

Dynamics of Political Polarization.*

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Abstract

This article accounts for two puzzling paradoxes. The first paradox is the simultaneous absence and presence of attitude polarization, the fact that global attitude polarization is relatively rare, even though pundits describe it as common. The second paradox is the simultaneous presence and absence of social polarization, the fact that while individuals experienced attitude homogeneity in their interpersonal networks, their networks are characterized by attitude heterogeneity. These paradoxes give rise to numerous scholarly arguments. By deploying a formal model of interpersonal influence over attitudes in a context where individuals hold simultaneous positions on multiple issues we show why these arguments are not mutually exclusive and how they meaningfully refer to the same social setting. It follows that the results from this model provide a single parsimonious account for both paradoxes. The framework we develop may be generalized to a wider array of problems, including classic problems in collective action.

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1 Introduction

In this article we provide a parsimonious account for two puzzling empirical outcomes. The first is the simultaneous presence and absence of political polarization - the fact that attitudes rarely polarize, even though people believe polarization to be common. The second is the simultaneous presence and absence of social polarization - the fact that while individuals experience attitude homogeneity in their interpersonal networks, these networks retain attitude heterogeneity overall. We do this by investigating the joint effects of personal influence on attitudes and social relations.

The first paradox emerges most crisply in the contrast between the observations of pundits, and expert knowledge. For example, lay observers routinely assume that America is increasingly politically polarized, this belief contrasts rather sharply with the scholarly evidence on political polarization (DiMaggio, Evans and Bryson 1996; Evans 2003; Baker 2005; Fiorina, Abrams and Pope 2005), which suggests that aside from a small set of take-off issues, “the policy preferences of different social groupings generally move in parallel with each other” (Page and Shapiro 1992:288). In general, on moral, social, economic, and foreign policy issues there is little evidence of increasing polarization.

Against this background why do pundits believe that attitudes are increasingly polarized? One answer is trivial: people attend to the wrong population, focusing only on the attitudes of political elites. The second answer is more substantial: at some times typically for very short periods, some issues become the focus of intense attention and consequently appear to radically polarize Americans - for example, attitudes towards abortion, gays in the military, and more recently, attitudes towards the Iraq war (Shapiro and Bloch-Elkon 2006). We can call these few issues take-off issues. It often happens that our collective attention to the take-off issues distracts us from the larger number of issues in which attitudes remain parallel, thus individuals perceive the macro-structure as polarized despite the fact that in the context of a population of issues, polarization is absent.

The second paradox emerges most crisply in the contrast between everyday experience and expert knowledge. The everyday experience of Americans is consistent with the idea that their social world is polarized. Here as well one observes a complex duality. On one hand, our ordinary experience is that the people we talk to about issues salient to us have beliefs similar to ours on those issues. This phenomenon is typically accounted for by sociologists who note the macro-level dynamics that lead to persistent race, ethnic, and social class segregation, thereby enhancing probability of contact with

categorically similar individuals (Massey 1996; Abramson and Tobin 1995; Jargowsky 1996). Since there is some relationship between attitudes and social background, the fact that socially similar individuals are more likely to interact is seen to yield segregated social and ideational communities. On the other hand, there has been no real change in the relationship between attitudes and attributes (DiMaggio et al. 1996; Evans 2003; Fiorina et al. 2005) - that is, the social background determinants of attitudes are as weak today as they were fifty years ago. These dual views give rise to an asymmetry between lived experience and “sociological reality.” This asymmetry is a consequence of the fact that people interact with a limited number of others and talk to far fewer about political issues important to them. Thus while individuals experience attitude homogeneity, the larger group in which they are embedded retains attitude heterogeneity.

In order to study the simultaneous evolution of political views and patterns of social interaction, and thus observe the ideational and structural conditions that underpin those rare moments in which political and social polarization occurs, we deploy a formal model of interpersonal influence over attitudes in a context where individuals hold simultaneous positions on multiple issues - for example, abortion, highway construction, campaign reform and pollution abatement - just as real people do. In our model social structural dynamics operate to enhance the probability that people with similar attitudes will interact with others with similar attitudes, but actors also interact with those whose positions on attitudes are different. Actors are most likely to interact around the issue that is most salient to them, choosing that topic over topics that they have little interest in. These conversations provide the foundation for personal influence. This influence may operate to bring individuals closer together or it may induce greater distance.

To anticipate the main results - obtained by studying the model through computer simulation - we observe that the simultaneous presence and absence of political polarization may be accounted for by the fact that most attitudes are not polarized while some attitudes at some times attract disproportionate attention and become polarized, while the simultaneous presence and absence of social polarization arises from the fact that people discuss important issues selectively, and thus experience homogeneous environments, although the actual attitude distribution of those around them is heterogeneous.

In more general terms, we show that simple mechanisms of social interaction and personal influence can lead to both social segregation and ideological polarization. Along the way, we identify the social dynamics that underlay issue takeoff, and therefore describe one of the structural de-

terminants of ideational change. Because the model operates on attitudes that individuals hold in the context of 'tangible' social relations, within an observable network structure, the framework we develop is amenable to generalization to a diverse set of problems, including classic problems in collective action.

The structure for this article is straightforward. We first consider the literature(s) on ideological and social polarization. Building on empirical findings arising from public opinion research and studies of group dynamics, as well as previous models of social influence, we describe a model for political influence in the context of interpersonal relations. Simulation results from this model are described, first for exemplary cases as illustration, and subsequently for the entire population of observed outcomes. In the discussion we relate these results back to our empirical puzzles. Finally, we generalize the model to a wide array of contexts, including those relevant for collective action.

2 Political and Social Polarization in Contemporary America

Scholars who engage the political polarization debate tend to argue that while political elites and party activists are increasingly polarized, ordinary citizens are not. Fiorina, for example, suggests that:

Americans are closely divided, but we are not deeply divided, and we are closely divided because many of us are ambivalent and uncertain, and consequently reluctant to make firm commitments to parties, politicians, or policies. We divide evenly in elections or sit them out entirely because we instinctively seek the center while the parties and candidates hang out on the extremes (Fiorina et al. 2005, p. ix).

If scholars tend to agree that elite and activist polarization has increased,¹ they also tend to agree that public opinion polarization has not followed

¹This may be more true for the right, than for the left. For the right a soft ideological realignment of the party elite initiated under Reagan, as a consequence of his economic and social programs was radically accelerated by a new cohort of strongly conservative republicans from the South who replaced the moderate wing of the Republican Party (Wilcox 1995). The collapse of the Democratic Party in the South led the party as a whole to appear more liberal, even as it was pursuing traditional centrist policy agendas. These dynamics led to a decline of bipartisanship in Congress (Poole, Rosenthal 1997) and contributed to the further polarization of party activists, through both persuasion and mechanisms of selective recruitment and de-recruitment (Saunders and Abramowitz 2004).

suit to the same extent, despite elite polarization has been accompanied by a parallel rise in wealth disparity in the population (McCarty, Poole and Rosenthal 2006). Whether or not one looks for polarization across all Americans or one tracks changes within population subgroups, available empirical data suggest that there is no evidence for polarization, overall, except for some take-off issues. Considering the population as a whole, DiMaggio et al. (1996) show that:

Americans have become more united in their views on women's role in the public sphere, in their acceptance of racial integration and in their opinions on matters related to crime and justice. These trends represent movement toward consensus on liberal views and racial integration and gender and on tougher positions on crime. By contrast, Americans have become more divided in their attitudes toward abortion and, less dramatically, in their feelings towards the poor.(715)

Evans (2003) subsequently confirms these results, although he finds new evidence of increasing polarization on attitudes toward sexuality. While considering changes within population subgroups, most empirical work shows that inter-group polarization is mild. Specifically, with respect to age, gender, education, region, and religious affiliation we observe stability or even instances of depolarization in inter-group differences. In fact, the evidence suggests that variance and bimodality (two measures commonly used for assessing polarization) have not increased for most attitudes. Likewise, attitudes are not now more constrained by categorical group memberships. That is, the attitudes of high school graduates and college graduates, men and women, the old and the young, and so on are not increasingly dissimilar.

In the same vein, Fiorina et al. (2005) dispute “The Myth of a Polarized America” and suggest that the “Culture War” commonly conjured up in the media is a fictive construction. According to their analysis, there is no popular polarization, but simply partisan polarization, that is “those who affiliate with a party are more likely to affiliate with the ‘correct’ party today than they were in earlier periods” (2005, p. 25).² It is the political elite and a small number of party activists that are polarized.³

²Likewise, Bartels has shown that the impact of partisanship on voting behavior grew over time (Bartels 2000:35).

³Of course, others disagree. For example, Abramowitz and Sounders (2005) argue that divisions between red states and blue states between religious voters and secular voters and between Democrats and Republicans “are not confined to a small minority of elected officials and activists – they involve a large segment of the public and they are likely to increase in the future as a result of long-term trends affecting American society.” (abstract)

Without getting lost in the details we can summarize the three main findings upon which scholars agree. First, while American public opinion since 1990 is increasingly divided on abortion, and more recently on sexuality morality and the war in Iraq (DiMaggio et al 1996; Evans 2003; Shapiro and Bloch-Elkon 2006), we observe stability and even depolarization on all the remaining issues. Second, we do observe some growth in partisan polarization: those who are politically active, who identify themselves with a party and/or place themselves on the liberal/conservative continuum, tend to have more extreme position than the rest of the population. Third, we do not observe popular polarization along the lines of gender, age, education, race, region and religious denomination (although church attendance is associated with polarized attitudes). With respect to these demographic and social categories, the parallel public still holds for the vast majority of issues.

Despite these findings, people experience the world as more polarized than it really is. This leads pundits to claim increasing polarization, inducing the asymmetry between lay and expert opinions (Kohut, et al. 2000; Greenberg 2004; Abramowitz and Saunders 2005). As indicated earlier, making sense of this asymmetry is one contribution of this article. The account we provide hinges on the fact that one or two issues, for very short periods of time, monopolize debate and emerge as highly polarized.

While it is a cultural invariant of all societies that people tend to interact with people that are similar to them (McPherson, Smith-Lovin and Cook 2001), changes in the overall level of social segregation - and the lines along which segregation is organized - are relevant in order to understand the dynamics of everyday interaction and personal influence. This is because social structural changes which give rise to segregation or integration shape interaction dynamics by shaping the probability of encounters. Against this background, recent studies on social inequality and segregation provide a detailed picture of the trends in spatial segregation with respect to class, life course, race and ethnicity that have characterized American society during the second half of the 20th century (Massey 1996, Logan, Stults and Parley 2004). From the 1970s on, we observe a rise in residential segregation by income and social class (Abramson and Tobin 1995; Jargowsky 1996) and in some cases the spatial structuring of affluence and poverty has been magnified by race and ethnic differences (Massey, Denton 1989). In addition to the persistence or even amplification of traditional patterns of segregation, in the last decades scholars have reported new forms of segregation arising from choices and life-styles. For example, young single adults increasingly concentrate in center cities. Likewise, homosexuals have disproportionately

relocated to a handful of large cities.

