Emergence of polarized ideological opinions in multidimensional topic spaces

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INTRODUCTION

According to classical opinion dynamics models in which social interactions add constructively to opinion formation, the increasing interaction rates of modern societies would eventually lead to a global consensus, even on controversial issues [1, 2]. This classical prediction has been recently challenged by the empirical observation of opinion polarization, i.e. the presence of two well-separated peaks in the opinion distribution. Polarization can be found, both offline [3, 4], and in online social media [5, 7], where polarized debates have been observed with respect to several areas and issues, ranging from political orientation [8–10], US and French presidential elections [11], to street protests [12]. Interestingly, polarization seems to burst especially in public discussions evolving around politically and ethically controversial issues such as abortion [13] or climate change [14–16]. Different modeling approaches have investigated opinion polarization on single topics as the result of repulsive interactions among agents [17], biased assimilation [18], or social re-inforcement mechanisms [19–21].

Topics are rarely discussed in isolation. Especially with growing connectedness [22] and increased information flow [23], the processes of opinion formation take place simultaneously. For heterogeneous opinion distributions deviating from a global consensus, another striking feature can often be observed: issue alignment [4, 24, 25], whose presence implies that individuals are much more likely to have a certain combination of opinions than others, a state that can be defined as an ideological opinion state. For some combinations of topics the alignment is quite intuitive. For example, opinions with respect to rights of transgender people [26] and same-sex couples may be correlated. In this case, the majority of individuals would mainly split into two groups, those who deny certain rights to both, transgender people and same-sex couples, and those who support them, while the mixed positions would be rare. While the two gender-related issues can be considered as quite related, in what follows we will show that also opinions on rather unrelated issues might be strongly correlated. Which underlying mechanism might drive such ideological states to emerge?

While considerable efforts have been recently put into measuring and modeling opinion polarization, the phenomenon of issue alignment got much less attention. This problem has been mainly approached by agent-based modeling within multidimensional opinion spaces, inspired by Axelrod’s seminal work on cultural diversity [27]. Models based on the concept of a confidence bound illustrated how opinion alignment can result from a dependence between opinion dimensions combined with assimilation and rejection mechanisms [28], and from assumed correlations between individual and immutable agents’ attributes [25, 29]. Other attempts include the extension of Heider’s cognitive balance theory [30] to multiple dimensions, in a well-mixed population [31].

However, all these works assume an a priori, static social network structure (or a well-mixed population) as a substrate for opinion formation, and/or encode issue alignment directly as correlations between individual attributes. On the contrary, social interactions are known to evolve in time [32, 33], and such evolution can have a strong impact on the dynamical processes running on top of such time-varying networks, such as opinion formation (see [34] for an extensive review). This is particularly true for social media platforms, which have been shown to be the major news source for up to 62% of adults in the U.S. [35]. On such platforms the process of opinion formation is continuously shaped by the new information and content shared by users on the platform [35].

In this paper, we propose a simple model featuring the emergence of polarized ideological states from microscopic interactions between individuals, assuming neither a preexisting social structure, nor a confidence bound or correlated individual attributes of the agents. We find that the co-evolution of social interactions and opinions can not only lead to extreme opinions, but can also cause issue alignment. Strikingly, such issue alignment emerges also for rather unrelated topics that are sufficiently controversial, due to the reinforcement mecha-
nism mediated by social interactions. Our model is based on a minimal set of assumptions. First, opinions evolve according to the social interactions among the agents, which are ruled by homophily: two agents sharing similar opinions are more likely to interact [37] [38]. Second, connected agents sharing similar opinions can mutually reinforce each other’s stance. Within the theory of group polarization [39] [40] this happens when individuals, through the exchange of arguments, influence each other in an additive way [41]. Third, opinions lay in a multidimensional Euclidean space, spanned by a non-orthogonal basis formed by topics. Topics can be controversial and mutually overlapping, i.e. there may exist an intersection of arguments that is valid for several topics.

With these assumptions, our model generates three different scenarios: i) convergence toward a global consensus, ii) polarization of non-correlated opinions, and iii) polarization with issues alignment, i.e. a polarized ideological state. Interestingly, ideology emerges from uncorrelated polarization simply by relaxing the assumption of an orthogonal basis of the topic space. We analytically and numerically characterize the transitions between these three states, in dependence on the controversialness and overlap of the topics discussed. We compare the model’s behavior with empirical opinion polls from the American national election surveys (ANES) [42]. In a pairwise comparison of a broad selection of topics, we can observe several realizations of the scenarios proposed by the model. In particular, we found a number of non-trivial cases where opinions are polarized and aligned, but the opinion correlation cannot be simply traced back to the similarity between topics, validating the model’s behavior.

Our framework is built on the generalization of a simple one-dimensional model describing polarization dynamics [19] to multiple dimensions, assuming the non-orthogonal topic basis. This assumption implies that topics, forming the basis of the space where opinions lay, may not be completely independent but rather can show a certain degree of overlap. As suggested by argument exchange theory [43], a non-vanishing overlap between two topics might arise due to a common set of arguments which simultaneously supports or rejects certain stances on both topics. As overlap increases, the correlation between related topics is expected to be higher. We will show, however, also small overlaps critically determine the opinion formation, and hence, ideological opinion states may also emerge for rather unrelated topics.

Interestingly, non-orthogonal bases (equivalently, skew coordinate systems) have been recently proposed to solve some well-known problems of classical vector space models for representing text documents [44]. Within this framework, documents are represented as vectors in an underlying space, whose basis is formed by the terms used in the documents. Crucially, if the terms are assumed as orthogonal, similarity measures (such as cosine similarity) can not precisely describe the relationship between documents, if terms are not independent. When the assumption of orthogonality is relaxed, such as in Latent Semantic Indexing or distance metric learning, similarity measures work much better [45]. Our approach follows a similar idea: if the orthogonality of topics is relaxed, i.e. if topics can overlap, the correlation between opinions with respect to different topics can naturally emerge through the proposed reinforcement dynamics from social interactions.

A MODEL OF OPINION DYNAMICS IN A MULTIDIMENSIONAL TOPIC SPACE

Let us consider a system of $N$ agents. Each agent $i$ holds opinions towards $T$ distinct topics, represented by the opinion vector $\mathbf{x}_i = (x_i^1, x_i^2, \ldots, x_i^{T-1}, x_i^T)$. In this notation, the component $x_i^v \in [-\infty, +\infty]$ denotes the opinion of agent $i$ towards topic $v$. For each topic $v$, the sign of the opinion $x_i^v$, $\text{sgn}(x_i^v)$, describes the qualitative stance of agent $i$ towards the topic (i.e., in favor or against the issue), while the absolute value of $x_i^v$, $|x_i^v|$, quantifies the strength of his/her opinion, or the conviction, with respect to one of the sides. The opinion vector $\mathbf{x}_i$ represents the position of an agent $i$ in the $T$-dimensional topic space $\mathcal{T}$. The opinion vector $\mathbf{x}_i$ can be written as $\mathbf{x}_i = \sum_{v=1}^{T} x_i^v \mathbf{e}^v$, where $\{x_i^v\}$ are the coordinates of agent $i$ and $\{\mathbf{e}^v\}$ form a basis of the Euclidean space $\mathcal{T}$, representing the topics under consideration. To form the basis in $\mathcal{T}$, $\{\mathbf{e}^v\}$ have to be assumed linearly independent, but are not necessarily orthogonal.

The opinion vectors of agents evolve in time, i.e. $\mathbf{x}_i = \mathbf{x}_i(t)$, where we will omit the dependence on $t$ in the following for brevity. We assume that the evolution of opinions follows a radicalization dynamics, a recently proposed mechanism that reproduces polarization and echo chambers found in empirical social networks [19] [46]. Within this framework, the opinions of an agent are reinforced by interactions with other agents sharing similar views. The mechanism is inspired by the phenomenon of group polarization [39], by which interactions within a group can drive opinions to become more extreme. The social interactions responsible for the opinion dynamics are not static but evolve in time as well [36] [47].

The social interactions among the agents are described by the following set of $N \times T$ ordinary differential equations,

$$\dot{x}_i^v = -x_i^v + K \sum_j A_{ij}(t) \tanh (\alpha \mathbf{x}_j^v) ,$$

where $K > 0$ denotes the social influence strength acting globally among agents – the larger $K$, the stronger the social influence exerted by the agents on their peers [19]. The interpretation of the sigmoidal non-linearity $\tanh(\ldots)$ and the matrix $\Phi$ will be discussed a couple of lines below.

