

Like a natural system, democracy faces collapse as polarization leads to loss of diversity

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The increasingly polarized political landscape in the United States—and much of the world—is experiencing a catastrophic loss of diversity that threatens the stability not only of democracy, but also of society, according to a series of new studies published in a special issue of the *Proceedings of the National Academy of Sciences*. Conducted by interdisciplinary teams of political scientists and complex systems theorists—including several led by Princeton researchers—the studies examine political polarization as a collection of complex ever-evolving systems. Credit: Egan Jimenez, Princeton School of Public and International Affairs

Much like an overexploited ecosystem, the increasingly polarized political landscape in the United States—and much of the world—is experiencing a catastrophic loss of diversity that threatens the resilience not only of democracy, but also of society, according to a series of new studies that examine political polarization as a collection of complex ever-evolving systems.

Fifteen interdisciplinary teams of political scientists and complex systems theorists in the natural sciences and engineering explored how polarization is produced and influenced over time by the actions and interactions of individual voters, people in power, and various social networks. Ultimately, as social interactions and individual decisions isolate people into only a few intractable camps, the political system becomes incapable of addressing the range of issues—or formulating the variety of solutions—necessary for government to function and provide the services critical for society.

The studies were published Dec. 6 in a special issue of the *Proceedings of the National Academy of Sciences* that stemmed from a collaboration between Princeton University and Arizona State University (ASU) and includes several papers led by Princeton researchers.

"The complex systems perspective demonstrates that the loss of diversity associated with polarization undermines cooperation and the ability of societies to provide the [public goods](#) that make for a healthy society," according to an introduction by issue editors Simon Levin, Princeton's James S. McDonnell Distinguished University Professor in Ecology and Evolutionary Biology, Helen Milner, the B.C. Forbes Professor of Public Affairs and professor of politics and international affairs at Princeton, and Charles Perrings, professor of environmental economics at ASU.

"Polarization is a dynamic process and that is what complexity theory can best help us understand," they wrote. "As environmental and

complexity scientists have shown in other contexts, diversity maintenance is critical for many systems to thrive, and often to survive at all."

Complex adaptive systems are widespread in fields from physics and financial systems to natural systems driven by evolution and socioeconomic-political systems, said Levin, who is director of the Center for BioComplexity based in Princeton's High Meadows Environmental Institute (HMEI).

"These systems are composed of individual agents, in which there is an interplay, and perhaps a coevolution, between the attitudes and actions of individual agents and the emergent properties of the systems to which they belong," he said. "Similar challenges exist across these applications, involving the need for a statistical mechanics to scale from individuals to collectives, to the emergence of patterns and processes such as social norms."

Despite the rise of partisanship, populism and polarization, these phenomena have not been thoroughly studied as dynamic systems consisting of multiple interacting components and large-scale features, Milner said.

"James Madison had hoped that the system devised in the Constitution would avoid the sorts of polarization that political parties can produce and that can undermine the workings of government," Milner said.

"Sadly, we are seeing polarization today and a subsequent loss of diversity in the range of positions in society within the United States and globally," she said. "The papers in this issue demonstrate from a systems perspective the forces that lead to polarization—and some of the consequences of it—with the hope that understanding them will lead to better governance."

The studies from Princeton researchers are summarized below. The papers explored issues from how people unwittingly isolate themselves into partisan networks through social media and how to ensure successful electoral reforms using models, to how public opinion fuels extremism among political elites, as well as the potential benefits of polarization under the right circumstances.

People unwittingly polarize themselves by ditching followers considered untrustworthy

A computational model tested with Twitter data showed that social media users may inadvertently sort themselves into polarized networks by "unfollowing" users they consider untrustworthy news sources. Princeton researchers Andy Guess, assistant professor of politics and public affairs, Corina Tarnita, professor of ecology and evolutionary biology, and first author Christopher Tokita, who received his Ph.D. from Princeton in 2021, found that when people are less reactive to news, their online environment remains politically mixed.

When users constantly react to and share articles from their preferred news sources, however, they are more likely to develop politically isolated networks, or what the researchers call "epistemic bubbles." Once users are in these bubbles, they actually miss out on more news articles, including those from their preferred media outlets.

"It's not hard to find evidence of polarized discourse on social media, but we know less about the mechanisms of how social media can drive people apart," Guess said. "Our contribution is to show that polarization of online social networks emerges naturally as people curate their feeds. Counterintuitively, this can occur even without knowing other users' partisan identities."