As spatial segregation has remained stable or even increased, there is also evidence that the integrative role of voluntary associations is less salient today than in the relatively recent past. First, there is a general sense that membership in such associations is declining. More important, even when not in decline, voluntary associations are more homogeneous with respect to social class, race, ethnicity, and religious orientation today than in the past. Skocpol (2003), for example, argues that voluntary groups have been largely transformed into advocacy groups and non-profit organizations, directed by professionals oriented to lobbying activities. Therefore, one of the by-products of a rich associational life, the possibility of building social relations with a broad, heterogeneous set of other people is reduced (Putnam 2000). Persistent spatial segregation and increased associational segregation provide the sociological foundation for the idea that today, more than in the past, people talk to people who are categorically more similar and therefore the structural foundation for the everyday experience that the people we talk to share our attitudes. This is true. But at the same time it is also true that the relationship between categorical attributes and attitudes is no stronger today than in the past; people hold contradictory and inconsistent attitudes, and, on many issues, people have only weak opinions at best. Thus while our conversations tend towards homogeneity (because we discuss only a subset of possible political issues with a subset of possible interlocutors), the network we are embedded retains heterogeneity of interest on diverse attitudes. In sum, with respect to ideational dynamics, polarization on one issue need not lead to polarization on all issues, with respect to social segregation, there may not be a mapping between social and attitudinal polarization. In fact, as we will suggest, such a mapping is unlikely. The same dynamic that leads to an intense focus on a single issue - and consequent social structural and attitudinal polarization - maintains attitude heterogeneity on others. These twin dynamics make possible the experience of homogeneity in individual discussion networks, within heterogeneous social structures.

3 Model Framework

Empirical research has greatly contributed to our understanding of interpersonal influence (Lazarsfeld, Berelson, and Gaudet 1948; Katz and Lazarsfeld 1955). This empirical research has shown, that in general, social proximity and frequent interaction usually lead to attitude conformity: from acquaintances to intimates, individuals' opinions are shaped by seemingly

minor interactions with persons arising from diverse social contexts (Huckfeldt and Sprague 1995; Zuckerman 2005). While small-scale interactions are believed to cumulate into macro level outcomes, empirical studies focusing on the micro-sphere of personal contacts have provided a fragile foundation for a direct appreciation of any macro effect. Here we deploy a formal model of social influence that allows us to link patterns of micro-interaction with macro-structural outcomes (Hedstrm 2005).

We build on the substantial contributions of previous scholars who have studied processes of social influence and opinion change through analytical and simulation models. Mainly focused on the generation of group consensus, the earliest models of interpersonal influence led to universal agreement (French 1955; Harary 1959; De Groot 1974; see also Abelson 1964), while subsequent models reached equilibrium outcomes different from full consensus (Abelson 1979; Marsden 1981; Nowak, Szamrej, and Latan 1990; Hegselmann and Krause 2002). In this vein, Friedkin and Johnsen (1990; Friedkin 1999) integrated previous work on opinion formation with recent developments in network analysis in a general framework - social influence network theory - which is consistent with both theories of social conformity and social conflict, thus able to account also for patterns of disagreement in a group.

Models that involve dynamics of interpersonal influence differ broadly in their scope, ranging from the study of dynamics of ideological polarization (Nowak, Szamrej, and Latan 1990; Hegselmann and Krause 2002; Macy, Kitts, Flache, and Benard 2003), collective action (Kim and Bearman 1997), and collective decision-making (Marsden 1981) to the persistence of cultural differences (Axelrod 1997) and political disagreement (Huckfeld, Johnson and Sprague 2004).

Our main goal has been to deploy a model of interpersonal influence sensitive to dynamics of political discussion, where actors hold multiple opinions on diverse issues, interact with others relative to the intensity and orientation of their political preferences, and through evolving discussion networks shape their and others political contexts. In the model, opinion change depends on two factors: the selection of interaction partners - which determines the aggregate structure of the discussion network - and the process of interpersonal influence - which determines the dynamics of opinion change. In the next section, we organize the description of the model deployed here around these two elements, and summarize the simulation algorithm in Table 1.

INITIAL CONDITIONS:

100 actors

4 issues; issue interest \sim Normal ($\mu = 0, \rho = 33.3$); interest range (-100; +100).

Initialize Perceived ideological distance $\lambda =$ mean Euclidean distance among actors

ITERATION FLOW:

Selection of interaction partners

At each iteration for each actor:

Random sample of potential interlocutors \sim to the overall level of interest

Draw from the sample the actual interlocutors with $p = 1 - \lambda$

Process of Interpersonal influence

For each pair of actors previously selected:

Select the issue for discussion

Compute the change for each actor based on their interest on the issue

Determine direction of change according to the sign of the issue

Update actors' level of interest

Update actors' perceived ideological distance with the current/actual distance

Save all necessary information

(Repeat 500 times)

Table 1: Outline of the Simulation Algorithm.

3.1 Structure and Choice in Interaction

In general, people interact with people who are similar to them. Rich women marry rich men proportionally more often than poor women do. Republicans are more likely to know Republicans than Democrats. Overweight individuals are more likely to eat at fast-food restaurants than thin people and are therefore more likely to meet other overweight individuals. There are thus strong pressures towards homophily in social relations. At the same time, it happens that overweight persons meet slim ones, Democrats know Republicans, and rich people fall in love with not so wealthy ones. Despite a clear tendency toward homophily, people are also in touch with people different from them. Social similarities affect patterns of interaction, but they do not completely determine them. Accordingly, in the model deployed here, actors can accommodate their preferences and enforce homogeneity in the process, but room is always present for casual encounters with new and different actors.

Previous scholars have been sensitive to the role of social structure in shaping social influence. Most often, scholars model influence intensity as a function of actors' structural proximity and thus assume for all pairs in a set of actors, a matrix of influence coefficients that varies across pairs of actors. An actors' opinion is then adjusted to other actors' opinions proportional to these influence coefficients (French 1956; Harary 1959; DeGroot 1974). In this approach, every actor is potentially affected, albeit with different intensity, by the opinion of all other actors (Marsden 1981; Friedkin and Johnsen 1990) or by a subgroup of similar people (Hegselmann and Krause 2002).

Other models instead explicitly consider the presence of a spatial context (Nowak, Szamrej, and Latan 1990; Axelrod 1997) or a tangible relational structure (Marsden 1981; Kim and Bearman 1997) within which individuals are embedded and discuss the relation between structural dynamics and attitude change. In both cases, individuals are influenced exclusively by those to whom they are connected in a relational structure or context that remains stable over time. In a similar model, Huckfeldt et al. (2004) introduced some freedom in the choice of interactants, by allowing actors to have multiple contexts and to search for the more agreeable discussants.

To make our model more sensitive to empirical evidence arising from studies of public opinion and political discussion networks, we allow actors to select their discussion partners on the basis of their ideological similarity and interact more or less often according to their overall interest in political matters. Thus instead of fixing actors into a predetermined, stable network

structure, we induce actors' discussion networks from the dynamics of local interaction in which they are involved. In this regard, the political network structure is shaped through patterns of interaction and evolves over time.⁴

An extremely fruitful distinction of the basic features of the system responsible for homophily is between "the individual level propensity to choose similar others (choice homophily) and the composition of the groups in the system, which dictate the possibilities for friendship choice (induced homophily)" (Mcpherson and Smith-Lovin 1987:371). Empirical studies suggest that a focus on choice homophily is warranted, as individuals exert significant freedom in selecting among the members of their social groups those they want to talk with about important matters and political issues (Huckfeldt and Sprague 1995). In the model deployed here actors learn about other actors' attitudes through interaction. This enables actors to map their ideological distance with respect to other actors. Actors then adjust their future interactions in order to reduce conflict and maximize the exposure to actors more similar to them. While ideological affinity does not drive all encounters – since actors are not stuck in fixed relationships – it does affect the unfolding of personal relations.

In sum, the likelihood actors have to get into a discussion with other people both depends on their personal level of political commitment and on the level of ideological affinity they have with other people. First, the more one is committed to a cause, the more one is likely to start a conversation. Second, actors tend to interact with others that are ideologically similar to them. Third, actors have some degree of freedom in deciding with whom they discuss their ideas and thus change interlocutors from time to time. Fourth, through interaction, actors acquire information about the ideological positions of others and adjust their future behavior accordingly.

Despite the necessary simplification that any analytical formalization imposes, the model deployed here retains the multiple and sometimes contradictory dynamics previously described. Specifically, the model operates with 100 actors ($N=100$), each of them holding an opinion on four different issue-domains (hereafter referred to simply as issues). In this framework, actors may be in favor or against a social policy associated with each issue. We capture intensity of sentiment, either positive or negative by values that are allowed to range from -100 to 100.⁵ Here, an interest of 0 indicates that

⁴Similarly, Carley proposed a dynamic model in which the probability of interaction changes over time and it is function of the amount of information shared by the actors (1991).

⁵Algebraically, it is the same as modeling two qualitatively different features of interest, its arithmetic *sign* (+ or -) and its *strength* (ranging from 0 to 100).

the actor has no interest on the issue. Interest increases as values move toward either 100 or -100. The overall interest distribution follows a normal distribution centered on 0 and with a standard deviation of 33. The four issues are independent.⁶ In this way, we model issue interest and extremity of opinion with a unique parameter. Although analytically distinct, these two aspects are empirically related: The more people are interested in an issue the more they tend to have extreme views (Baldassarri 2007). There are cognitive and motivational reasons for this. Attitude involvement induces biased information-gathering strategies that are then likely to reinforce one’s opinion and make it more extreme. In turn, attitude extremity makes it more accessible, thus important to individuals (Lavine, Borgida, and Sullivan 2000). On this ground, extremity of opinion can be regarded at as a good proxy for issue interest, and *vice versa*.