According to Eq. (1), the opinion of agent $i$ towards topic $v$, $x_i^v$, evolves depending on the aggregated inputs from
his/her neighbors, determined by the temporal adjacency ma-
we use $\tanh(\alpha \Phi x)$, which tunes the mutual influences that the
small $\alpha$, the social influence of individuals with moderate
influence on others. The parameter $\alpha$ can thus be interpreted as the controversial-
ness of the topic, which has been shown to be an important
factor driving the emergence of polarization in debates on line social media [49].

According to Eq. (1), an agent $j$ exerts social influence on
a connected agent $i$ with respect to all topics under considera-
tion, and the opinion of an agent towards a specific topic is
not only influenced by the opinion of others on the same topic but, in general, also about other topics. This is reflected in the
symmetric topic overlap matrix $\Phi$, which encodes the relation between topics. If the element $\Phi_{v,z}$ is different from zero, the opinions of agents on topic $v$ can influence the opinions
of other agents with respect to topic $z$, and vice versa.

The matrix $\Phi$ has a geometric interpretation in the latent
topic space. The element $\Phi_{v,z}$ can be interpreted as a scalar product of topics $v$ and $z$, $\Phi_{v,z} = e^v \cdot e^z = \cos(\delta_{v,z})$, where $\delta_{v,z}$ represents the angle between topics $v$ and $z$, as shown in Fig. [T] for $T = 2$. In relation to our introductory example, $\cos(\delta_{v,z})$ quantifies the overlap between topic $v$ (rights of transgender people) and $z$ (rights of same-sex couples). The scalar product between two opinion vectors $x_i$ and $x_j$ in the topic space $T$ spanned by such non-orthogonal topics, is computed as

$$x_i \cdot x_j = x_i^T \Phi x_j = \sum_{v,z} x_i^v x_j^z \cos(\delta_{v,z}),$$

involving the overlap matrix $\Phi$. Note that it always holds $\Phi_{v,v} = 1$, so that if all topics are orthogonal, $\Phi_{v,z} = 0$, the matrix $\Phi$ reduces to a unit matrix, and Eq. (1) decouples with respect to topics.

The contact patterns among the agents, which sustains the opinion formation, evolves according to the activity driven (AD) model [50–53]. This gives rise to a temporal network which changes at discrete time intervals. According to the original AD model, each agent $i$ is characterized by an activity $a_i \in [\varepsilon, 1]$, representing his/her propensity to contact

\[ m \] distinct other agents chosen at random. Activities are extracted from a power law distribution $F(\alpha) \sim \alpha^{-\gamma}$, as suggested by empirical findings [50, 52]. The set of parameters ($\varepsilon, \gamma, m$) fully encodes the basic AD dynamics. Furthermore, we assume that social interactions are ruled by homophily, a well-known empirical feature in both offline [54, 55] and online [56, 57] social networks. To this end, the probability $p_{ij}$ that an active agent $i$ will contact a peer $j$ is modeled as a decreasing function of the distance between their opinions,

$$p_{ij} = \frac{d(x_i, x_j)^{-\beta}}{\sum_j d(x_i, x_j)^{-\beta}},$$

where $d(x_i, x_j)$ is the usual Euclidean distance between opinion vectors (cf. Fig. [1] generated by the scalar product defined in Eq. (2), while the exponent $\beta$ controls the power law decay of the connection probability with opinion distance.

As a result of Eq. (3), two agents $i$ and $j$ are more likely to interact if they are close in the topic space $T$, i.e. the distance $d(x_i, x_j)$ is small. Upon such interaction (i.e., if $A_{ij}(t) = 1$), the opinions of agent $j$ influence all opinions of agent $i$, following the sigmoidal influence function in Eq. (1). In the case of orthogonal topics ($\Phi = 1$) social influence takes place only between opinions on the same topic. If the stances of two interacting agents $i$ and $j$ on a topic $v$ are equal, i.e. $\text{sgn}(x_i^v) = \text{sgn}(x_j^v)$, they will increase their current conviction on topic $v$, which is given by the absolute values of the opinion coordinates $|x_i^v|$ and $|x_j^v|$. On the contrary, for $\text{sgn}(x_i^v) \neq \text{sgn}(x_j^v)$, they will tend to decrease their conviction on that topic and converge towards a consensus. Crucially, for non-orthogonal topics $v$ and $z$, $\cos(\delta_{v,z}) \neq 0$, the opinion with respect to topic $v$ of agent $j$, $x_j^v$, will influence

![Illustration of two non-orthogonal topics as basis for the topic space $T$](image-url)

For $T = 2$, the non-orthogonal, normalized basis is uniquely defined by the angle $\delta$. Geometrically, $\cos(\delta)$ quantifies the overlap between basis vectors, interpreted as a topical overlap, here the rights of same-sex couples ($e^v$) and transgender people ($e^z$). The opinion distance between two agents $i$ and $j$, $d(x_i, x_j)$, is computed by the scalar product defined in Eq. (2).
the opinion of agent $i$ on topic $z$, $x^z_i$: an argument supporting a topic is logically connected to the other topic.

**EMERGENCE OF CONSENSUS, POLARIZATION AND IDEOLOGICAL PHASES**

The model in a one-dimensional space, corresponding to a single topic ($T = 1$), has been shown to reproduce empirical data for polarized debates on Twitter, with respect to polarization of opinions and segregation of social interactions \[19\]. A phase transition between a global consensus and polarized state emerged as social influence (tuned by parameter $K$) and the controversialness of the topic discussed (represented by $\alpha$) increased. In the following, we explore the impact of multiple topics and their potential overlap within this framework for $T > 1$. Following empirical observations, we set the parameters of the basic AD model to $(\epsilon, \gamma, m) = (0.01, 2.1, 10)$ \[50\]–\[53\], and consider a regime of strong social influence and strong homophily, by setting $K = 3$ and $\beta = 3$.

We investigate the emergence of different opinion states for long times in dependence of $\alpha$ and of the topics overlaps. Due to the fluctuations induced by the stochastic interaction dynamics, the states other than consensus are not stable for $t \to \infty$. However, for sufficiently high values of $\beta$ (i.e. homophily), they been shown to be meta-stable \[19\], numerically indistinguishable from stable states. Therefore, we will refer to them as steady states in the following. Furthermore, we focus on a regime of fast-switching interactions, i.e. opinions evolve at a slower rate than social interactions. This choice is motivated by the assumption that multiple social inputs are necessary to change an agent's opinion substantially (i.e. homophily), they been shown to be meta-stable \[19\], numerically indistinguishable from stable states. Therefore, we will refer to them as steady states in the following. Furthermore, we focus on a regime of fast-switching interactions, i.e.

If topics are not controversial (i.e. for $\alpha$ small), agents reach a global consensus, as shown in Fig. 2(a). Starting from normally distributed opinions in the two-dimensional topic space, opinions converge towards the state of vanishing convictions, i.e. $||x_i(t \to \infty)|| = 0 \forall i$. In this regime, the dynamics is dominated by the decay terms $(-x^1_i, -x^2_i)$ in Eq. (4), which mimic the agents’ finite opinion memory. The fast relaxation toward the global consensus is due to the lack of sufficient social influence from interacting peers. This situation is also depicted in the final opinion distributions $P_1(x)$ and $P_2(x)$, plotted on the marginals of Fig. 3(a): For both topics, the opinion distribution is peaked around $x = 0$.

If topics are controversial – for larger values of $\alpha$ – the situation is drastically different, cf. Fig. 2(b)-(c). The social influence among the agents dominates the opinion evolution, destabilizing the global consensus. The opinions of agents do not converge but are widely spread and potentially reach convictions much stronger than in the initial configuration. Note that for polarization to emerge, the presence of homophily is a necessary condition \[19\]. In this regime, the overlap between topics, encoded by $\cos(\delta)$, crucially determines the dynamics and the possible emergence of ideological states in the system.

If topics do not overlap, i.e. $\cos(\delta) = 0$, the opinions with respect to each topic evolve independently. That is, the opinion dynamics with respect to each topic decouple, and can be effectively captured by the one-dimensional model of \[19\]. In this regime of strong social influence, homophily and controversial topics, a polarized state emerges, as shown in Fig. 2(b). In polarized states, the opinion distributions are bimodal for each topic, as shown on the marginals plots of Fig. 2(b). The polarization of opinions with respect to a certain topic $v$ can be quantified by variance $\sigma^v_2(x)$ of the opinion distribution $P_v(x)$. A small value of the variance $\sigma^v_2(x)$ implies a consensus-like opinion distribution with respect to topic $v$, while a large $\sigma^v_2(x)$ value indicates polarization. The variances $\sigma^v_1(x)$ and $\sigma^v_2(x)$ of the respective marginal distributions are reported in the caption of Fig. 2. For orthogonal topics, all possible combinations of qualitative stances occur, i.e. $\{\text{sgn}(x^1_i), \text{sgn}(x^2_i)\} \in \{(-, +), (+, +), (-, -), (+, -)\}$. These four groups, highlighted by different colors in Fig. 2(b), represent individuals taking all different stances as expected when the two topics are orthogonal. Note that the opinion correlation in both polarized and consensus states is low, as reported in Fig. 2(a) and Fig. 2(b).