Conservative swings in public opinion ramp up Republican lawmaker extremism

Researchers have linked the current extremism of Republican members of the U.S. Congress to public opinion. While it is well-documented that Americans are not as polarized as the people they elect, a study led by Naomi Ehrich Leonard, Princeton's Edwin S. Wilsey Professor of Mechanical and Aerospace Engineering, and Keena Lipsitz, associate professor of political science at Queens College, CUNY, with Princeton doctoral student Anastasia Bizyaeva shows that Americans are still partly to blame for the extremism of their elected officials.

The researchers found that over time, conservative swings in public opinion—which are typically slightly larger and more prolonged than liberal swings—exacerbate the self-reinforcement processes for Republican lawmakers, wherein legislators respond to favorable public opinion by further bolstering their own positions. They identified a tipping point beyond which the process of polarization speeds up as the forces driving it are compounded and the forces mitigating polarization are overwhelmed. They report that Republicans may have passed this critical threshold while Democrats are quickly approaching it.

"By combining our expertise on political processes together with our expertise on feedback and nonlinearity in complex time-varying processes, we were able to make new discoveries about the mechanisms that can explain, and potentially mitigate, political polarization," Leonard said.

"Until now, the ways in which public opinion changes over time had not been implicated in the political polarization of lawmakers," she said. "Yet, by accounting for nonlinearity in how lawmakers respond to public opinion, we show that these differences matter significantly and small

differences in public opinion swings can in fact lead to large changes in polarization. I am hopeful that the analytical tools we developed for this study will prove useful in finding ways to slow down the trend."

Progressive taxation could reduce economic hardships, social tensions fueling polarization

Intergroup conflict triggered by economic hardship can reduce social and economic interactions, which in turn further exacerbates economic decline and political polarization, according to a paper coauthored by Nolan McCarty, Princeton's Susan Dod Brown Professor of Politics and Public Affairs, and Joshua Plotkin, a professor of natural sciences at the University of Pennsylvania who received his Ph.D. from Princeton. The findings suggest that progressive taxation designed to ensure an adequate social safety net could help prevent the economic anxieties that fuel ethnic and racial conflict.

"During the past 20 years, the United States and many other countries have experienced profound economic, social and political upheaval—including economic crises, escalating inequality, the exacerbation of racial and ethnic conflicts, and deepening [political polarization](#)," McCarty said. "Our paper is an attempt to understand the complex dynamics that link these developments and explore ways to break the negative cycle."

Diversity of social networks can intensify or moderate personal attitudes

The social networks to which people belong can "rewire" their personal attitudes over time to reflect the opinions of the people they're linked to, according to a study led by former Princeton postdoctoral fellow Fernando Santos, an assistant professor at the University of Amsterdam,

with Simon Levin, Princeton's James S. McDonnell Distinguished University Professor in Ecology and Evolutionary Biology, and Yphtach Lelkes, associate professor of communication at the University of Pennsylvania.

The researchers found that when people preferentially connect to people with similar opinions, they create an echo chamber that increasingly polarizes the views of everyone in the network. On the other hand, people who are part of a network consisting of a variety of viewpoints tend to moderate one another. Understanding that social networks influence polarization—rather than merely reflect it—could be crucial in developing interventions to curb polarization online and the spread of political extremism, the researchers report.

"This is a relatively new phenomenon, and like other internet and media mechanisms, has likely sped and reinforced the segmentation of our societies," Levin said.

Polarization can benefit society when opposing sides consist of diverse populations

Polarization may actually benefit society when opposing viewpoints each represent a variety of people and communities with shared values, according to research led by Vitor Vasconcelos, assistant professor at the University of Amsterdam and past postdoctoral research associate at Princeton, with Elke Weber, the Gerhard R. Andlinger Professor in Energy and the Environment and professor of psychology and the School of Public and International Affairs, Princeton associate research scholar Sara Constantino, and Simon Levin, Princeton's James S. McDonnell Distinguished University Professor in Ecology and Evolutionary Biology. Polarization becomes harmful when it segregates social networks and excludes information about the preferences of people other than close

neighbors. Cooperation becomes less likely when these local networks distort or undermine the value of working with opponents, which can result in a number of effects including the weakening of democratic processes.

"Pluralistic societies thrive when members with different values and beliefs manage to discuss these differences and leverage them to generate win-win solutions," said Weber, who is an associated faculty member in HMEI. "Our paper shows that collective benefits are reduced by the polarization of social networks that restrict communication and negotiation across partisan lines, not the fact that we disagree on values."