We now describe the process of social selection that guides the dynamic formation of discussion dyads. As indicated earlier, two aspects are relevant here. On one hand, actors’ overall level of interest affects their frequency of interaction; on the other hand, ideological affinity shapes the selection of specific discussants. With respect to ideological similarity, actors are not universally knowledgeable about the attitudes of those around them. Their knowledge about other actors’ opinions depends on the history of their personal interaction (Huckfeldt et al. 2004). We therefore distinguish, for each pair of actors, between their real ideological distance ($d_{ab}^{(t)}$) and their perceived ideological distance ($\lambda_{ab}^{(t)}$). The latter is updated to the former when actors interact. Specifically, we define the ideological distance $d_{ab}^{(t)}$ between actor a and actor b at time t as the Euclidean distance in the four dimensional space of the four issues i , normalized to a range 0-1 by dividing for the maximum value of all pairs:

$$d_{ab}^{(t)} = \frac{\sqrt{\sum_{i=1}^4 (a_i^{(t)} - b_i^{(t)})^2}}{\max_{\{a,b\} \in N} \left[\sqrt{\sum_{i=1}^4 (a_i^{(t)} - b_i^{(t)})^2} \right]} \quad (1)$$

The perceived ideological distance $\lambda_{ab}^{(t)}$ is initialized as the average distance at time 0 (t_0) over all $a - b$ dyads. When actors interact, they acquire

⁶We investigated a wide range of alternative models where we allow for correlations between issues. With respect to the argument and the main results presented in the article, there is no difference between a model in which issues are independent and one in which issues are correlated.

information about each other’s ideological positions and update their perceived ideological distance to match the actual ideological distance between them. Formally,

$$\lambda_{ab}^{(t)} = \begin{cases} \overline{d^{(t_0)}} & \text{if actors } a \text{ and } b \text{ never interact before} \\ d_{ab}^{t-c} & \text{if actors } a \text{ and } b \text{ last interacted at time } t - c \end{cases} \quad (2)$$

For any pair of actors a and b , the probability of interaction is proportional to their interest and an inverse function of the perceived ideological distance between the two. Combining these two elements, actor a ’s chance to interact with actor b at time t ($P_{ab}^{(t)}$), is proportional to the overall interest of actor a , to the overall interest of actor b , and inversely related to the perceived ideological distance ($\lambda_{ab}^{(t)}$) between the two. Formally,

$$P_{ab}^{(t)} = \frac{\eta * \left[\left(\frac{\sum_{i=1}^4 |a_i^{(t)}|}{4} \right)^2 + \left(\frac{\sum_{i=1}^4 |b_i^{(t)}|}{4} \right)^2 \right] * (1 - \lambda_{ab}^{(t)})}{100} \quad (3)$$

where $P_{ab}^{(t)} \sim 1$ if both actors strongly agree ($\lambda_{ab}^{(t)} \sim 0$) and all four issues are maximally salient to them, while $P_{ab}^{(t)} \sim 0$ in the case they strongly disagree ($\lambda_{ab}^{(t)} \sim 1$) or they have no interest on the four issues.⁷

While, of course, actor a and b have the same probability to interact with each other – interaction is reciprocal! – their respective total number of interactions might differ, due to differences in their overall level of interest. By conditioning the probability of interaction on actors’ overall level of interest, we create a context in which a few people almost never engage in political matters, some discuss politics sometimes, and others more often, thus introducing in the model a realistic feature of population heterogeneity (Eliasoph 1998; Delli Carpini and Keeter 1996).

⁷Operationally, for each actor at each time period t , we randomly selected from the population a number of potential interlocutors as function of actor’s overall level of interest. Specifically, the number of people selected is proportional to the sum of the squared mean of interest over the four issues. Given this set of potential interlocutors, the probability of a discussion taking place is inversely proportional to the perceived ideological distance. Specifically, the interaction between actor a and b is defined as the outcome of a random draw from a Bernoulli distribution with probability equal to 1 minus the perceived ideological distance between a and b . η is a scaling factor (here, .005) that limits the number of interactions to a reasonable range. In general, at time 1, actors have between 0 and 6 conversations, while at time 500, 0 to 12.

Finally, with respect to the selection process, note that the process of information updating, by which, after their first, casual encounter, actors a and b 's perceived ideological distance matches their real ideological distance, has a key role in introducing relational historicity into the selection dynamic. In fact, further interactions are affected by this change in the perceived distance λ_{ab} : Positive interactions increase the probability of future (positive) political discussions while disagreement or conflict reduces the chances of future encounters.

While actors will not pursue disagreement, nonetheless there are situations in which people happen to have an alternative perspective on relevant aspects of social life. Dog owners are more likely to become friends with neighbors who own dogs, but owning a dog also increases one's probability of contact with neighbors who intensely dislike dogs (after all, even good dogs bark frequently enough to induce complaints from dog-haters). Likewise, community groups mobilize (in favor or against) specific issues that are promoted by other groups, individuals or local institutions. Those with intense opinions on these issues are more likely to interact than those without, and so on. It follows that not only similarities but also strong differences can induce social interaction. In fact, the persistence of attitude heterogeneity in discussion networks is well documented empirically. For example, Huckfeldt, Johnson, and Sprague (2004) show that "political disagreement was a common event among citizens () even within closely held networks of political communication" (63). Looking at respondent agreement with discussants who support Bush or Gore by respondent's partisanship, they found that "more than one-third of the two party voters report at least one discussant who voted for the opposite party's candidate" (37).

Consequently, in our model, discussions are about the topic that both actors are most interested in. This is true even if they do not share the same view. When actors interact, they select from the portfolio of issues available the issue with the highest joint relevance, defined as the issue for which the sum of a and b 's absolute values is maximum. Specifically:

$$\text{Salient issue} = i \text{ such that } \max \left(\left| a_i^{(t)} \right| + \left| b_i^{(t)} \right| \right) \text{ for } i = (1, \dots, 4) \text{ at time } t \quad (4)$$

Thus while issue selection is based on level of interest, actors need not hold the same position. Actors might discuss a certain topic either because they have strongly complementary views or strongly competing views on the same issue. Baseball fans, if they sit at the same dinner table, will talk about baseball whatever team they root for. Those who care deeply about an issue - the death penalty, global warming, threats to world peace

- will also talk about those issues, amongst friends and kin, certainly when they share the same opinion, but also when they disagree. Overall, in our model, actors are more likely to discuss issues they agree upon, this follows from the mechanisms of social selection and information updating previously described. Nonetheless, by choosing discussion issues on the basis of their salience and independently from actors' respective positions, we allow some room for disagreement.

3.2 Mechanisms of Social Influence

Discussion with others about views important to oneself may amplify, reinforce or reduce commitment to one's beliefs. In fact, most empirical studies of group dynamics and persuasive communication, as shown by Kitts (2006), suggest that while interaction with similar (or liked) others reduces distance, interaction with dissimilar others may increase distance leading to group polarization. Experimental studies in social psychology suggest three complementary explanations for the 'group polarization phenomenon'. The *persuasive arguments* explanation suggests that while actors do not originally hold the entire set of arguments in support of their perspective that, through conversation, they come to share a broader set of arguments that favor their initial attitudes, and thus move towards more extreme positions. The *social comparison* explanation suggests that polarization occurs when group members, through interaction, become aware of the fact that their attitude is shared by a larger group of people than expected, thereby enhancing commitment (Myers and Lamm 1976). Lastly, individual's attitudes become more extreme in case of *repeated attitude expression*, an effect augmented by social interaction (Brauer, Gliner, and Judd 1995). These three mechanisms are consistent with the model deployed here.

Specifically, when interlocutors share the same view, interaction leads to a *reinforcement* of their belief. Where discussants differ, either *compromise* or *conflict* can result (Hovland, Harvey, and Sherif 1957). In the case of disagreement, a simple mechanism of dissonance reduction (Festinger 1957; Hedstrm 1996) shapes whether or not the two parties will move toward a compromise, or exacerbate their differences. In real life, conversations usually unfold upon a variety of subjects and this gives ego the opportunity to evaluate positions and reasons of alter on a broad set of issues. If actors have opposite attitudes on a salient issue their interaction will lead to compromise when compromising reduces dissonance. Likewise, actors will commit to their beliefs when commitment (amplification of conflict) reduces dissonance.

	a b ++	a b --	a b + -		a b - +	
			conflict	compromise	conflict	compromise
Change for a	+ Δa_i	- Δa_i	+ Δa_i	- Δa_i	- Δa_i	+ Δa_i
Change for b	+ Δb_i	- Δb_i	- Δb_i	+ Δb_i	+ Δb_i	- Δb_i
relative movement	$\rightarrow \leftarrow$	$\rightarrow \leftarrow$	$\leftarrow \rightarrow$	$\rightarrow \leftarrow$	$\leftarrow \rightarrow$	$\rightarrow \leftarrow$

Table 2: Directionality of Opinion Change.

In general, the direction of opinion change depends on interactants' relative position. Table 2 shows, for a pair of actors a and b the four possible combinations of interest orientation (+ +, - -, + -, and - +) and the consequent direction of their opinion change. If actors share the same orientation, interactions reinforce their respective commitments and they end up closer to each other (the distance among them is reduced since actors that have lower absolute levels of interest move more than those with higher levels of interest). If they have contrasting views on the focal issue, but share similar opinions on the remaining issues, they compromise by reducing their commitment on the salient issue. Also in this case, actors move closer to each other. In contrast, if they disagree on other issues, their commitment on the focal issue is reinforced and their opinion diverges further.

We now consider intensity of opinion change. In one modeling tradition, single interactions can radically change individuals' opinions; attitudes are seen as categorical and interpersonal influence induces categorical changes in individual's opinion, that is, a change in states (Axelrod 1997; Huckefeld et al. 2004; Watts and Dodds 2005). In contrast, other models – and the model deployed here – assume that opinions are continuous and actors change position by some constant fraction of the distance between actors (Abelson 1964; Marsden 1981). Of course, people may recall conversations in which a sharp argument was enough to change their (or others') mind, but the fact that they remember such events tells us that they are quite exceptional. While people usually do not keep track of the myriads of unperceivable, small attitudinal changes that occur in their everyday life, it is from this crevice unfolding of incremental tiny modifications in people's attitudes that both stability and change in mass opinions arise. We model interpersonal influence as bidirectional – both interlocutors change their opinion as a consequence of the interaction – but the magnitude of attitude change depends on their personal level of commitment. Group dynamics and political opinion research both suggest that those least susceptible to influence are those who either hold strong beliefs or are indifferent to the issue at hand. It follows that individuals with moderate interest in an issue

are most susceptible to influence (Zaller 1991; Converse 1964; Brauer, et al. 1995). Accordingly, in our model people have a low probability of discussing issues of low interest to them, and consequently their opinion on such issues is rarely modified. In contrast, while highly committed persons interact frequently with others, their opinion rarely changes dramatically. In fact, we model opinion change as inversely proportional to ego’s level of interest. In sum, changes in people’s opinion are incremental and sensitive to their level of interest – the magnitude of change decreases as actor’s interest (positive or negative) increases. Formally,

$$\Delta a_i^{(t)} = \mu * \frac{\left| \left| a_i^{(t)} \right| - \left| b_i^{(t)} \right| \right|}{\left| a_i^{(t)} \right|} \quad \text{for } a_i^{(t)} \neq 0 \quad (5)$$

where μ is a scaling factor (here, .1) that restricts the range of attitude change given an interaction. For instance, here, the maximum change is 19.9 points, when a_i is 1 and b_i is 100. In sum, we represent opinion change as an interpersonal process, where the intensity and direction of the change depend on the relative position of discussion partners. Intensity is a function of the difference in the level of interest of the two interlocutors. Direction is determined by the signs of their preferences. It may strengthen or weaken an actor’s interest in a specific issue. To exemplify the process of interpersonal influence captured in our model, we consider three simple scenarios. In scenario 1, actor a ’s interest in the four issues is respectively (50, -23, 6, 11) while b ’s interest is (20, 30, -50, 4). Following condition (4) actors will discuss issue 1, since it is the issue for which the sum of the absolute values is greatest. Following equation (5), the change for actor a is .6 while the change for b is 1.5. Since actor a and b share the same sign on issue 1 the conversation reinforces their respective commitment, shifting their new values to $a_1 = 50.6$ and $b_1 = 21.5$, thus reducing their relative distance. In scenario 2, actors a and b have the same absolute values, but they now have different signs on the most salient issue: a now has a negative interest on issue 1 (-50, -23, 6, 11) while b remains positive (20, 30, -50, 4). In this context, both the discussion issue and the attitude change for each actor remain the same. Note that the actors in this scenario hold alternative views on the discussion issue and have contrasting opinions on most of the remaining issue. This is a conflict situation, thus actors’ commitment on the focal issue is reinforced and their opinion diverges further: a will move more strongly negative, while b becomes more positive. The new values will be $a_1 = -50.6$ and $b_1 = 21.5$. Lastly, in scenario 3 actors still have the same

absolute values and alternative signs on the discussion issue, but they agree on the remaining issues: a now has values (-50, 23, 6, 11) while b remains the same (20, 30, 50, 4). In this case, since actors share similar opinions on the remaining issues they compromise by reducing their commitment on the salient issue, thus the new values will be $a_1 = -49.4$ and $b_1 = 18.5$.