This situation radically changes if topics overlap ($\cos(\delta) > 0$), i.e. they are non-orthogonal in the underlying space. In this case, according to Eq. (4), the opinions with respect to one topic can influence the opinions with respect to the others, and vice versa. Fig. 2(c) shows this situation for $\delta = \pi/4$, i.e. $\cos(\delta) = 1/\sqrt{2}$. At odds with the orthogonal case, not all combinations of opinion stances are realized in the (quasi)-steady opinion state. Instead, the dynamics selects only the opinion states where agents show the same stance on both topics, i.e. $\{\text{sgn}(x^1_i), \text{sgn}(x^2_i)\} \in \{(-, -), (+, +)\}$. The other stance combinations gradually disappear during approaching the steady state. The final opinion distributions $P_1(x)$ and
FIG. 2. Temporal evolution of the agents’ opinions in a $T = 2$ topic space. Evolution of opinions from numerical simulations (a)-(c) and corresponding deterministic dynamics (d)-(f) from mean-field approximation, with identical values of $\alpha$ and $\delta$ (see Methods for details). The trajectories of the agents’ opinions are depicted as grey lines, final opinions are colored according to $\phi$. This is indicated by the marginal distributions $P_1(x)$ and corresponding deterministic dynamics (d)-(f) from mean-field approximation, with identical values of $\alpha$.

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$P_2(x)$ are again bimodal, as shown in the marginal plots of Fig. 2(c), but the opinions are highly correlated, with the Pearson correlation coefficient $\rho(x^1, x^2) \simeq 1$.

This state of the system, characterized by opinions which are both polarized, $\sigma^2_1(x), \sigma^2_2(x) \gg 0$, and correlated, $\rho(x^1, x^2) \gg 0$, is characterized as a polarized ideological state. In the underlying topic space, this situation translates into a symmetry breaking and consequent dimensionality reduction: The opinion of an agent towards one topic is able to predict his/her opinion towards ones. For example, an individual who strongly opposes the idea of same-sex marriage, will also mostly likely argue against transgender people being allowed to use the toilets corresponding to their identified genders.

The dynamics of the model given by Eq. (1) can, in the thermodynamic limit ($N \to \infty$) and for strong homophily ($\beta \gg 1$), be qualitatively captured within a mean-field approximation, as shown in the Methods section. Figures 2(d), (e), and (f) show the attractors of the deterministic, mean-field dynamics for the same values of the parameters $\alpha$ and $\cos(\delta)$ as in Figures 2(a), (b), and (c), respectively. The resulting dynamics look remarkably similar to the behavior of the full stochastic model. For low $\alpha$, there is only one stable fixed point, corresponding to the global consensus at $x_i(t \to \infty) = 0 \forall i$, as shown in Fig. 2(d). As $\alpha$ increases, the consensus is destabilized. If topics are orthogonal, this results in four stable fixed points corresponding to an uncorrelated polarized state (Fig. 2(f)). If topics overlap the symmetry is broken and only two stable fixed points emerge, corresponding to the ideological state, depicted in Fig. 2(f).

Within the mean-field approximation, the transition between a global consensus and polarization can be described analytically. For $T = 2$ the stability limits of the consensus phase are determined by the critical controversialness, $\alpha_c$, as

$$\alpha_c = \frac{1}{K m(a)[1 + \cos(\delta)]},$$

which is depicted in Fig. 3 as black dashed line. It depends inversely on the product of social influence strength $K$, the number of agents contacted by an active agent $m$, the average activity $\langle a \rangle$, and a factor $[1 + \cos(\delta)]$ accounting for the overlap of the two topics. The different regimes of polarization, i.e., polarization of non-correlated opinions and the ideological phase can be distinguished numerically, see Methods section for details.

Figure 3 shows the stability regions in the $\alpha$-$\cos(\delta)$ plane, colored according to the corresponding phases, consensus (green), polarization of uncorrelated opinions (blue), and ideology (red). Note that the phase diagram is symmetric with respect to the line of vanishing overlaps $\cos(\delta) = 0$ (orthogonal topics). For this case, no ideological states emerge. By
The phase diagram and regions of consensus and opinion polarization, as given by Eq. (5). The dashed line depicts the critical controversialness $\alpha_c$ according to the corresponding states: consensus (green), uncorrelated (blue) and ideological state (red). The black dashed line depicts the critical controversialness $\alpha_c$ separating the regions of consensus and opinion polarization, as given by Eq. (5). The phase diagram and $\alpha_c$ are symmetric with respect to $\cos(\delta) = 0$, i.e. $\delta = \pi/2$, see Methods. The symbols (square, cross, rhombus) depict the parameter combinations of $\alpha$ and $\cos(\delta)$ used in Fig. 4 and Fig. 5.

FIG. 3. Stability regions of the mean-field approximation as a function of the topic overlap $\cos(\delta)$ and controversialness $\alpha$ for $Km(\alpha) = 1$. The different regions in the phase space are colored according to the corresponding states: consensus (green), uncorrelated opinion polarization (blue) and ideological state (red). The black dashed line depicts the critical controversialness $\alpha_c$ separating the regions of consensus and opinion polarization, as given by Eq. (5). The phase diagram and $\alpha_c$ are symmetric with respect to $\cos(\delta) = 0$, i.e. $\delta = \pi/2$, see Methods. The symbols (square, cross, rhombus) depict the parameter combinations of $\alpha$ and $\cos(\delta)$ used in Fig. 4 and Fig. 5.

contrast, for finite overlaps, $\cos(\delta) > 0$, i.e. non-orthogonal topics, ideological states emerge and their region of stability (red region) widens as the topics’ overlap, $\cos(\delta)$, increases. If topics are sufficiently controversial, i.e. for $\alpha > \alpha_c$, as given by Equation (5) (plotted as a dashed line in Fig 3), consensus is de-stabilized and polarization emerges. The larger the overlap between topics (the larger the value of $\cos(\delta)$), the smaller is the critical controversialness $\alpha_c$, necessary to de-stabilize consensus and promote polarization.

SOCIAL NETWORK’S TOPOLOGY REFLECTS OPINION SEGREGATION

On social media, opinion polarization can be reflected in the topology of the corresponding social networks: The users interact more likely with peers sharing similar opinions, a situation known as ‘echo-chambers’ [54,59]. Our model assumes that the opinion evolution is coupled to the dynamics of the underlying social network via Eqs. (1) and (3). This mechanism yields a social network structure which is shaped by the process of opinion formation. Figures 4(a), (b), and (c) show the social networks generated by the model for the same parameters employed in Fig. 3(a), (b), and (c), corresponding to global consensus, uncorrelated polarization, and ideological state, respectively. The networks result from the time-integration of the last 70 time steps of the temporal adjacency matrix $A_{ij}(t)$, once the system reaches a steady state. Each node corresponds to an agent $i$, size of the node is proportional to his conviction (given by $r_i$), while the color represents the opinion in the polar coordinate $\varphi_i$.

Fig. 4(a) shows the system approaching global consensus. While nodes with similar opinions are more likely to be connected – an effect caused by homophily, also in the case of low $\alpha$ – no clear groups emerge in the network structure. Fig. 4(b) shows that in the uncorrelated polarized case, on the contrary, four groups are clearly visible, each one characterized by a different opinion (color coded as in Fig. 2). A similar situation is visible in Fig. 4(c), depicting the ideological state, where the social network is mainly segregated into two groups, holding different opinions.

These observations can be quantified by a community detection analysis. Figs. 4 (d), (e), (f) show the community structure of the corresponding networks, plotted as polar bar plots, as obtained by the Louvain algorithm [60]. Each community is represented as a different angle sector, which is oriented (polar angle) according to the average opinion ($\varphi$) within that community. The size of the community is represented by the radius of each bar, while the width and color of each sector represent the average cosine similarity between nodes in that community, the mean scalar product of opinion directions calculated according to Eq. (2) and averaged over all pairs of agents within the community.

