2008**, *114*, 408–446. [CrossRef]
2. Bramson, A.; Grim, P.; Singer, D.J.; Berger, W.J.; Sack, G.; Fisher, S.; Holman, B. Understanding polarization: Meanings, measures, and model evaluation. *Philos. Sci.* **2017**, *84*, 115–159. [CrossRef]
3. Burgess, G.; Burgess, H.; Kaufman, S. Applying conflict resolution insights to the hyper-polarized, society-wide conflicts threatening liberal democracies. *Confl. Resolut. Quart.* **2022**, *39*, 355–369. [CrossRef]
4. Burgess, G.; Burgess, H. Challenging "Bad-Faith" actors who seek to amplify and exploit our conflicts. In *Beyond Intractability/Moving Beyong Intractability. Conflict Frontiers Seminar*; March 2021; Available online: https://www.beyondintractability.org/frontiers/bad-faith-actors (accessed on 10 December 2023).
5. McCoy, J.; Press, B.; Somer, M.; Tuncel, O. Reducing pernicious polarization: A comparative historical analysis of depolarization. In *Carnegie Endowment for International Peace (CEP). Publications*; Coherent Digital, LLC: Alexandria, VA, USA, 5 May 2022; Available online: https://policycommons.net/artifacts/2392500/reducing-pernicious-polarization/3413931/ (accessed on 10 December 2023).
6. McCoy, J.; Somer, M. (Eds.) Special Issue: Polarization and Democracy: A Janus-faced Relationship with Pernicious Consequences. *Am. Behav. Sci.* **2018**, *62*, 3–145. Available online: https://journals.sagepub.com/toc/absb/62/1 (accessed on 10 December 2023).
7. McCoy, J.; Rahman, T.; Somer, M. Polarization and the global crisis of democracy: Common patterns, dynamics, and pernicious consequences for democratic polities. *Am. Behav. Sci.* **2018**, *62*, 16–42. [CrossRef]

8. Somer, M.; McCoy, J. Déjà vu? Polarization and endangered democracies in the 21st century. *Am. Behav. Sci.* **2018**, *62*, 3–15. [CrossRef]
9. Böttcher, L.; Gersbach, H. The great divide: Drivers of polarization in the US public. *EPJ Data Sci.* **2020**, *9*, 32. [CrossRef] [PubMed]
10. Schaeffer, K. Far more Americans see 'very strong' partisan conflicts now than in the last two presidential election years. *Pew Research Center*, 4 March 2020. Available online: https://pewrsr.ch/2uRKXSs(accessed on 10 December 2023).
11. Kaufman, M.; Kaufman, S.; Diep, H.T. Statistical mechanics of political polarization. *Entropy* **2022**, *24*, 1262. [CrossRef] [PubMed]
12. Manning, J.E. *Membership of the 118th Congress: A Profile*; CRS Report R47470; U.S. Congressional Research Service: Washington, DC, USA, 2023. Available online: https://crsreports.congress.gov/product/pdf/R/R47470 (accessed on 10 December 2023).
13. Williamson, E. Hundreds of Biden nominees stuck in Senate limbo amid G.O.P. blockade. *The New York Times*, 8 January 2022. Available online: https://www.nytimes.com/2022/01/08/us/politics/biden-nominees-senate-confirmation.html(accessed on 10 December 2023).
14. Walter, J.; Helmore, E. Joe Manching hails expansive bill he finally agrees to as "great for America". *The Guardian*, 31 July 2022. Available online: https://www.theguardian.com/us-news/2022/jul/31/joe-manchin-hails-deal-inflation-reduction-act(accessed on 10 December 2023).
15. Newport, F. Update: Partisan gaps expand most on government power, climate. *Gallup*, 7 August 2023. Available online: https://news.gallup.com/poll/509129/update-partisan-gaps-expand-government-power-climate.aspx?version=print&thank-you-subscription-form=1(accessed on 10 December 2023).