Contrarians at the gate: How strong local attitudes can breed opposition

Local variations in political attitudes can lead to polarization, particularly after political unrest, according to research led by Olivia Chu, a Princeton graduate student in quantitative and computational biology, with coauthors Grigore Pop-Eleches, professor of politics and international affairs, and Jonathan Donges, a visiting research collaborator in HMEI from the Potsdam Institute for Climate Impact Research. They deployed an adaptive voter model—which is used to study opinion dynamics—across Ukraine to determine how people's perceptions of the European Union differed based on how people in their communities and social circles discussed revolutions, mass protests, and other political shocks.

"Our research shows that rather than sweeping everyone along, the effect of revolutions on how people think about politics depends in part on the attitudes of the people with whom they talk about politics," Pop-Eleches said. "Those who mostly talk to supporters of the revolution are likely to change their opinions in the opposite direction from those who talk to

opponents. This can lead to pockets of increased polarization even in countries where most people support the goals of the revolution."

Partisan interpersonal interactions can weaken Madison's cure for factions

A study led by Corina Tarnita, professor of ecology and evolutionary biology, and doctoral student Mari Kawakatsu in Princeton's Program in Applied and Computational Mathematics examined how partisan interpersonal interactions can weaken processes that the framers of the US Constitution viewed as safeguards against factions and polarization. Kawakatsu and Tarnita co-authored the study with Simon Levin, Princeton's James S. McDonnell Distinguished University Professor in Ecology and Evolutionary Biology, and Yphtach Lelkes, associate professor of communication at the University of Pennsylvania.

The researchers were inspired by James Madison's essay, "Federalist No. 10," in which he argued that a republic mitigates the dangers of factions by fostering a diversity of political interests. But Americans today care about many more political issues than they did 75 years ago, yet polarization is worse. The authors developed a theoretical model of cultural evolution to investigate the possible role that interactions among partisan opinionated citizens play in this puzzle.

Their analysis confirmed Madison's intuition that societal cohesion increases when individuals care about a greater diversity of issues. But there is a twist—under extreme partisanship, individuals' openness to learning from peers with a different political ideology is diminished. This leads to greater tribalism that drastically diminishes interest diversity, which leads to high within-ideology camaraderie and heightened polarization.

But the researchers also found a silver lining: The harmful effects of extreme partisanship are only substantial when individuals are primarily relying on social peers to shape their opinions and strategies and are limited in their independent exploration. "Our model suggests that actively pursuing learning from beyond one's social network is crucial to maintaining a cohesive society," said Tarnita, who is associated faculty in HMEI and director of the environmental studies program at Princeton.

"Although both opinion formation and cooperation are well-explored topics, we understand relatively little about the coupled dynamics of cooperation and polarization," Kawakatsu said. "The unexpected interactions we found between partisanship, cooperation and independent exploration highlight the need to study [polarization](#) in a coupled, multi-level context."

Complex systems theory can lead to deeper understanding, better design of lasting reforms to American democracy

The implications of democracy reforms such as ranked-choice voting and citizen redistricting may be better understood using dynamic systems theory based in engineering and biology, according to an analysis led by Sam Wang, professor of neuroscience and director of the Electoral Innovation Lab at Princeton.

Wang and a multi-institutional team of political scientists report that systems-based theory typically used in the sciences can help understand the myriad of interactions that lead to current weaknesses in American democracy—particularly polarized institutions, unresponsive representatives, and the ability of a faction of voters to gain power at the expense of the majority. Concepts such as nonlinearities and amplification, positive and negative feedback, and integration over time

can help identify problems in representation and institutional power.

Similarly, the effectiveness of any proposed reform is difficult to predict against a backdrop of complex network interactions. A mathematically rich description of how electoral mechanisms interact can maximize the impacts of reforms in the context of the politics and procedures of individual states.

"Our core objective was to translate the American [political system](#) into a mathematical complex-systems framework that fosters participation by scholars of the [natural sciences](#)," Wang said.

"We want to encourage natural scientists to build models that reproduce political phenomena, create simulations to explore alternative scenarios, and design interventions that may improve the function of democracy," he said. "These goals are analogous to those of engineers—to understand a system of many parts well enough to make repairs or improvements."

More information: The special issue, "The Dynamics of Political Polarization," was published Dec. 6 by the *Proceedings of the National Academy of Sciences*.

Provided by Princeton University

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