In the global consensus case (Fig. 4 (d)), many communities are present and rather randomly oriented. Each community is characterized by a heterogeneous spectrum of opinions, (low values of the average cosine similarity). On the contrary, when consensus is broken, the average opinion of the agents within each community is aligned with the dynamical attractors shown in Fig. 2(e) and (f). In the uncorrelated polarized case, Fig. 4 (e), the communities are characterized by four typical average opinions, corresponding to the four colors shown in Fig. 4(b). Within each community, opinions are very similar, with large values of the average cosine similarity. In the ideological phase – Fig. 4 (f), communities are characterized by only two typical averages opinions and a strong homogeneity of opinions (very high average cosine similarity).

COMPARISON WITH EMPirical DATA

The presence of three different scenarios suggested by our model can be compared with empirical data. In what follows, we investigate the degree of polarization and correlation between opinions with respect to different topics using data collected by the American National Election Study (ANES). The ANES study is a continuation of a series of surveys run since 1948, with the main objective of analyzing public opinion and voting behavior in the U.S. presidential elections by interviewing a representative sample of U.S. citizens. The ANES data have been proven to be suitable for a variety of research purposes, ranging from examining the drivers for public attitudes towards specific topics like immigration [61], observing...
FIG. 4. Community structure of the social networks. Visualization of the social networks aggregated over the last 70 time steps (top) and corresponding community detection (bottom) for three different dynamical regimes: (approaching) consensus (a), uncorrelated polarized state (b) and ideological state (c). The model parameters were set as in Fig. 2(a)-(c), i.e. $\alpha = 0.05$, $\delta = \pi/2$ (a), $\alpha = 3$, $\delta = \pi/2$ (b), $\alpha = 3$, $\delta = \pi/4$ (c). In the network illustrations each node is colored according its opinion angle $\varphi$, size is proportional to its conviction $r$. Communities are represented in the polar bar plot below each network. Each community is represented by a bar: the radius represents the size, color and width correspond to the average cosine similarity between all pairs of agents within the community. The orientation represents the average opinion angle $\langle \varphi \rangle$ of all agents within the community. Communities containing less than 5% of the total number of nodes are not shown.

longitudinal developments of trust in the American government [62], or characterizing long-term trends of polarization [4, 63].

For our analysis, we select a total of 67 questions with overall 253984 valid responses from the 2016 ANES. See Methods for details on the selection criteria and the SI for a complete list of analyzed questions. Respondents are assigned an individual ID, such that their answers to different questions can be related to each other. In the following, we will focus on two key features of the ANES data: i) the distribution of responses with respect to each question, quantifying the degree of polarization or consensus toward a certain topic, and ii) the correlation between responses with respect to different pairs of questions, revealing which issues are aligned and thus contribute to an ideological state.

A schematic illustration of the subset of considered issues is given in Fig. 5. On top of Fig. 5(a), we plot the variance $\sigma^2_v(x)$ of the response distribution to question $v$. Questions are sorted according to $\sigma^2_v(x)$ in descending order, from questions with most polarized responses to less polarizing ones. While for the majority of questions (on the right side of the marginal plot) a consensus looks achievable, few questions (on the left side of the plot) are strongly polarized, such as the question of whether “voting is a duty”. Panel (a) shows the correlation matrix of the responses, sorted according to their variance. The cell $(v, z)$ is color coded according to the absolute value of the Pearson correlation between the opinion distributions $P_v(x)$ and $P_z(x)$, $|\rho_{vz}|$. The full distribution of correlation values for all investigated pairs of questions is reported in the SI. The average correlation value is 0.2, but the distribution is broad: some pairs of questions are weakly correlated, while others are strongly so. Note that although there is a small dependence of the strength of correlation on the variance (slight decay of correlation towards the bottom right), both large and small correlation values can be observed in all parts of the matrix.

Panels (b)-(d) of Fig. 5 show three prototypical cases corresponding to the three steady states found in our model: consensus (d), polarization (b) and ideological state (c). The first case corresponds to questions whose responses are both peaked around a neutral opinion, with a low variance of the opinion distribution. This case is shown in Fig. 5(d) by questions “Do you favor, oppose the U.S. making free trade agreements with other countries?” vs. “How willing should the United States be to use military force to solve international problems?”. Fig. 5(b) shows the questions “Do you consider voting a choice or duty” vs. “Do you favor, oppose the health care reform law passed in 2010?” (obamacare law), which have polarized responses that are not correlated. Finally, the case of polarized opinions that are strongly corre-
FIG. 5. Responses to questions from the ANES survey. a) Variance of all responses and absolute value of pairwise Pearson correlation. b)-d) Scatter plots of selected pairs of questions $v$ and $z$, where each dot represents one respondent by his/her responses to both questions. The marginal plots represent the response distributions $P_v(x)$ and $P_z(x)$. To improve the visualization, data is jittered [64], i.e. some noise is applied to each data point. The examples are selected to represent different combinations of response variance (opinion polarization) and response correlation: d) low variance ($\sigma^2_v = 0.08$, $\sigma^2_z = 0.25$) and low correlation ($\rho(v, z) = 0.02$) for questions V162176x vs. V161154, denoting ANES IDs (see also main text and SI for a complete list of IDs); b) high variance ($\sigma^2_v = 0.58$, $\sigma^2_z = 0.64$) and low correlation ($\rho(v, z) = 0.03$) for V161151x vs. V161114x; and c) high variance ($\sigma^2_v = 0.62$, $\sigma^2_z = 0.49$) and high correlation ($\rho(v, z) = 0.44$) for V161228x vs. V161196x.

lated is shown in Fig. 5(c), with the questions “Should transgender people have to use the bathrooms of the gender they were born as, or should they be allowed to use the bathrooms of their identified gender?” vs. “Do you favor, oppose building a wall on the U.S. border with Mexico?”.

One may expect strong opinion correlations only for a pair of questions dealing with very similar topics, such as the one stated in our initial example, about transgender bathrooms and same-sex marriage, which seem intimately related to each other. In the SI we show that the responses to these questions are indeed strongly correlated. The question about building the wall to Mexico, however, seems to be rather unrelated to the issue of transgender bathrooms, so that the high correlation in Fig. 5(c) comes as a surprise. This is not a rare example, and three more are shown in Fig. S3(c)-(f) of the SI. Our model proposes a mechanism which explains the emergence of correlations between opinions with respect to topics with small overlap: If topics are sufficiently controversial, social interactions can reinforce the stance of individuals and trigger the formation of ideological states, as suggested by Fig. 5.

CONCLUSIONS

To sum up, we proposed a simple model able to reproduce crucial features of opinion dynamics as measured in survey data, such as consensus, opinion polarization, and correlation of opinions on different issues, i.e. ideological states. Our model is based on three main ingredients, inspired by empirical evidence: i) The opinion formation is driven by time-varying, homophilic social interactions among the agents, ii) agents sharing similar opinions can mutually reinforce each other’s stance, and iii) opinions lay in a multidimensional space, where topics form a non-orthogonal basis (i.e. they can overlap) and can be controversial. Opinion correlations emerge as soon as the assumption of an orthogonal basis is relaxed and topics are allowed to partly overlap. Ideological states appear as a purely collective phenomenon without
explicit assumptions of individual attributes of agents favoring one partisanship over another. We analytically and numerically characterize the transitions between the three states, consensus, polarization, and ideology, in dependence on the controversialness and overlap of the topics discussed. The model describes the possibility of strong correlations between opinions with respect to rather unrelated topics provided they are controversial enough, which prediction is corroborated by empirical data of questionnaire surveys.

Of course, our work comes with limitations. With respect to the modelling perspective, it is important to note that our model is based on a minimal number of assumptions. It disregards some empirical features of social interactions such as individual preferences of the agents. This is, however, a necessary trade-off between including realistic features of human behavior and the need to keep the model as simple as possible and the number of parameters small. With respect to the empirical validation, the direct tests about the role of social interactions and the impact of the temporal dimension (evolution of opinions) are not possible. However, a data set which is comprehensive of a large set of topics, such as the ANES, and includes the aforementioned temporal and network information is absent, to the best of our knowledge, and would be quite difficult to collect, also for privacy constraints. The ideal venue to build such data sets could be online social media, where users can take advantage of anonymity in expressing their opinions and social interactions could be reconstructed. We left the design of such as study as important future work. The proposed framework also suggests another interesting direction for future work: to investigate the relation between opinion polarization and issue alignment, whose empirical evidence remains unclear.

Finally, it would be extremely interesting to directly quantify topic overlaps in surveys, such as the ANES. This challenge could be addressed by topic modelling of large data sets related to the topics under consideration, such as news articles, and then projecting the trained model (i.e., the topics forming the basis of the space) to the survey data under consideration.