4 Results

Computer simulations allow us to study the functioning of specific mechanisms in simplified social settings and to investigate the range of outcomes they generate. We run 1000 simulations of the model. In order to get to polarization, we first consider issues. Figure 1 reports graphs for 8 different simulation outcomes. For each simulation, we plot the selection frequency for each issue over time. As can be seen, the outcomes differ qualitatively. In some instances, multiple issues are discussed at comparable rates, whereas in other cases a single issue takes off. In order to summarize the range of outcomes into a synthetic index we compute a Herfindahl and Hirschman index of concentration (hereafter, the HH index):

$$HH = \sum_{i=1}^4 P_i^2 \quad (6)$$

where P_i represents the probability of discussion of issue i at time 500. P_i^2 can be interpreted, in our case, as the probability that two actors, randomly selected from the population, will speak about issue i . The HH index is the sum of these values and it increases according to the relative popularity of some issues. The histogram at the center of Figure 1 shows the HH distribution for the entire set of simulation outcomes. Reading from bottom-left to bottom-right the simulation outcomes are ordered by the HH Index, reported inside the box (Figure 1).

While our interest naturally draws us to consider the unusual cases where take-off occurs, it is important to also understand what happens most often. Throughout, we distinguish between two qualitatively different outcomes: take-off ($HH > .4$), in which the debate polarizes around a single issue (13% of the outcomes) and non take-off ($HH < .4$), in which issues are more evenly discussed. Note that, in more than 90% of cases in which the HH index is greater than .4, the most popular issue is discussed at least twice as often as the second most popular issue. While we distinguish between take-off and non-take-off outcomes in order to stress qualitative differences,

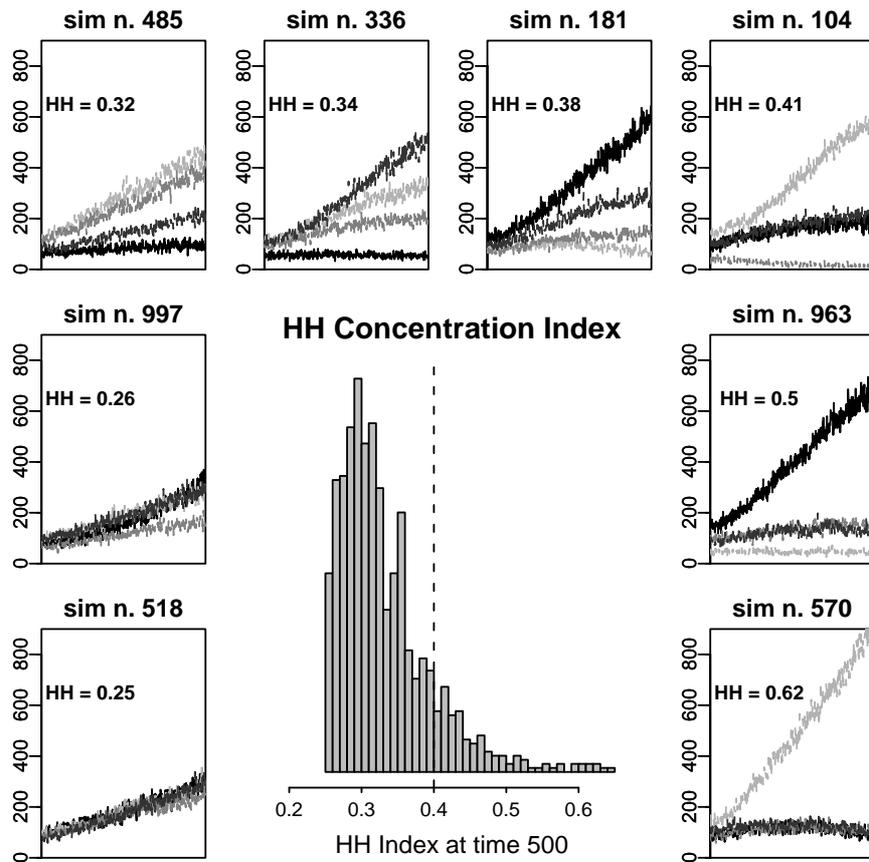


Figure 1: Frequency of Issue Discussion over Time.

The histogram in the center shows the distribution of the HH Index of concentration at time 500. The dashed indicates the .4 cut point that distinguishes between non take-off and take-off outcomes. Reading from bottom-left to bottom-right we display 8 simulation outcomes that are ordered by the HH Index, reported inside the box. For each simulation outcome, the graph shows the frequency of discussion of each issue over time. x-axis: time (from 1 to 500); y-axis: frequency of discussion.

the model generates a continuous distribution of outcomes.⁸ The presentation of the results unfolds as follows: we first consider two case studies by reporting results from a non take-off and a take-off situation. This provides a suggestive sketch of the differences observed between two typical cases. It is then followed by a more systematic analysis of the entire set of outcomes that basically confirms the case study findings. Focusing on the ideological conditions for issue take-off, we show that in take-off situations the most popular issue is highly polarized, relative to the other issues. We then consider the structural properties that arise from people’s patterns of interaction. We model the network structure by tracing the observed social relations actors engage over time, and we show that network structures in take-off situations are significantly more polarized than in non take-off situations. We consider the relationship between ideational and structural polarization and the level of asymmetry in issue popularity; in simple terms, take-off arises when the dynamics that induce ideological and structural polarization intersect. Here we show that the rise of a single issue is associated with an oversimplified social structure, characterized by a single dominant cleavage. In contrast, where there are multiple foci of discussion, social structure appears more complex and nuanced. Implications for understanding the determinants of political and social polarization are considered.

4.1 Case Studies

The model generates qualitatively different outcomes with respect to the level of asymmetry in issue popularity. Here we describe the ideological and structural characteristics that distinguish take-off and non take-off situations by portraying in detail two simulation outcomes – which can be regarded as ‘virtual’ case studies.

4.1.1 Routine Outcomes: The non Take-off Context

We start with the more frequent outcome, non take-off. Specifically, we consider simulation number 997, the second from the bottom-left in Figure 1. We first assess the extent of attitude polarization on two dimensions, dispersion and bimodality. Following DiMaggio et al. (1996) we use variance in order to measure the level of issue dispersion and kurtosis in order to measure bimodality. Dispersion refers to the average distance between two

⁸We use a cut-off value of .4 to distinguish between take-off and non-take-off contexts. The differences we highlight between these two contexts are robust. Cut-off values between .35 and .45 reveal the same substantive dynamics. Analyses available on request.

persons randomly chosen from a population and it captures the intensity of opinion divergence. The more a population is polarized, the greater the average distance between its members. Kurtosis⁹ measures the extent to which the population splits evenly into two groups. Kurtosis increases as attitudes radicalize and reaches its maximum value when moderation gives way to extremist views on either side of the issue. Note that while variance captures the strength of opinion divergence, kurtosis refers to the shape of attitude distribution and allows us to distinguish between cases in which actors' opinions organize around two alternative positions and cases in which the distribution of opinion is unimodal.

Figure 2 reports the attitude distributions (as histograms) of the four issues at times 1, 100, 200, 350 and 500. For each issue at each time we report kurtosis and variance. Initially, all issue distributions are essentially normal. As time passes, the number of actors with modest commitment to issues decreases, their attitudes become stronger, either positive or negative. Across the whole set of issues and times, both dispersion and bimodality increase leading toward a more polarized – or at least flat – attitude distribution.

We now consider the structure of interpersonal relations. We induce discussion networks from patterns of social interaction. Sociologists have defined relations in numerous ways, however there is virtually full agreement on the fact that sustained interaction is a relevant part of what constitutes a social tie. At different points in time, we consider the number of interactions each pair of actors has previously had and we draw a link between actor a and b when their number of interactions is significantly higher than expected if they were to select their discussion partners at random. Specifically, we define a measure of preferential association between actor a and b at time t ($A_{ab}^{(t)}$) as the difference between the observed ($Obs_{ab}^{(t)}$) and expected ($Exp_{ab}^{(t)}$) number of interactions (x) divided by the expected number of interactions.¹⁰

⁹For each issue i , we computed kurtosis as:

$$kurtosis_i = \frac{\sum_{a=1}^N (i_a - \bar{i})^4}{N * sd(i)^4} - 3 \quad (7)$$

where \bar{i} is the average opinion on issue i , $sd(i)$ is the standard deviation, and N is the number of actors.

¹⁰Where $Obs_{ab}^{(t)}$ is the total number of interactions actors a and b had till time t :

$$Obs_{ab}^{(t)} = \sum_{t=1}^T x_{ab} \quad (8)$$

and $Exp_{ab}^{(t)}$ is the product of each actor's total number of interactions divided by the total

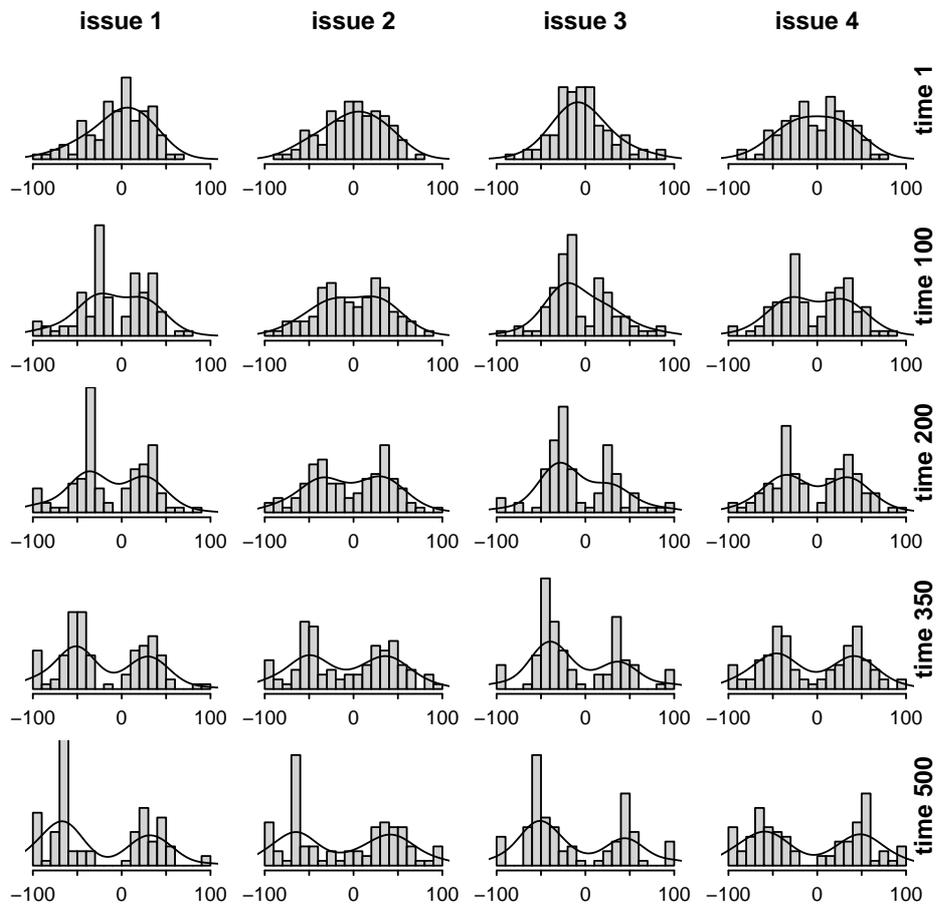


Figure 2: Issue Interest Over Time in a Non Take-off Case (997). Columns display the interest distribution of the four issues at times 1, 100, 200, 350, and 500. The table shows the values of kurtosis and variance associated with different points in time. The case is simulation number 997, an instance where take off does not occur.