16. Doherty, C.; Kiley, J.; Johnson, B. The partisan divide on political values grows even wider. *Pew Research Center*, 5 October 2017. Available online: https://www.pewresearch.org/politics/2017/10/05/the-partisan-divide-on-political-values-grows-evenwider/(accessed on 10 December 2023).
17. Fukuyama, F. Paths to depolarization. *Persuasion*, 3 August 2022. Available online: https://www.persuasion.community/p/fukuyama-paths-to-depolarization(accessed on 10 December 2023).
18. Klein, E.; Robison, J. Like, post, and distrust? How social media use affects trust in government. *Political Commun.* **2020**, *37*, 46–64. [CrossRef]
19. Rekker, R. The nature and origins of political polarization over science. *Public Underst. Sci.* **2021**, *30*, 352–368. [CrossRef]
20. Kubin, E.; von Sikorski, C. The role of (social) media in political polarization: A systematic review. *Ann. Int. Commun. Assoc.* **2021**, *45*, 188–206. [CrossRef]
21. Maes, M.; Flache, A. Differentiation without distancing. Explaining bi-polarization of opinions without negative influence. *PLoS ONE* **2013**, *8*, e74516. [CrossRef] [PubMed]
22. Dandekar, P.; Goel, A.; Lee, D.T. Biased assimilation, homophily, and the dynamics of polarization. *Proc. Natl. Acad. Sci. USA* **2013**, *110*, 5791–5796. [CrossRef] [PubMed]
23. Doise, W. Intergroup relations and polarization of individual and collective judgments. *J. Personal. Soc. Psychol.* **1969**, *12*, 136–143. [CrossRef]
24. Mackie, D.; Cooper, J. Attitude polarization: Effects of group membership. *J. Personal. Soc. Psychol.* **1984**, *46*, 575–585. [CrossRef]
25. Nuesser, A.; Johnston, R.; Bodet, M.A. The dynamics of polarization and depolarization: Methodological considerations and European evidence. In Proceedings of the American Political Association 2014 Annual Meeting and Exhibition, Washington, DC, USA, 28–31 August 2014; Available online: https://ssrn.com/abstract=2452108 (accessed on 10 December 2023).
26. van der Linden, S.; Leiserowitz, A.; Maibach, E.W. Communicating the scientific consensus on human-caused climate change is an effective and depolarizing public engagement strategy: Experimental evidence from a large national replication study. *SSRN* **2016**, 2733956. [CrossRef]
27. Liu, R.; Wang, L.; Jia, C.; Vosoughi, S. Political depolarization of news articles using attribute-aware word embeddings. *Proceed. Intl. AAAI Conf. Weblogs Soc. Media* **2021**, *15*, 385–396. [CrossRef]
28. Ojer, J.; Starnini, M.; Pastor-Satorras, R. Modeling explosive opinion depolarization in interdependent topics. *Phys. Rev. Lett.* **2023**, *130*, 207401. [CrossRef] [PubMed]
29. Sude, D.J.; Knobloch-Westerwick, S. When we have to get along: Depolarizing impacts of cross-cutting social media. *Int. J. Commun.* **2023**, *17*, 5268–5290.
30. Vinokur, A.; Burnstein, E. Depolarization of attitudes in groups. *J. Personal. Soc. Psychol.* **1978**, *36*, 872–885. [CrossRef]
31. Brauer, M.; Judd, C.M. Group polarization and repeated attitude expressions: A new take on an old topic. *Eur. Rev. Soc. Psychol.* **1996**, *7*, 173–207. [CrossRef]
32. McCoy, J.; Somer, M. Toward a theory of pernicious polarization and how it harms democracies: Comparative evidence and possible remedies. *Ann. Am. Acad. Political Soc. Sci.* **2019**, *681*, 234–271. [CrossRef]
33. Somer, M.; McCoy, J. Transformations through polarizations and global threats to democracy. *Ann. Am. Acad. Political Soc. Sci.* **2019**, *681*, 8–22. [CrossRef]
34. Sobkowicz, P. Social depolarization and diversity of opinions—Unified ABM framework. *Entropy* **2023**, *25*, 568. [CrossRef] [PubMed]
35. McCoy, J.; Somer, M. Overcoming polarization. *J. Democr.* **2021**, *32*, 6–21. [CrossRef]
36. The Hyper-Polarization Crisis: A Conflict Resolution Challenge. In *Beyond Intractability/Moving Beyond Intractability. Constructive Conflict Initiative*; Available online: https://www.beyondintractability.org/crq-bi-hyper-polarization-discussion (accessed on 10 December 2023).