METHODS

Numerical simulations

For the numerical simulations of Eqs. (2) we set the basic simulation parameters to the following values: $N = 1000$, $T = 2$, $\beta = 3$, $K = 3$. The parameters of the basic AD model are set to $(m = 10$, $\epsilon = 0.01$, $\gamma = 2.1)$, the activity of agents is drawn from the distribution $F(a) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(a-\mu)^2}{2\sigma^2}}$. The results depicted in Figs. 2 differ with respect to the values of $\alpha$ and $\delta$, as reported in the captions and the main text. The initial opinions are sampled from a two dimensional Gaussian distribution with zero mean and unit variance ($\mu = 0$, $\sigma^2 = 1$).

The temporal network $A_{ij}(t)$ and the opinion vectors $x_i$ are updated at each time step $t$ as follows.

- The temporal network $A_{ij}(t)$ is initially empty. Each agent $i$ is activated with probability $a_i$.
- Each active agent $i$ contacts $m$ distinct agents. Each agent $j$ is chosen according to Eq. (3), where the opinion distance $d(x_i,x_j)$, between agents $i$ and $j$, is computed involving Eq. (2). The elements of the temporal adjacency matrix $A_{ij}(t)$ are set to $A_{ij}(t) = A_{ji}(t) = 1$ if agent $i$ contacts agent $j$, or vice-versa.
- After the temporal adjacency matrix $A_{ij}(t)$ is generated, for each agent $i$ the aggregated social input coming from its neighbors is computed and the opinion vector $x_i(t+1)$ is updated by numerically integrating Eq. (1) using an explicit Runge-Kutta 4th order method with $dt = 0.01$.

Mean-field approximation

For an arbitrary number of topics $T$, in case of a large number of agents ($N \gg 1$) and strong homophily ($\beta \gg 1$), an agent’s opinions will be close to the opinions of its interaction partners, i.e. we have $x_i^t \approx x_j^t \equiv x^t$ in Eq. (2). In this approximation, the dynamics of a single agent is then effectively described solely by interactions with neighbors holding the same opinion, i.e., a self-interacting agent. For fast switching interactions, the average number of interactions received by an agent at each time step can be approximated by $m(a)$. Hence, Eqs. (1) reduce to

$$\dot{x}^v = -x^v + Km(a) \tanh (\alpha [\Phi x]^v),$$

which describes the opinion dynamics of agents, depending on the topic overlap matrix $\Phi$.

The relation between the controversialness $\alpha$ and the topic overlap $\cos(\delta)$, marking the transition between a global consensus and the emergence of opinion polarization, can be derived using the Jacobian of Eq. (6). To capture the transition analytically, we additionally assume that all pairwise topic overlaps are equal, i.e. the angles between topic are $\delta_{vz} = \delta \ \forall v,z$. The Jacobian of Eqs. (6) evaluated at $x = 0$ yields

$$J(0) = \begin{pmatrix}
-1 + \Lambda \alpha & \Lambda \alpha \cos(\delta) & \ldots & \Lambda \alpha \cos(\delta) \\
\Lambda \alpha \cos(\delta) & -1 + \Lambda \alpha & \ldots & \Lambda \alpha \cos(\delta) \\
\vdots & \vdots & \ddots & \vdots \\
\Lambda \alpha \cos(\delta) & \Lambda \alpha \cos(\delta) & \ldots & -1 + \Lambda \alpha 
\end{pmatrix},$$

where we have defined $\Lambda = Km(a)$ for brevity. The largest eigenvalue of $J(0)$, $\lambda_{\text{max}}$, is given as

$$\lambda_{\text{max}} = (T-1)(-1 + Km(a)\alpha) + Km(a)\alpha \cos(\delta).$$

If $\lambda_{\text{max}} < 0$ the full consensus is stable. Finally, setting Eq. (8) to zero and solving for $\alpha$ yields

$$\alpha_c = \frac{T-1}{Km(a)[T-1 + \cos(\delta)]},$$
which relates the critical controversialness $\alpha_c$ to the topic overlap $\cos(\delta)$ for an arbitrary number of topics $T$.

For the sake of simplicity, in the paper we consider the case of two topics. Setting $T = 2$ in Eq. (9) yields Eq. (5). In this case, Eqs. (6) is reduced to the following non-linear system of equations

$$
\begin{align*}
x_1^+ &= -x_1^+ + Km(a) \tanh \left( \alpha [x_1^+ + \cos(\delta) x_2^+] \right) \\
x_2^+ &= -x_2^+ + Km(a) \tanh \left( \alpha [\cos(\delta) x_1^+ + x_2^+] \right) 
\end{align*}
$$

which give rise, for $Km(a) = 1$, to the attractor dynamics depicted in subpanels (d)-(f) of Fig. 2.

The stability regions in the $\alpha - \cos(\delta)$ space, depicted in Fig. 3, are computed based on the Jacobian of Eqs. (10). While the critical controversialness (black dashed line in Fig. 3) is analytically given by Eq. (5), the regions of stability for correlated and uncorrelated polarization must be determined numerically. In the mean-field approximation, we define as uncorrelated polarized states all situations in which the system has two stable fixed points $x^*$ with $\text{sgn}(x_1^*) = (-, +)$ and $\text{sgn}(x_2^*) = (+, -)$, respectively. The stability of these fixed points is determined numerically in a two-step procedure. Upon discretizing the $\alpha - \cos(\delta)$ plane, we first compute, for each $(\alpha, \cos(\delta))$ parameter combination, the values of the two fixed points by using the Newton-Raphson method [45]. In a second step, we numerically determine the stability of these fixed points $x^*$ by computing the largest eigenvalue of $J(x^*)$. If negative, the corresponding fixed points are stable, and the system is in an uncorrelated polarized state. Otherwise, they are unstable and the system will fall to a polarized ideological state.

Note that for $\cos(\delta) < 0$ ($\delta \in [\pi/2, \pi]$) the stability of the system is reversed giving rise to negatively correlated opinions, as shown in the SI. This does, however, not lead to qualitatively new dynamical features. With respect to our empirical data analysis, this merely corresponds to re-formulating one of the two questions with a reversed scale. Therefore, we omit this range of negative topic overlap and focus on $\delta \in [0, \pi/2]$, i.e. positive overlaps.

**Empirical Data**

The data set analyzed for this work is the 2016 American National Election Survey (ANES) [42]. It includes a total set of 1842 questions. Each of the 4270 respondents is assigned an individual ID, which allows us to correlate responses given by a respondent to different questions. In order to quantify the degree of polarization and issue alignment we compute the variances of responses to single questions and the Pearson correlation coefficients $\rho$ between the responses to pairs of questions. In the caption of Fig. 5, we report these values for the three examples discussed in the main text, other values can be found in the SI.

This procedure requires a numerical scale for the responses. Therefore, we first exclude all questions with free-text answers, such as “What kind of work did you do on your last regular job?””. The remaining questions are multiple-choice questions, not all well suited for our purpose. We only select those questions whose response scale allows us to quantify both the qualitative stance (favor or oppose) and the conviction (e.g., favor a great deal, ..., neutral, ... strongly oppose) of the respondent towards the issue, with at least a 4-point scale. Questions whose response scale do not ensure this or questions which do not ask about a specific opinion, such as “Which of the following radio programs do you listen to regularly?” are excluded. In the last step, we exclude questions regarding political parties or presidential candidates. These selection criteria reduce the 2016 ANES data set to a total of 67 questions, depicted in Fig. 5. We report the complete list of selected questions in the SI, together with the question IDs to locate them in the data set provided by [42].

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Generally, topics can be characterized by different values of controversialness. To account for this we generalize Eqs. (3) of the main text to

\begin{align}
\dot{x}_v &= -x_v + K \sum_j A_{ij}(t) \tanh [\alpha_1 (x_j + \cos(\delta)x_j^2)] \\
\dot{x}_v &= -x_v + K \sum_j A_{ij}(t) \tanh [\alpha_2 (\cos(\delta)x_j + x_j^2)] ,
\end{align}

where \( \alpha_1 \) and \( \alpha_2 \) denote the controversialness values of topics 1 and 2, respectively. While in the main paper, we focused on situations of consensus or polarization in both considered topic dimensions (\( v = 1, 2 \)), here we succinctly discuss a case of different \( \alpha \)-values. For one small and one large value of \( \alpha \), as shown in Fig. S1(a), the dynamics of each topic dimensions strongly depends on the respective controversialness. Due to the small value of \( \alpha_1 (=0.05) \), agents approach consensus with respect to topic \( v = 1 \), while polarization emerges in the other topic dimension \( v = 2 \) as \( \alpha_2 = 3 \) is large. A similar behavior arises for the mean-field approximation, were two stable fixed points can be observed at \( x^* \sim (0, \pm 1) \), cf. Fig. S1(c). Interestingly, similar states are can also be found in the ANES data set, e.g. see Fig. S1(a), where the responses with respect to one issue (“attitude towards Muslims”) show a (neutral) consensus-like situation, while answers with respect to the second question (“service to same-sex couples”) are strongly polarized.