$$A_{ab}^{(t)} = \frac{Obs_{ab}^{(t)} - Exp_{ab}^{(t)}}{Exp_{ab}^{(t)}} \quad (10)$$

The logic here is similar to the one used to compute models of independence¹¹ and it allows us to take into account and control for actors' different interaction frequencies (degrees). For each dyad a and b , $A_{ab}^{(t)}$ values close to zero indicate that they interact at chance levels, while deviations from zero indicate that social selection is operating. Negative values indicate that actor a avoids interaction with b while positive values indicate that a disproportionately selects b as a discussion partner. Note that this measure is not affected by frequency of interaction since we control for degree. Consequently, A captures a pure tendency for selection and avoidance of specific discussion partners. Technically, to distinguish between repeated interactions and more occasional ones, we draw a link between actors a and b if their propensity of association is at least two standard deviations greater than the average propensity of association for actor a . Relations are then treated as symmetric.

$$a \rightarrow b \quad \text{if } A_{ab}^{(t)} > 2 \text{ s.d.}(A_{a+}^{(t)}) \quad (11)$$

The derived discussion network can thus be considered an indicator of social structure in which only recurrent patterns of interaction constitute social ties.

Figure 3 reports the evolution over time of the emergent structure of political discussion in a non take-off situation. Nodes are shaded with respect to actor position on the most popular issue – black indicates a positive attitude, white negative. The structure of the graph remains remarkably stable over time. Most striking is the absence of sub-group formation. In fact, there is no indication that a leading logic of association between actors emerges. If actors are increasingly committed to their ideas, (which they are), this commitment – in a non take-off situation – carries few implications for social structure.

number of interactions among all the actors.

$$Exp_{ab}^{(t)} = \frac{\sum_{t-1}^T a_{a+} * \sum_{t-1}^T a_{b+}}{\sum_{t-1}^T a_{++}} \quad (9)$$

¹¹While this strategy might be problematic for relational data in which there are triadic tendencies and more complex forms of interaction, it is appropriate in the case networks are built starting from dyadic interactions.

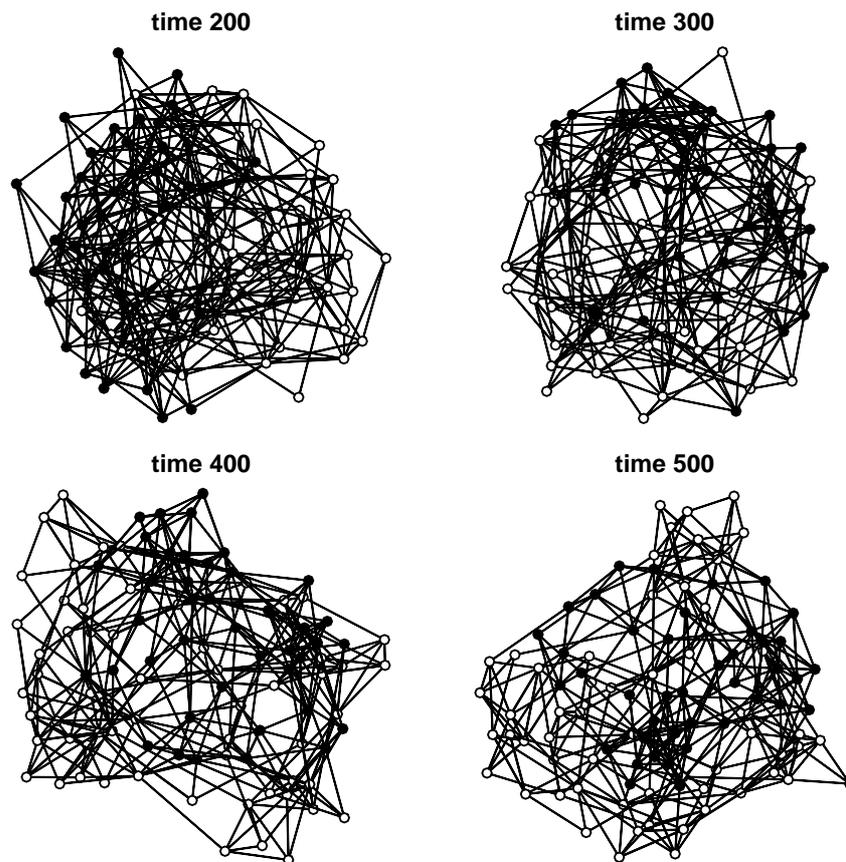


Figure 3: Discussion Networks over Time in a Non Take-off Case (#997). Actors (circles, or nodes) are connected (by arcs) if their frequency of interaction is higher than expected by chance. Nodes are colored according to the sign of the most frequently discussed issue. Black is positive, white is negative. Simulation number 997, non take-off. Graphs layout is a variant of Fruchterman and Reingold's force-directed placement algorithm implemented in R by Carter Butts. All graphs in the article are visualized using this algorithm.

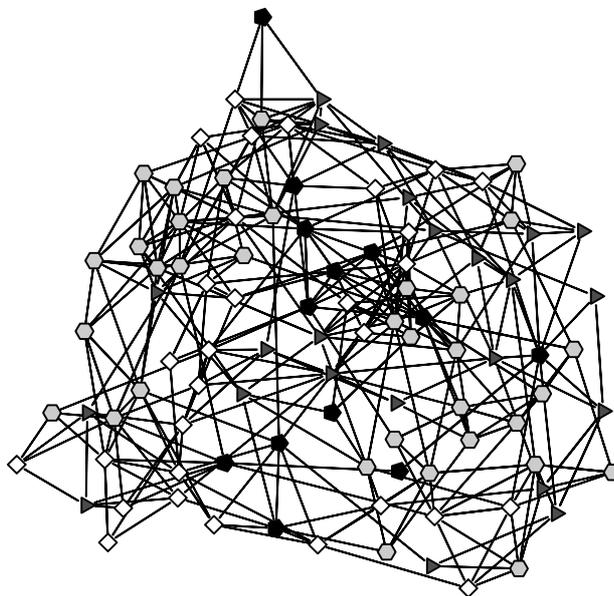


Figure 4: Discussion Network at Time 500 in a Non Take-off Case (#997). Nodes represent the issue that has been discussed most frequently by each actor. Color and shape distinguish different issues: dark gray triangles symbolize issue 1, white squares refer to issue 2, black pentagons issue 3 and light grey hexagons issue 4. Simulation number 997, non take-off.

It is possible that the population is not polarized on the most salient issue and that Figure 3 represses nascent conflict on other issues. We consider this idea in Figure 4 which reproduces the discussion network at time 500 – shown at the bottom-right in Figure 3 – and reports the issue discussed more frequently by each actor. It is evident that while actors tend to associate with others that share their viewpoint, the macro structure is integrated with respect to attitudes.

In sum, the normal outcome is that issues will not take off, that is, attention is devoted relatively evenly to all four issues over time. On each issue, as time elapses, opinions diverge slightly, the distribution of attitudes becomes therefore increasingly flat. With respect to social structure, there is little change. This does not mean that people do not associate with others who share the same opinions. More often than not, they do.¹² But the structure of interactions is not polarized, giving rise to the second puzzle we started with – while individuals experienced attitude homogeneity in their interpersonal networks, these networks retain attitude heterogeneity overall.

4.1.2 Non Routine Outcomes: The Take-off Context

We now consider a take-off situation, specifically simulation number 963, the second from the bottom-right in Figure 1. Recall that take-off is relatively rare, occurring only 13% of the time. From a quick glance at our case study we can see that one issue (here issue 1) takes off; that is, becomes the focus of intense discussion. In this instance, issue 1 is three times more frequently discussed than the other issues.

As before, we first consider attitude dispersion and bimodality for each issue. Figure 5 reports attitude distributions of the four issues over time. A direct comparison between Figure 5 (take off) and Figure 2 (non-take-off) reveals a different pattern. The take off issue (issue 1) polarizes rapidly; by time 200 the middle of the distribution is largely absent. By time 500, the distribution is bi-modal; everyone is radicalized – almost all of the actors have interest values higher than 50 or lower than -50. This is not the case for the other issues where the majority of actors have positions between -50 and 50. The values of kurtosis and variance provide more detailed quantitative evidence for this clear qualitative finding.

¹²One reader suggested that the most efficient test of this assertion, of course, would be to assess dyadic autocorrelation. Here we note that the autocorrelation between dyadic relations and each of the four issues is significant, with Moran's I statistic of autocorrelation ranging between .77 and .86 (Cliff and Ord 1973). It has to be this way, given the underlying selection model.

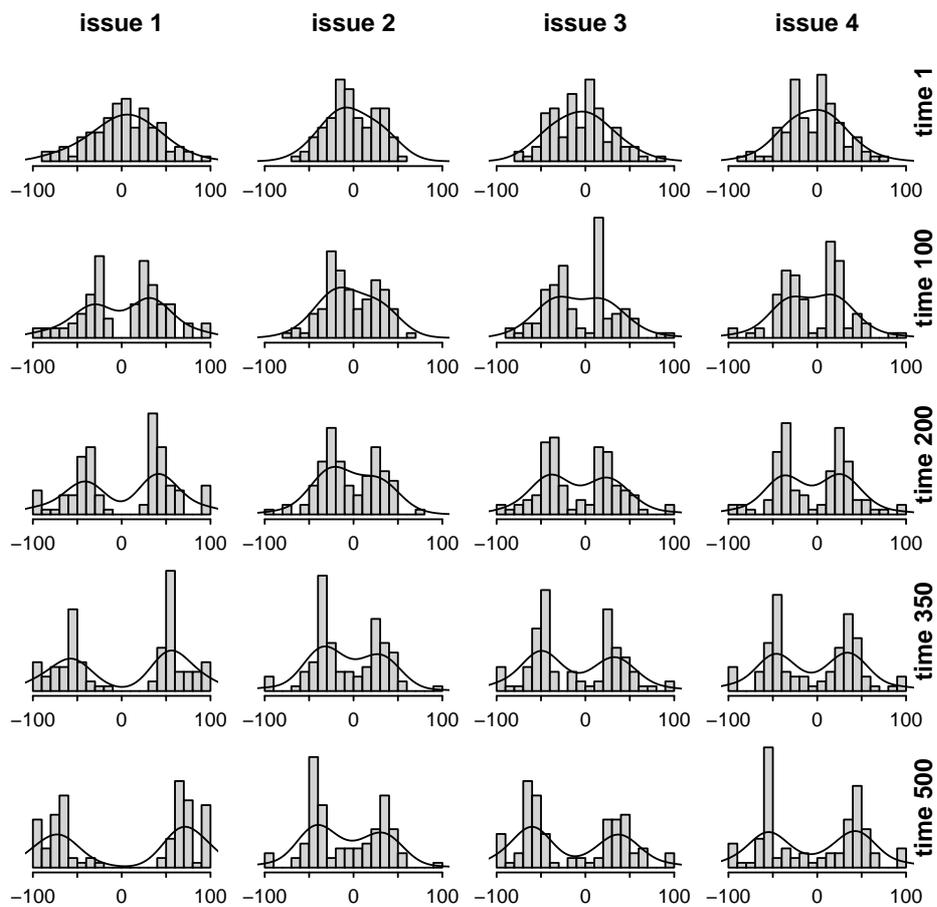


Figure 5: Issue Interest Over Time in a Take-off Case (#963). Columns display the interest distribution of the four issues at times 1, 100, 200, 350, and 500. The table shows the values of kurtosis and variance associated with different points in time. The case is simulation number 963, an instance where take-off does occur.