37. Diamond, M.J.; Lobitz, W.C. When familiarity breeds respect: The effects of an experimental depolarization program on police and student attitudes toward each other. *J. Soc. Iss.* **1973**, *29*, 95–109. [CrossRef]
38. Currin, C.B.; Vera, S.V.; Khaledi-Nasab, A. Depolarization of echo chambers by random dynamical nudge. *Sci. Rep.* **2022**, *12*, 9234. [CrossRef] [PubMed]
39. Galam, S. *Sociophysics. A Physicist's Modeling of Psycho-political Phenomena*; Springer Science + Business Medai, LLC: New York, NY, USA, 2012; pp. 3–19. [CrossRef]
40. Galam, S. Unanimity, coexistence, and rigidity: Three sides of polarization. *Entropy* **2023**, *25*, 622. [CrossRef] [PubMed]
41. Galam, S. Opinion dynamics and unifying principles: A global unifying frame. *Entropy* **2022**, *24*, 1201. [CrossRef]
42. Diep, H.T.; Kaufman, M.; Kaufman, S. An agent-based statistical physics model for political polarization: A Monte Carlo study. *Entropy* **2023**, *25*, 981. [CrossRef]
43. Epstein, J.M. Agent-based computational models and generative social science. *Complexity* **1999**, *4*, 41–60. [CrossRef]
44. Lempert, R. Agent-based modeling as organizational and public policy simulators. *Proc. Natl. Acad. Sci. USA* **2002**, *99* (Suppl. S3), 7195–7196. [CrossRef] [PubMed]
45. Kaufman, M.; Diep, H.T.; Kaufman, S. Sociophysics of intractable conflicts: Three-group dynamics. *Phys. A* **2019**, *517*, 175–187. [CrossRef]
46. Batty, M.; Torrens, P.M. Modelling complexity: The limits to prediction. *Cybergeo Eur. J. Geogr.* **2001**, *Dossiers*, 201. [CrossRef]
47. Jones, J. U.S Party Preferences Evenly Split in 2022 after Shift to GOP. *Gallup*, 12 January 2023. Available online: https://news.gallup.com/poll/467897/party-preferences-evenly-split-2022-shift-gop.aspx(accessed on 10 December 2023).
48. Gallup. Party Affiliation. Trend since 2004. Available online: https://news.gallup.com/poll/15370/party-affiliation.aspx (accessed on 10 December 2022).
49. Blume, M. Theory of the first-order magnetic phase change in UO_2. *Phys. Rev.* **1966**, *141*, 517–525. [CrossRef]
50. Capel, H.W. On the possibility of first-order phase transitions in Ising systems of triplet ions with zero-field splitting. *Physica* **1966**, *32*, 966–988. [CrossRef]
51. Blume, M.; Emery, V.J.; Griffiths, R.B. Ising model for the λ transition and phase separation in He^3–He^4 mixtures. *Phys. Rev. A* **1971**, *4*, 1071–1077. [CrossRef]
52. Lipiecki, A.; Sznajd-Weron, K. Polarization in the three-state q-voter model with anticonformity and bounded confidence. *Chaos Solitons Fractals* **2022**, *165*, 112809. [CrossRef]
53. Burgess, G.; Burgess, H. Massively Parallel Peacebuilding. *Beyond Intractability*, 2020. Available online: https://www.beyondintractability.org/frontiers/mpp-paper(accessed on 10 December 2023).