As we discuss in the Methods section, the dynamics towards polarized ideological states is reversed for negative overlaps, \( \cos(\delta) < 0 \), i.e. for topic angles \( \delta \in [\pi/2, \pi] \). In Fig. S1(b) such a situation is depicted for \( \delta = 3\pi/4 \), which corresponds to the mirrored state emerging for \( \delta = \pi/4 \), where opinions show strong negative correlations \( \rho(x^*, x^2) \sim -1 \). This behavior is also reflected in the attractor dynamics of the mean-field approximation, depicted in Fig. S1(b).
FIG. S1. Simulations of the full stochastic system and the corresponding mean-field approximations for $\alpha_1 = 0.05$, $\alpha_2 = 3$ in panels (a) and (c), $\delta = \pi/2$ and $\alpha_1 = \alpha_2 = 3$, $\delta = 3\pi/4$ in panels (b) and (d). All remaining parameters were set as in Fig. 1 of the main text: $N = 1000$, $K = 3$, $\beta = 3$.

ADDITIONAL INFORMATION ON ANES DATA

| Question tuple $(v, z)$                                           | $\sigma_v^2$ | $\sigma_z^2$ | $|\rho(x^v, x^z)|$ | $p$-value ($\rho$) |
|-----------------------------------------------------------------|---------------|---------------|---------------------|-------------------|
| "Obamacare", "voting: duty or choice"                          | 0.5869515     | 0.6468563     | 0.03278208          | 0.03263277        |
| "use of military", "free trade"                                | 0.08553101    | 0.2579248     | 0.0203656           | 0.2235222         |
| "wall with Mexico", "transgender bathroom"                     | 0.6236126     | 0.4494401     | 0.4497568           | 0.0              |
| "attitude towards muslims", "services to same-sex couples"     | 0.2102911     | 0.4781575     | 0.2022116           | 0.0              |
| "services to same-sex couples", "transgender bathroom"         | 0.4781575     | 0.4494401     | 0.5041266           | 0.0              |
| "environment regulations", "insurance plan"                    | 0.3026623     | 0.4105342     | 0.5030662           | 0.0              |
| "climate change action", "transgender bathroom"                | 0.387588      | 0.4494401     | 0.3925486           | 0.0              |
| "asylum for Syrian refugees", "transgender bathroom"           | 0.460483      | 0.4494401     | 0.4842694           | 0.0              |
| "asylum for Syrian refugees", "blacks should help themselves"  | 0.460483      | 0.3558101     | 0.4841681           | 0.0              |

Table I. Variances of responses to single questions ($\sigma_v^2$, $\sigma_z^2$), and Pearson correlations between responses to both questions, $\rho(x^v, x^z)$, for all shown question combinations in Fig. 4 (main text) and Fig. S3.
FIG. S2. Distribution of the Pearson correlation values between all 67 selected questions.
FIG. S3. Scatter plots of selected pairs of questions, additional to those shown in the main text. a) Consensus (“attitude toward Muslims”) vs polarization (“service to same-sex couples”), b) - f) polarized correlated responses with high variance and high correlation. Note that some topics have large overlap, like panel b), while other topics are rather unrelated, see panels c) - f).
Table II. Overview of all 67 analyzed questions, their abbreviated labels and ANES IDs.