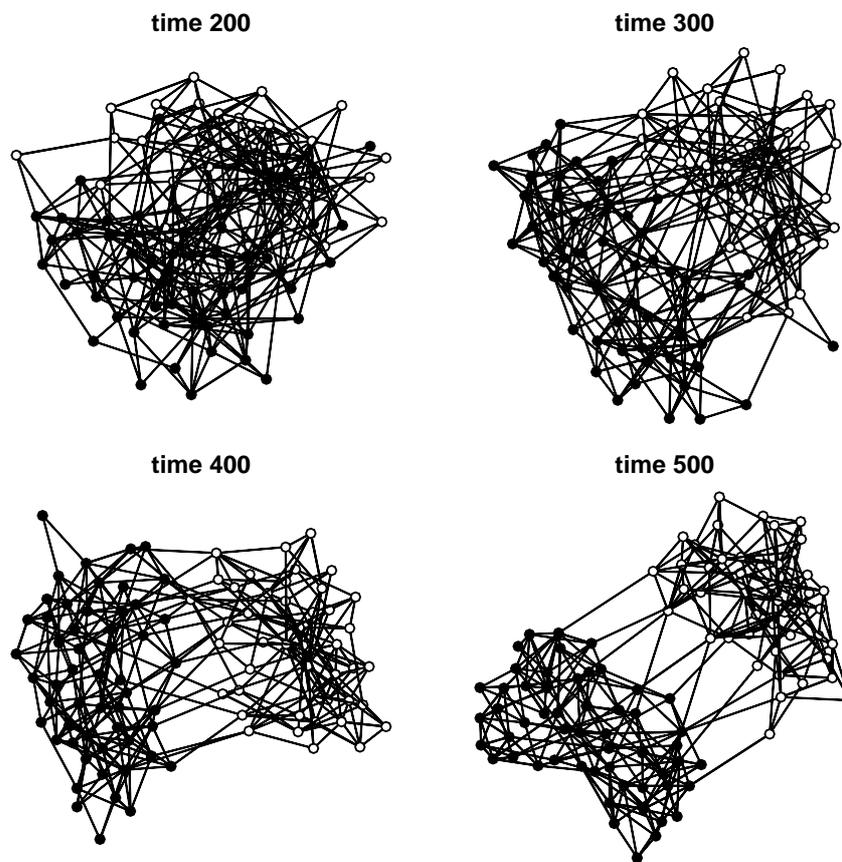


Figure 6: Discussion Network over Time in a Take-off Case (#963). Actors (circles) are connected (by arcs) if their frequency of interaction is higher than expected by chance. Nodes are colored according to the sign of the most popular issue. Black is positive, white is negative. Simulation number 963, take-off.

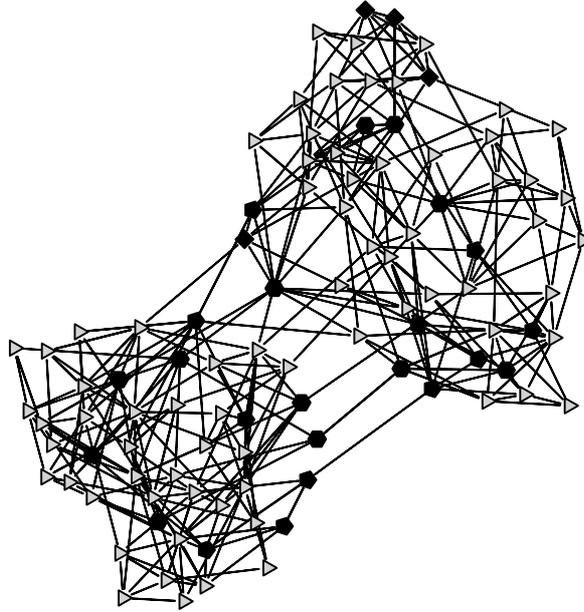


Figure 7: Discussion Network at Time 500 in a Take-off Case (#963). Nodes represent the issue that has been discussed more frequently by each actor. The color distinguishes between the most popular issue (grey) and all the other issues (black). Simulation number 963, take-off.

Take-off issues are more likely to be salient issues, and consequently, attitudes on them are more likely to be polarized. But it is not clear if ideational polarization induces social polarization. This is the problem we now consider. Figure 6 reports the emergent structure of political discussion over time. We observe dramatic structural polarization visible by time 300 and deeply encoded by time 500. Thus, patterns of political discussion in take-off situations induce polarized structures of interaction. What divides actors into alternative camps is their opinion on the most popular issue, as shown by the color of the nodes, where black is positive and white negative.

Take off contexts are contexts in which salient issues emerge, but they do not completely dominate political discourse. Here, as shown in Figure 7, for more than 25% of the actors, some issue other than issue number 1 is the most salient. Moreover, these actors are not marginalized; rather they serve as bridges between the two otherwise disconnected areas of the polarized graph. Here we observe an interesting irony, marginal issues serve as a glue

for social structure; the actors who focus on marginal issues integrate what would be otherwise increasingly disjoint worlds.

These results shed some light on the first puzzle we started with – that attitudes polarize rarely, even though people experience it as common. Here, when an issue becomes the focus of intense attention and consequently radically polarizes actors, individuals experience polarization in their discussion networks. However, with respect to the population of issues, polarization is largely absent. That is, the fact that one issue is polarized carries few implications for polarization on other issues. This is what we observe empirically as well; when people change their opinion on pollution abatement (for example) there is no reason to expect a corresponding change in attitude on other issues, for example, abortion, gay marriage, or educational vouchers. If we surveyed actors in our take-off context we would discover the fascinating result that on most attitudes their opinions are parallel, but on one, divergent. This, of course, is what many opinion surveys reveal. Since take-off issues come and go, different actors at different times serve as the glue for the social system; their roles change even if their attitudes do not. This simple fact provides an unanticipated foundation for social stability.

5 General Findings

We now generalize the qualitative findings from the case studies to the entire population of 1000 simulations; this requires a change in focus - and measurement. We first focus on ideological polarization and show that take-off issues are distinguished by their relative polarization – that is, their polarization with respect to other issues. We then turn to the intercalation of structural and ideological polarization and finally on the consequences that more or less segregated patterns of discussion have on the aggregate level of issues closure as well as on individual’s experience.

5.1 Ideological Polarization

To gain analytic leverage, we compute an index of polarization that combines dispersion and bimodality (here, the product of variance and kurtosis) such that the level of ideological polarization increases when the index increases. We then plot the level of polarization of the most popular issue against the average level of polarization of the other issues. Figure 8 shows the dynamic of attitude polarization distinguishing between non take-off (black dots) and take-off (white xs) cases. The x-axis reports polarization of the most popular issue, the y-axis reports polarization of the other issues.

Each point represents the coordinates for one simulation. The goal is to reveal relative levels of polarization.

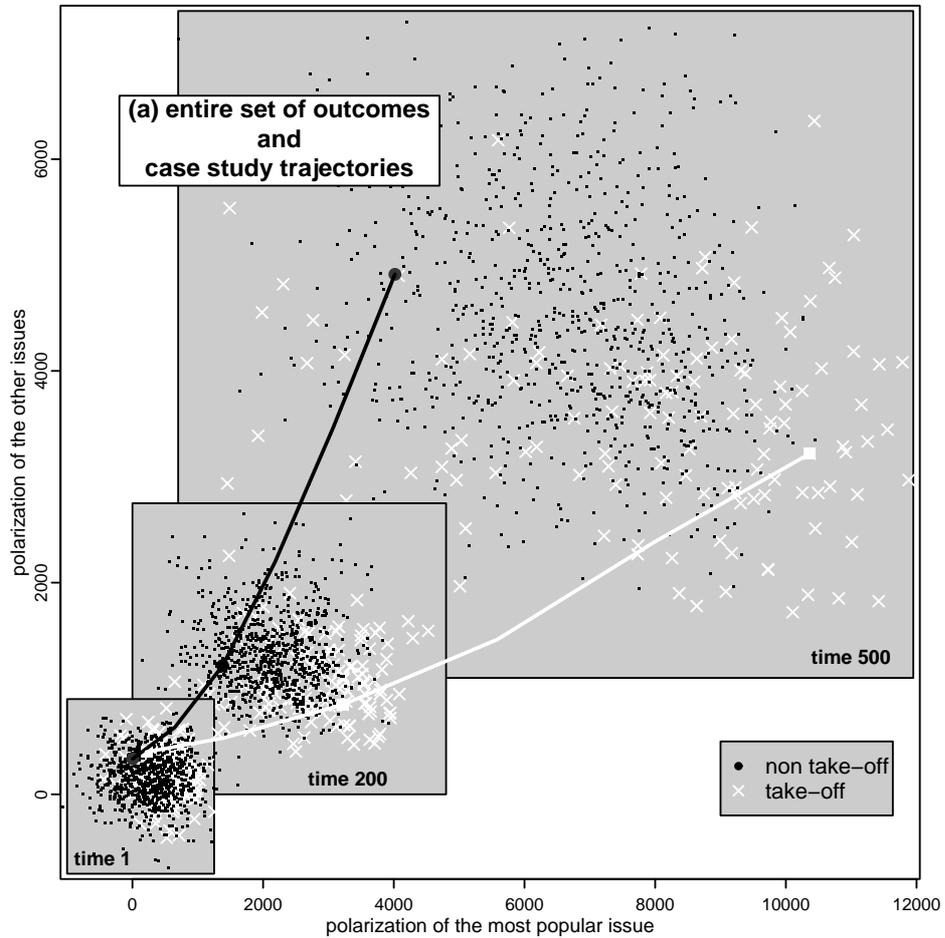
At time 1 (the small box in the bottom-left corner of Figure 8) take-off and non take-off contexts cannot be distinguished with respect to relative polarization, across all issues, whether popular or not. At time 200 (the center box) one can already see a dense cloud of take-off outcomes in the lower-right side signifying that the popular issue in take-off outcomes is relatively more polarized than the other issues. The relation appears even stronger at time 500. Lines show the respective trajectories of the two case studies. Figure 8 reveals that while the absolute level of polarization of the most popular issue tends to be higher in take-off than in non take-off outcomes, take-off outcomes are distinguished by their relative level of polarization. Thus, although the level of polarization of the most popular issue makes a difference, more critical is the level of polarization with respect to the polarization of the other issues. It follows that a polarized public discourse emerges from attitude polarization on a specific topic while attitudes on the remaining issues do not lean toward extreme values.

5.2 Structural and Ideological Polarization

From the case studies we observe that asymmetries in discussion frequency are responsible both for dynamics of ideological polarization and for crystallization of patterns of social interaction. This suggests that issue popularity is at the origin of emergent processes of polarization of interpersonal relations. In order to test this hypothesis, we partition the social networks into subgroups and compute a measure of structural polarization.¹³ To accomplish this, for different time periods, we first run CONCOR on the actor by actor cumulative discussion network to induce a 2-group solution such that groups are relatively even in size.¹⁴ To identify the best fit to a two group solution, in the second stage we iteratively assess whether or not node out-degree is disproportionately within group. If so, the assignment is retained. The procedure is continued until convergence. Second, we use a measure of modularity, which is often used to assess the performance of a graph partition, to evaluate the level of polarization of the two group (module) partition. A good partition is one that maximizes the number of within-module links (or minimize between-module links). In a two module solution, the lower the relative number of links between modules, the higher

¹³We thank James Moody for providing the partitioning solution.

¹⁴We opted for a 2-group solution on empirical grounds, since this was the most appropriate (and often times the only feasible) partitioning solution for most of the cases.



(a) Plot of the polarization of the most popular issue against the polarization of the other issues at times 1, 200 and 500. Take-off outcomes (white xs) have higher level of polarization on the most popular issue and lower level of polarization on the other issues than non take-off outcomes (black dots). Lines show the trajectory of the case studies.

(b) Plot of the average polarization of the most popular issue against the average polarization of the other issues in take-off (white) and non take-off (black) outcomes.

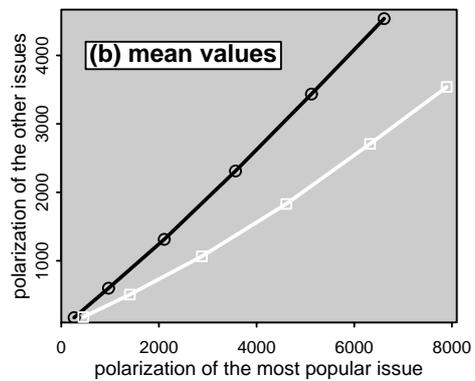


Figure 8: Relative Level of Polarization of the Issues over Time.

the modularity measure, and thus the level of polarization of the graph. Formally, the measure of modularity (M) for a two-group partition is:

$$M = \sum_{s=1}^2 \left[\frac{l_s}{L} - \left(\frac{d_s}{2L} \right)^2 \right] \quad (12)$$

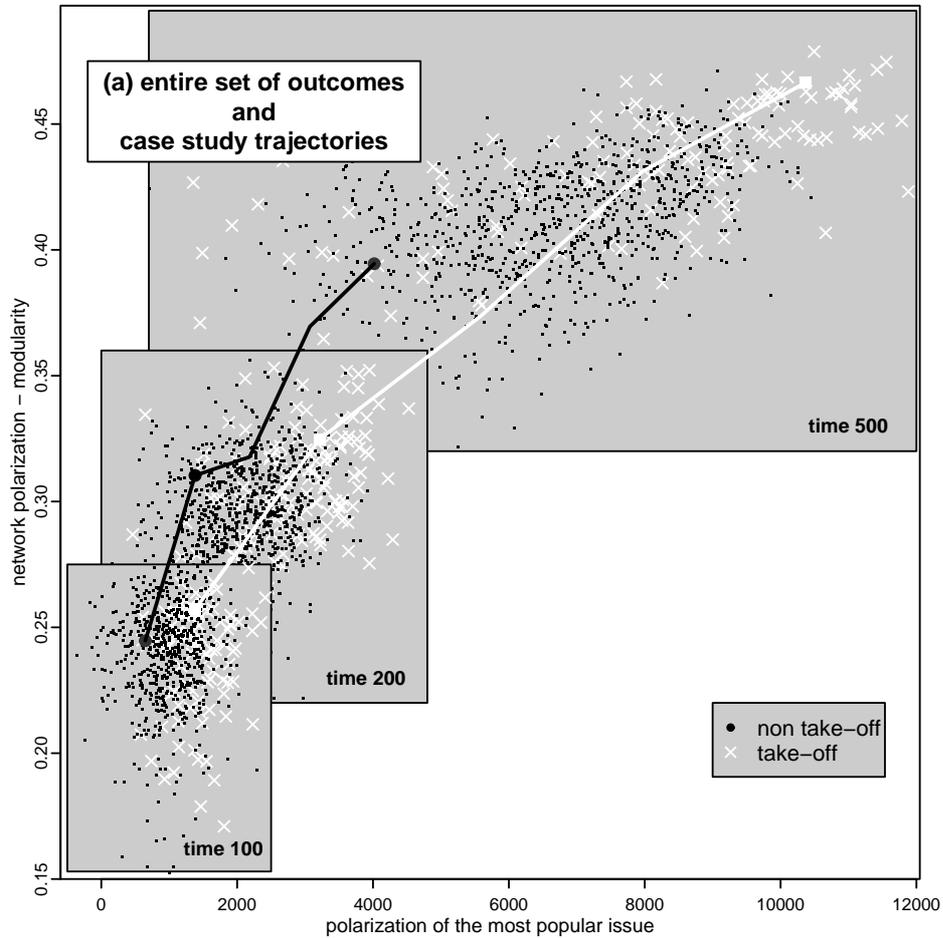
where L is the number of links in the network, l_s is the number of links between nodes in module s , and d_s is the sum of the degrees of the nodes in module s (Guimera, Amaral 2005:899).

Figure 9 summarizes the specific relation between ideological and structural polarization. Here we start at time 100, when take-off outcomes begin to be distinguished by increased levels of ideological polarization. For both take-off and non take-off contexts, there is no evidence of structural polarization. Around time 200 distinctive dynamics of social polarization that characterize take-off outcomes develop, emerge, and strengthen, amplifying attitude polarization. Here we see that take-off outcomes disproportionately occur when there is an intersection of highly polarized structures and high levels of ideological polarization. Consequently, the interplay between ideological and structural polarization provides the necessary condition for issue take-off. It follows that when public discourse polarizes around a single issue it is possible to observe the concurrent emergence of both ideological and structural polarization.

Further evidence on this regard is provided by the match between the structural partition of the graph and the attitude polarization around the most popular issue. Specifically, take-off contexts are six times more likely than non take-off contexts to reveal a pure correspondence between group membership and ideological position (20% versus 3%). We observe the reverse pattern in non take-off contexts. In sum, in take-off situations, actors with positive and negative attitudes on the core issue are split apart and thereby embedded within a dense ideological envelope which prevents them from interacting with those who have alternative positions.

5.3 Issue Closure and Actors' Experience

These patterns of segregation carry implications for issue closure – that is, the extent to which discussion occurs disproportionately within groups in which actors share the same attitude on the issue at hand. Consequently, we measure issue closure as the share of individuals that are embedded in completely homogeneous relational networks. Figure 10 plots the level of issue closure of the most popular issue against the average level of closure



(a) Plot of ideological polarization against structural polarization at times 100, 200 and 500. Take-off outcomes (white xs) show higher values in both ideological and structural measures of polarization than non take-off outcomes (black dots). Lines show the trajectory of the case studies.

(b) Plot of the average issue polarization against the average network polarization in take-off (white) and non take-off (black) outcomes.

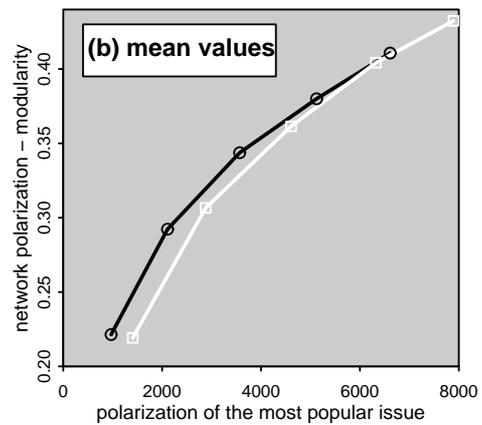


Figure 9: Ideological and Structural Polarization over Time.

of the other issues. The goal is to compare relative levels of issue closure across contexts. One can see that at time 100 issue closure is low for all issues in both contexts. Only around 20% of actors are embedded in completely homogenous networks. Over time, systematic differentiation between outcomes across contexts becomes increasingly evident. Here it is clear that take-off outcomes are distinguished by higher closure on the most popular issue and simultaneously, lower levels of closure on the other issues.

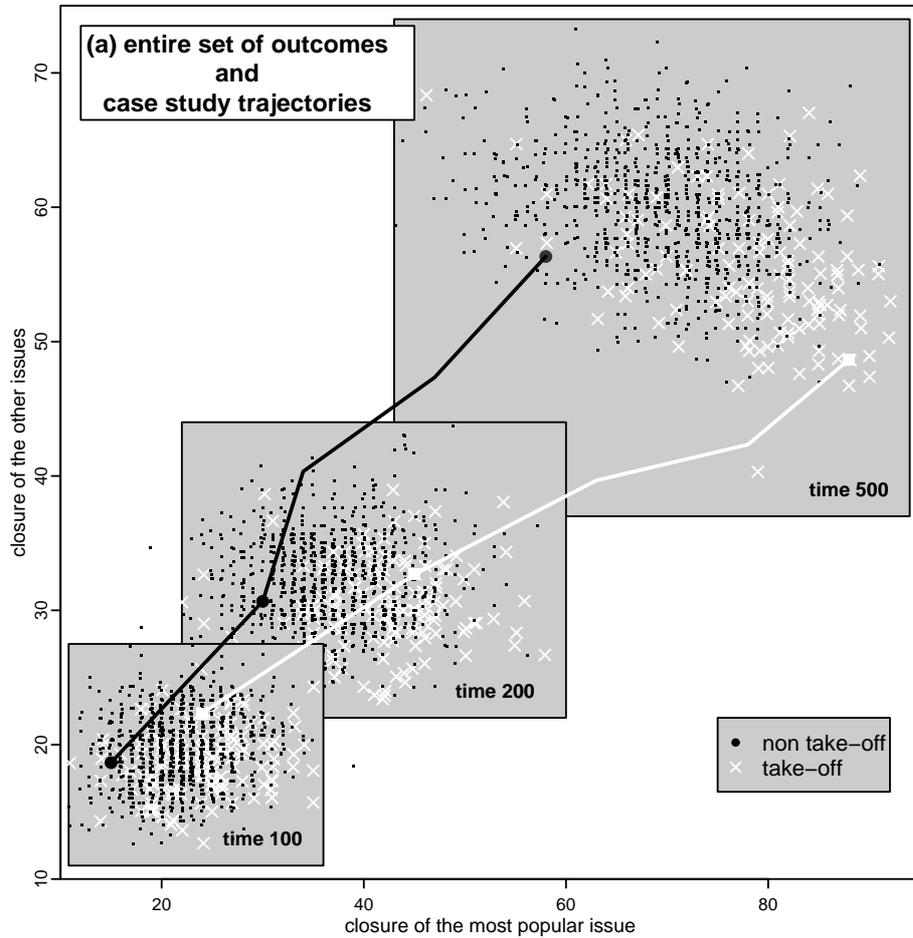
Figure 10 shows that when single issues dominate debate, social interactions tend to segregate actors who hold contrasting views on that issue. At the same time, the level of segregation with respect to the other issues is lower than in non take-off situations. Whereas conversation on the take-off issue tends to be between actors who share the same opinion, conversation on other issues tends to be discordant, that is conversation between actors who share different opinions. In a take-off context, discordant conversations on non take-off issues sustain social and attitudinal polarization on the take-off issue since discussion around other issues is less likely to polarize. The discordant conversations restrict the chance that actors' main focus of interest will drift and eventually that a new issue will take over.¹⁵

Of course, the monopolization of discussion does not take place only at the aggregate level – it also occurs in the unfolding of actors' experience. In order to evaluate individuals' heterogeneity of discussion topics, we compute the index of concentration (HH Index) at the individual level. Panel a in Figure 11 shows the trend over time of the average HH Index in take-off and in non take-off outcomes. Actors in non take-off contexts are more evenly exposed to the entire set of issues than are actors in take-off situations.¹⁶ But this does not necessarily mean that people experience heterogeneity in interaction with respect to attitudes.