| Question label | Question/Issue | ANES ID |
|----------------|----------------|---------|
| Obamacare      | Summary: Favor/oppose 2010 health care law | V161114x, V161151x |
|                | V161114a: IF R FAVORS THE 2010 HEALTH CARE LAW: Do you favor that [a great deal, moderately, or a little / a little, moderately, or a great deal]? |         |
|                | V161114b: IF R OPPOSES THE 2010 HEALTH CARE LAW: Do you oppose that [a great deal, moderately, or a little / a little, moderately, or a great deal]? |         |
| use of military| Summary: Voting as duty or choice | V161151x |
|                | V161151a: IF R CONSIDERS VOTING A DUTY: How strongly do you feel that voting is a duty? [Very strongly, moderately strongly, or a little strongly / A little strongly, moderately strongly, or very strongly]? |         |
|                | V161151b: IF R CONSIDERS VOTING A CHOICE: How strongly do you feel that voting is a choice? [Very strongly, moderately strongly, or a little strongly / A little strongly, moderately strongly, Or very strongly]? |         |
| insurance plan | Where would you place yourself on this scale, or haven’t you thought much about this? 1 (Govt insurance plan) – 7 (Private insurance plan) | V161184 |
| wall with Mexico| Summary: Build wall with Mexico | V161196x |
|                | V161196a: Do you favor, oppose, or neither favor nor oppose building a wall on the U.S. border with Mexico? |         |
| help for black people | Where would you place yourself on this scale, or haven’t you thought much about this? 1 (Govt should help Blacks) – 7 (Blacks should help themselves) | V161198 |
| environment regulations | Where would you place yourself on this scale, or haven’t you thought much about this? 1 (Regulate business to protect the environment and create jobs) – 7 (No regulation because it will not work and will cost jobs) | V161201 |
| Topic | Summary | Question 1 | Question 2 |
|-------|---------|------------|------------|
| asylum for Syrian refugees | Allow Syrian refugees | V161214: Do you favor, oppose, or neither favor nor oppose allowing Syrian refugees to come to the United States? | V161214a: IF R FAVORS ALLOWING SYRIAN REFUGEES TO COME TO THE U.S. / IF R OPPOSES ALLOWING SYRIAN REFUGEES TO COME TO THE U.S.: Do you favor that [a great deal, a moderate amount, or a little / a little, a moderate amount, or a great deal]? / Do you oppose that [a great deal, a moderate amount, or a little / a little, a moderate amount, or a great deal]? |
| climate change action | Govt action about rising temperatures | V161224: Do you think the federal government should be doing more about rising temperatures, should be doing less, or is it currently doing the right amount? | V161225a: IF R SAYS GOVERNMENT SHOULD DO MORE ABOUT RISING TEMPERATURES / IF R SAYS GOVERNMENT SHOULD DO LESS ABOUT RISING TEMPERATURES: Should it be doing a great deal [more/less], a moderate amount [more/less], or a little [more/less]? / Should it be doing a little [more/less], a moderate amount [more/less], or a great deal [more/less]? |
| free trade | Favor/oppose free trade agreements | V162176: Do you favor, oppose, or neither favor nor oppose the U.S. making free trade agreements with other countries? | V162176a: How strongly do you [favor/oppose] it? |
| transgender bathroom | Transgender policy | V161228: Should transgender people – that is, people who identify themselves as the sex or gender different from the one they were born as, or should they be allowed to use the bathrooms of their identified gender? | V161228a: IF R OPINION ON TRANSGENDER USE OF RESTROOMS OF IDENTIFIED GENDER IS NOT DK/RF: How strongly do you feel about that? [Very strongly, moderately strongly, or slightly strongly / Slightly strongly, moderately strongly or very strongly]? |
| attitude towards muslims | Where would you rate Muslims in general on this scale? 1 (Peaceful) - 7 (Violent) | | V162353 |
| service to same sex couples | Summary: Services to same sex couples  
V161227: Do you think business owners who provide wedding-related services should be allowed to refuse services to same-sex couples if same-sex marriage violates their religious beliefs, or do you think business owners should be required to provide services regardless of a couple's sexual orientation?  
V161227a: IF R OPINION ON REFUSING WEDDING SERVICES TO SAME-SEX COUPLES IS NOT DK/RF: How strongly do you feel that way? [Very strongly, moderately, or a little / A little, moderately, or very strongly]? |
|---|---|
| government services | Where would you place yourself on this scale, or haven't you thought much about this?  
1 (Govt should provide many fewer services) – 7 (Govt should provide many more services) |
| defense spending | Where would you place yourself on this scale, or haven't you thought much about this?  
1 (Govt should decrease defense spending) – 7 (Govt should increase spending) |
| gun access | How important is this issue [gun access] to you personally?  
[Extremely important, very important, somewhat important, not too important, or not important at all / Not important at all, not too important, somewhat important, very important, or extremely important]? |
| birthright | Summary: Birthright citizenship  
V161193: Some people have proposed that the U.S. Constitution should be changed so that the children of unauthorized immigrants do not automatically get citizenship if they are born in this country. Do you favor, oppose, or neither favor nor oppose this proposal?  
V161193a: IF R FAVORS CHANGING CONSTITUTION - US-BORN CHILDREN OF ILLEGAL IMMIGRANTS / IF R FAVORS CHANGING CONSTITUTION - US-BORN CHILDREN OF ILLEGAL IMMIGRANTS: Do you favor that [a great deal, a moderate amount, or a little / a little, a moderate amount, or a great deal]? / Do you oppose that [a great deal, a moderate amount, or a little / a little, a moderate amount, or a great deal]? |
| immigrant children | Summary: Children brought illegally  
V161195: What should happen to immigrants who were brought to the U.S. illegally as children and have lived here for at least 10 years and graduated high school here? Should they be sent back where they came from, or should they be allowed to live and work in the United States?  
V161195a: IF R OPINION ON ILLEGAL IMMIGRANT CHILDREN RAISED IN U.S. IS NOT DK/RF: Do you favor that [a great deal, a moderate amount, or a little / a little, a moderate amount, a great deal]?
| Importance of English | How important do you think it is that everyone in the United States learn to speak English? Very important, somewhat important, not very important, or not at all important? | V161197 |
|---|---|---|
| Affirmative Action | Summary: Favor or oppose affirmative action in universities  
V161204: Do you favor, oppose, or neither favor nor oppose allowing universities to increase the number of black students studying at their schools by considering race along with other factors when choosing students?  
V161204a: IF R FAVORS AFFIRMATIVE ACTION AT UNIVERSITIES: Do you favor that [a great deal, a moderate amount, or a little / a little, a moderate amount, or a great deal]?  
V161204b: IF R OPPOSES AFFIRMATIVE ACTION AT UNIVERSITIES: Do you oppose that [a great deal, a moderate amount, or a little / a little, a moderate amount, or a great deal]? | V161204x |
| Fight ISIS | Summary: Send troops to fight ISIS  
V161213: Do you favor, oppose, or neither favor nor oppose the U.S. sending ground troops to fight Islamic militants, such as ISIS, in Iraq and Syria?  
V161213a: IF R FAVORS SENDING U.S. GROUND TROOPS TO FIGHT ISLAMIC MILITANTS LIKE ISIS / IF R OPPOSES SENDING U.S. GROUND TROOPS TO FIGHT ISLAMIC MILITANTS LIKE ISIS: Do you favor that [a great deal, a moderate amount, or a little / a little, a moderate amount, or a great deal]? / Do you oppose that [a great deal, a moderate amount, or a little / a little, a moderate amount, or a great deal]? | V161213x |
| Parental Leave | Summary: Require employers to offer paid leave to new parents  
V161226: Do you favor/oppose, or neither favor nor oppose requiring employers to offer paid leave to parents of new children?  
V161226a: IF R FAVORS REQUIRING EMPLOYERS TO OFFER PAID LEAVE FOR NEW CHILDREN / IF R OPPOSES REQUIRING EMPLOYERS TO OFFER PAID LEAVE FOR NEW CHILDREN: Do you favor that a great deal, a moderate amount, or a little? / Do you oppose that a great deal, a moderate amount, or a little? | V161226x |
| Protection of Gay/lesb | Summary: Laws to protect gays and lesbians against job discrim  
V161229: Do you favor or oppose laws to protect gays and lesbians against job discrimination?  
V161229a: IF R FAVORS PROTECTING GAYS AND LESBIANS AGAINST JOB DISCRIMINATION / IF R OPPOSES PROTECTING GAYS AND LESBIANS AGAINST JOB DISCRIMINATION: [Do you favor such laws strongly or not strongly? / Do you oppose such laws strongly or not Strongly?] | V161229x |
| Topic                | Text                                                                 | Code        |
|---------------------|----------------------------------------------------------------------|-------------|
| abortion            | There has been some discussion about abortion during recent years. Which one of the opinions on this page best agrees with your view? 1 (By law, abortion should never be permitted), 2 (By law, only in case of rape, incest, or woman's life in danger), 3 (By law, for reasons other than rape, incest, or woman's life in danger if needed established) 4 (By law, abortion as a matter of personal choice) | V161232     |
| death penalty       | Summary: Favor or oppose death penalty V161233: Do you favor or oppose the death penalty for persons convicted of murder? V161233a: IF R FAVORS DEATH PENALTY FOR PERSONS CONVICTED OF MURDER / IF R OPPOSES DEATH PENALTY FOR PERSONS CONVICTED OF MURDER: Do you [favor / oppose] the death penalty for persons convicted of murder strongly or not strongly? | V161233x    |
| religious services  | IF R ATTENDS RELIGIOUS SERVICES: Do you go to religious services [every week, almost every week, once or twice a month, a few times a year, or never/ never, a few times a year, once or twice a month, almost every week, or every week]? | V161245     |
| rough-up protesters | When protestors get 'roughed up' for disrupting political events, how much do they generally deserve what happens to them? | V161343     |
| feminism            | How well does the term feminist' describe you? | V161346     |
| language sensitivity| Some people think that the way people talk needs to change with the times to be more sensitive to people from different backgrounds. Others think that this has already gone too far and many people are just too easily offended. Which is closer to your opinion? | V161362     |
| woman not appreciate men | 'Most women fail to appreciate fully all that men do for them.' (Do you agree strongly, agree somewhat, neither agree nor disagree, disagree somewhat, or disagree strongly with this statement?) | V161508     |
| countries like America | 'The world would be a better place if people from other countries were more like Americans.' Do you [agree strongly, agree somewhat, neither agree nor disagree, disagree somewhat, or disagree strongly / disagree strongly, disagree somewhat, neither agree nor disagree, agree somewhat, or agree strongly] with this statement? | V162123     |
| american flag       | Summary: How good/bad does R feel to see American flag V162125: IF R SEEING THE AMERICAN FLAG MAKES R FEEL GOOD / IF R SEEING THE AMERICAN FLAG MAKES R FEEL BAD: Does it make you feel [extremely good, moderately good, or a little good / a little good, moderately good, or extremely good]? / Does it make you feel [extremely bad, moderately bad, or a little bad / a little bad, moderately bad, or extremely bad]? | V162125x    |
| Topic               | Summary                                                                 | Question                                                                                     | Code   |
|--------------------|-------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|--------|
| vaccines           | Favor/oppose vaccines in schools                                        | IF R FAVORS REQUIRING VACCINATION IN ORDER FOR CHILDREN TO ATTEND SCHOOL / IF R OPPOSES REQUIRING VACCINATION IN ORDER FOR CHILDREN TO ATTEND SCHOOL: Do you favor that [a great deal, a moderate amount, or a little / a little, a moderate amount, or a great deal]? / Do you oppose that [a great deal, a moderate amount, or a little / a little, a moderate amount, or a great deal]? | V162147x |
| equal pay          | Favor/oppose equal pay for men and women                                 | IF FAVORS REQUIRING EMPLOYERS TO PAY MEN AND WOMEN SAME FOR THE SAME WORK/ IF OPPOSES REQUIRING EMPLOYERS TO PAY MEN AND WOMEN SAME FOR THE SAME WORK: Do you favor that [a great deal, a moderate amount, or a little / a little, a moderate amount, or a great deal]? / Do you oppose that [a great deal, a moderate amount, or a little / a little, a moderate amount, or a great deal]? | V162150x |
| support for israel | How much should U.S. support Israelis                                   | In the conflict between Palestinians and Israelis, how much should the United States support the Palestinians? [A great deal, a lot, a moderate amount, a little, or not at all / Not at all, a little, a moderate amount, a lot, or a great deal]? In this conflict, how much should the United States support the Israelis? [A great deal, a lot, a moderate amount, a little, or not at all / Not at all, a little, a moderate amount, a lot, or a great deal]? | V162155x |
| immigration        | Do you think the number of immigrants from foreign countries who are permitted to come to the United States to live should be increased/decreased? |                                                                                             | V162157 |
| threat of China's military | Do you think China's military is [a major threat to the security of the United States, a minor threat, or not a threat / not a threat, a minor threat, or a major threat to the security of the United States]? |                                                                                             | V162159 |
| worries about terrorists | How worried are you that the United States will experience a terrorist attack in the near future? |                                                                                             | V162160 |
| free thinkers      | ‘Our country needs free thinkers who will have the courage to defy traditional ways, even if this upsets many people.’ Do you [agree strongly, agree somewhat, neither agree nor disagree, disagree somewhat, or disagree strongly / disagree strongly, disagree somewhat, neither agree nor disagree, agree somewhat, or agree strongly] with this statement? |                                                                                             | V162168 |
| honor forefathers  | ‘Our country would be great if we honor the ways of our forefathers, do what the authorities tell us to do, and get rid of the “rotten apples” who are ruining everything.’ (Do you [agree strongly, agree somewhat, neither agree nor disagree, disagree somewhat, or disagree strongly / disagree strongly, disagree somewhat, neither agree nor disagree, agree somewhat, or agree strongly] with this statement?) |                                                                                             | V162169 |
| strong leader | ‘What our country really needs is a strong, determined leader who will crush evil and take us back to our true path.’ (Do you [agree strongly, agree somewhat, neither agree nor disagree, disagree somewhat, or disagree strongly] with this statement?) |
| business regulation | How much government regulation of business is good for society? [A great deal, a lot, a moderate amount, a little, or none at all / None at all, a little, a moderate amount, a lot, or a great deal] |
| spending on healthcare | Summary: Increase/decrease gov spending for health care |
| V162193b: Do you favor an increase, decrease, or no change in government spending to help people pay for health insurance when they can’t pay for it all themselves? |
| V162193a: Should it increase [a great deal, a moderate amount, or a little / a little, a moderate amount, or a great deal]? / Should it decrease [a great deal, a moderate amount, or a little / a little, a moderate amount, or a great deal]? |
| traditional family | ‘This country would have many fewer problems if there were more emphasis on traditional family ties.’ (Do you [agree strongly, agree somewhat, neither agree nor disagree, disagree somewhat, or disagree strongly] with this statement?) |
| help blacks | ‘Irish, Italians, Jewish and many other minorities overcame prejudice and worked their way up. Blacks should do the same without any special favors.’ Do you [agree strongly, agree somewhat, neither agree nor disagree, disagree somewhat, or disagree strongly] with this statement? |
| have a say in govt | ‘People like me don’t have any say about what the government does.’ (Do you [agree strongly, agree somewhat, neither agree nor disagree, disagree somewhat, or disagree strongly] with this statement?) |
| understand politics | How often do politics and government seem so complicated that you can’t really understand what’s going on? [Always, most of the time, about half the time, some of the time, or never / Never, some of the time, about half the time, most of the time, or always?] |
| influence of money on elections | (In your view, how often do the following things occur in this country’s elections?) Rich people buy elections [All of the time, most of the time, about half of the time, some of the time, never / Never, most of the time, about half of the time, some of the time, never] |
| Topic                                      | Question                                                                 | Code  |
|--------------------------------------------|--------------------------------------------------------------------------|-------|
| hispanics in politics                     | How important is it that more Hispanics be elected to political office?  | V162221 |
| woman should work                         | Summary: Better if man works and woman takes care of home.               | V162230 |
| attention to women                        | Summary: How much attn media should pay to discrim against Women.        | V162231 |
| preferentially hire blacks                | Summary: Favor preferential hiring and promotion of blacks               | V162238 |