In fact, if we look at how frequently people experience disagreement, we discover that there are no differences between take-off and non take-off contexts. Panel b in Figure 11 reports the trend over time of the percentage of discussions, on average, in which actors have contrasting views on the relevant issue. In both take-off and non-take-off contexts, the frequency

¹⁵This result is consistent with Rokkan's theory of cleavage crystallization (Lipset, Rokkan 1967). Here, Rokkan shows that the political systems that emerged after WWII were shaped by enduring territorial, religious, ethnic and/or ideological divisions. Such a "freezing effect" can be understood as a consequence of the structuring of public discourse that prevents the rise of new issue-cleavages.

¹⁶It could be otherwise. One can imagine a non-take off context in which individuals are clustered in multiple small subgroups where they discuss only one issue. Consequently, their individual HH index score would be high, while the overall HH index is low – as we observe for the non take off context.



(a) Plot of the level of closure of the most popular issue against the average closure of the other issues. Closure is defined as the number of individuals that are embedded in discussion networks homogeneous with respect to issue orientation. Take-off outcomes have higher closure on the popular issue and lower closure on the other issues. Lines show the trajectory of the case studies.

(b) Plot of the average closure of the most popular issue against the average closure of the other issues in take-off (white) and non take-off (black) outcomes.

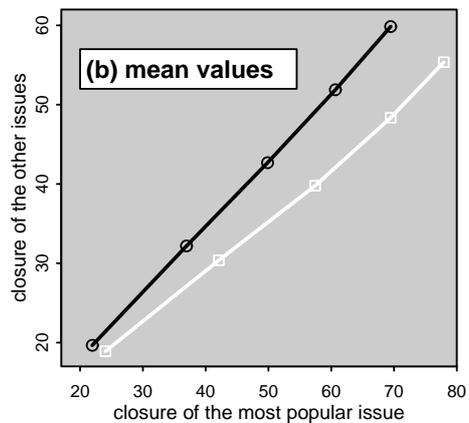


Figure 10: Relative Level of Issue Closure over Time.

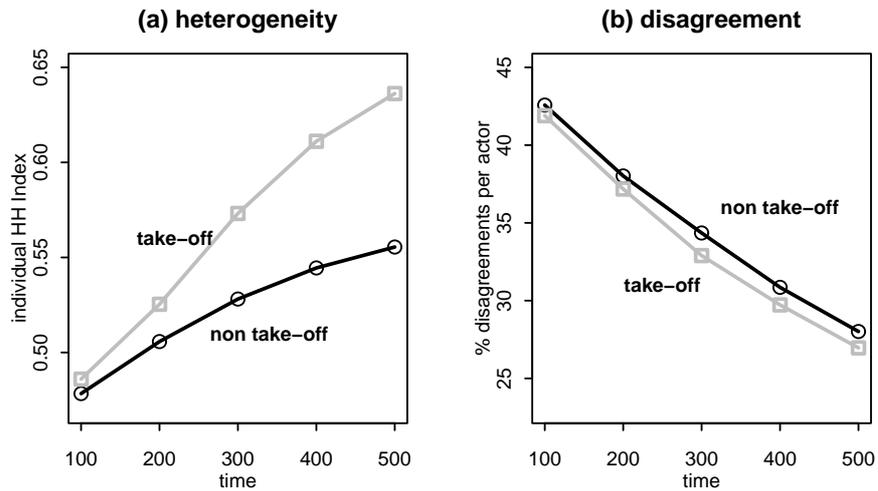


Figure 11: Discussion Patterns at the Individual Level: Heterogeneity and Disagreement.

(a) Trend of the mean HH Index over time in take-off and non take-off outcomes. In non take-off outcomes actors are exposed to more heterogeneous topics of discussion than in take-off contexts. (b) Trend of mean percentage disagreement experienced by actors in take-off and non take-off outcomes. In both contexts, people experience similar, decreasing levels of disagreement

of disagreement decreases as time elapses. It follows that the emergent relational patterns tend to minimize individual exposure to disagreement (and conflict), independent of the overall macro-structural features of the network of interaction. This induces, at the individual level, a misperception of the macro-structure that may carry implications for mobilization, a theme we consider subsequently.

6 Discussion

We started with the observation that some scholars argue that the United States is politically polarized, although only on one issue at a time, while others argue that we are not politically polarized, because public opinion is moderate (and changes are parallel) on a broad set of relevant issues. Likewise, with respect to social polarization we observe a similar debate. One group of scholars argues that the country is polarized, because people experience homogeneity in their everyday interactions. A second group argues

that we are not socially polarized because we do not observe divergence in attitudes along classical social categories, like age, education, income, race and ethnicity etc. In this article we provide a simple model that suggests why these arguments are not mutually exclusive and how they meaningfully refer to the same social setting; it follows that the results from this model provide a single parsimonious account for both paradoxes.

We first consider political polarization. Two results provide insight into the divergence of views between experts and lay observers. First, take-off is rare; in the empirical world, only a few issues are take-off issues. Second, for take off to occur one issue has to be relatively more polarized than others. It follows therefore, that we can observe ideological polarization on a single issue at a time. The fact that the take-off issue is disproportionately discussed leads to social structural change: actors compose themselves into new, polarized interactive sets, within which they experience increasing homogeneity, but the focus on the single issue means that the opinions they hold on the other issues remain heterogeneous. This fact gives rise to the expert conclusion that the country is not politically polarized, because public opinion is moderate on a broad set of issues.

We now turn to the mismatch between perceived and actual level of social polarization and the actual level of opinion polarization across social categories. People will talk about trivial issues – the weather or what to have for dinner – with most anyone, but for topics that are important to them, they reveal their views more selectively, disproportionately choosing people who they believe share views broadly similar to their own. Because actors will tend to talk to others who share their beliefs, both in take-off and non take-off contexts, the discussion of important issues will always induce, at the micro-level, the experience of a segregated discussion network. In non take-off contexts, actors will tend to perceive that the environment around them is polarized, even though this is not the case. In take-off contexts, when a single issue dominates discussion, individuals will overvalue the extent of ideational homogeneity because their contacts are disproportionately within a polarized subgroup. But even this experience is misleading with respect to issue heterogeneity, since public opinion remains heterogeneous on the broad range of other issues – the precise fact that provides the foundation for scholars' arguments that we do not observe increasing divergence in attitudes along classical social categories.

The relationship between single issue take-off and polarization reported in this article provides insight into the larger debate on political and social polarization. Experts who minimize the extent of polarization because it is restricted to single take-off issues ought to recognize that polarized in-

teraction structures, and therefore heightened radicalism, arise from single issues. At the same time, those who see in the appearance of such issues the emergence of fundamental cultural divides (and consequently, a “culture war”) (Kohut, et al. 2000; Greenberg 2004; Abramowitz and Saunders 2005) ought to recognize that polarization dynamics can be confined to single attitudes. Consequently, radicalization on one dimension of the political space may carry minimal potential for ‘societal disruption’, since opinions on other issues may maintain their heterogeneity.

6.1 Expansion to Collective Action

The model introduced here has applicability to a broader array of foci. Clearly, the simultaneous social and ideational polarization associated with take-off reveals the preconditions for collective action. Central to these dynamics are processes associated with identity formation. As suggested by Gould and others, identity is doubly meaningful for action when it is translated into (and transformed through) patterns of interaction such that class in itself becomes class for itself (Gould 1991; Marx 1852). Historically, collective action is made possible by the simultaneity of identity and interest. Against this background, we offer a simple model of social interaction and influence that simultaneously accounts for the emergence of a collective interest - an interest that enters and dominates the public sphere - and for the process of formation of social identities - in the form of sustained niches of social interaction. Moreover, we show that these two dimensions are interdependent. Meaningful social partitions cannot arise in the absence of salient issues. At the same time, attitude polarization is of little significance if not crystallized into relational patterns.

Consequently, the starting point for this analysis is the recognition that collective action involves persuasion and mobilization among actors that hold multiple and often alternative sets of preferences. To model this empirical reality, we need a model of social influence in which individual’s attitudes, social structure and the public interest itself are not fixed, predefined aspects (exogenous to the model) - rather they are shaped in interaction sequences. This framing shifts the focus of investigation from what makes collective action possible - i.e. the coordination problem, or in its more popular incarnation, the free-rider problem (Olson 1957; Heckathorn 1990; Macy 1990; Gould 1993; Marwell and Oliver 1993; Kim, Bearman 1997) - to broader themes, specifically the mobilization of identity, structural change, and their intercalation. This focus allows us to show that the ideational and structural preconditions that trigger take-off depend on interaction patterns

rather than on individual characteristics. Likewise we show that only by referring to the ecology of local interactions can we simultaneously account for issue popularity and structural polarization.

Finally, the approach deployed here reveals an interesting gap between experience and reality, a gap which turns out to be particularly relevant for the nurturing of collective action. Is polarization a perception or a reality? It seems that with respect to aggregate categories and social properties, polarization is often a perception, but it is a real perception since the experiences of ordinary people are often structured in such a way as to lead them into homogeneous and polarized environments. False perceptions of course can lead to real outcomes. At early stages of collective mobilization activists are not completely aware of their real chances (they overestimate them, since they do not hold universal knowledge about the attitudes and preferences of their fellow citizens). They also perceive society as more polarized than it is. These misperceptions of the macro-structure based on inferences from their micro-context leads them to take chances they would otherwise reject as hopeless. The limited perception of the external reality – specifically the fact that the people around them share their attitudes and the fact that society splits into apparently disjoint groups – can transform, in the context of action over the long run, otherwise negligible chances into tangible achievements. This is, of course, exactly why shared identities play such a strong role in fostering actors' commitment to their political beliefs and consequent action. Hope springs eternal not because people are hopeful, but because structures organize people into contexts where hope appears (to them) as rational inference.

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