| | V162230a: IF R SAYS IT IS BETTER FOR THE MAN TO WORK AND THE WOMAN TO STAY AT HOME: Is it [much better, somewhat better, or slightly better / slightly better, somewhat better or much better]? |       |
| | V162230b: IF R SAYS IT IS WORSE FOR THE MAN TO WORK AND THE WOMAN TO STAY AT HOME: Is it [much worse, somewhat worse, or slightly worse / slightly worse, somewhat worse or much worse]? |       |
| | V162231a: IF THE NEWS MEDIA SHOULD PAY MORE ATTENTION TO DISCRIMINATION AGAINST WOMEN: Should the media pay [a great deal more attention, somewhat more attention, or a little more attention / a little more attention, somewhat more attention, or a great deal more attention]? |       |
| | V162231b: IF THE NEWS MEDIA SHOULD PAY LESS ATTENTION TO DISCRIMINATION AGAINST WOMEN: Should the media pay [a great deal less attention, somewhat less attention, or a little less attention / a little less attention, somewhat less attention, or a great deal less attention]? |       |
| | V162232: When women demand equality these days, how often are they actually seeking special favors? [Always, most of the time, about half the time, some of the time, or never / Never, some of the time, about half the time, most of the time, or always? |       |
| | V162238a: IF R IS FOR PREFERENTIAL HIRING AND PROMOTION FOR BLACKS: Do you favor preference in hiring and promotion strongly or not strongly? |       |
| | V162238b: IF R IS AGAINST PREFERENTIAL HIRING AND PROMOTION FOR BLACKS: Do you oppose preference in hiring and promotion strongly or not strongly? |       |
| Importance of Equality | 'This country would be better off if we worried less about how equal people are.' (Do you [agree strongly, agree somewhat, neither agree nor disagree, disagree somewhat, or disagree strongly / disagree somewhat, or agree strongly] with this statement?) | V162244 |
|-----------------------|-------------------------------------------------------------------------------------------------|---------|
| Obama is / not Muslim | Summary: Barack Obama is/isn't Muslim V162255: Is Barack Obama a Muslim, or is he not a Muslim? V162255a: IF R SAYS THAT BARACK OBAMA IS A MUSLIM OR SAYS THAT BARACK OBAMA IS NOT A MUSLIM: How sure are you about that? [Extremely sure, very sure, moderately sure, a little sure, or not at all sure / Not at all sure, a little sure, moderately sure, very sure, or extremely sure]? | V162255x |
| Strong Leader Bending Rules | 'Having a strong leader in government is good for the United States even if the leader bends the rules to get things done.' (Do you [agree strongly, agree somewhat, neither agree nor disagree, disagree somewhat, or disagree strongly / disagree strongly, disagree somewhat, neither agree nor disagree, agree somewhat or agree strongly]?) | V162263 |
| Minorities Should Adopt Traditions | Now thinking about minorities in the United States. Do you [agree strongly, agree somewhat, neither agree nor disagree, disagree somewhat, or disagree strongly / disagree strongly, disagree somewhat, neither agree nor disagree, agree somewhat or agree strongly] with the following statement? 'Minorities should adapt to the customs and traditions of the United States' | V162266 |
| Immigrants Good for Economy | And now thinking specifically about immigrants. (Do you [agree strongly, agree somewhat, neither agree nor disagree, disagree somewhat, or disagree strongly / disagree strongly, disagree somewhat, neither agree nor disagree, agree somewhat or agree strongly] with the following statement?) 'Immigrants are generally good for America's economy.' | V162268 |
| Immigrants Increase Crime | (Do you [agree strongly, agree somewhat, neither agree nor disagree, disagree somewhat, or disagree strongly / disagree strongly, disagree somewhat, neither agree nor disagree, agree somewhat or agree strongly] with the following statement?) 'Immigrants increase crime rates in the United States.' | V162270 |
| Born in US | Some people say that the following things are important for being truly American. Others say they are not important. How important do you think the following is for being truly American... [very important, fairly important, not very important, or not important at all / not important at all, not very important, fairly important or very important]? To have been born in the United States | V162271 |
| Corruption in Politics | How widespread do you think corruption such as bribe taking is among politicians in the United States: [Very widespread, quite widespread, not very widespread, or it hardly happens at all / It hardly happens at all, is not very widespread, quite widespread, or very widespread]? | V162275 |
reduce income differences

Please say to what extend you agree or disagree with the following statement: ‘The government should take measures to reduce differences in income levels’. (Do you [agree strongly, agree somewhat, neither agree nor disagree, disagree somewhat, or disagree strongly / disagree strongly, disagree somewhat, neither agree nor disagree, agree somewhat or agree strongly]?)

V162276

torture of terrorists

Summary: Favor/oppose torture for suspected terrorists

V162295: Do you favor, oppose, or neither favor nor oppose the U.S. government torturing people who are suspected of being terrorists, to try to get information?

V162295a: IF R FAVORS USE OF TORTURE AGAINST SUSPECTED TERRORISTS: Do you favor that [a great deal, moderately, or a little / a little, moderately, or a great deal]?

V162295b: IF R OPPOSES USE OF TORTURE AGAINST SUSPECTED TERRORISTS: Do you oppose that [a great deal, moderately, or a little / a little, moderately, or a great deal]?

whites lazy

Where would you rate Whites in general on this scale? 1 (Hard-working) – 7 (Lazy)

V162345

christians patriotic

Where would you rate Christians in general on this scale? 1 (Patriotic) – 7 (Unpatriotic)

V162356

discrimination against blacks

How much discrimination is there in the United States today against each of the following groups? Blacks

V162357

discrimination against women

How much discrimination is there in the United States today against each of the following groups? Women

V162362