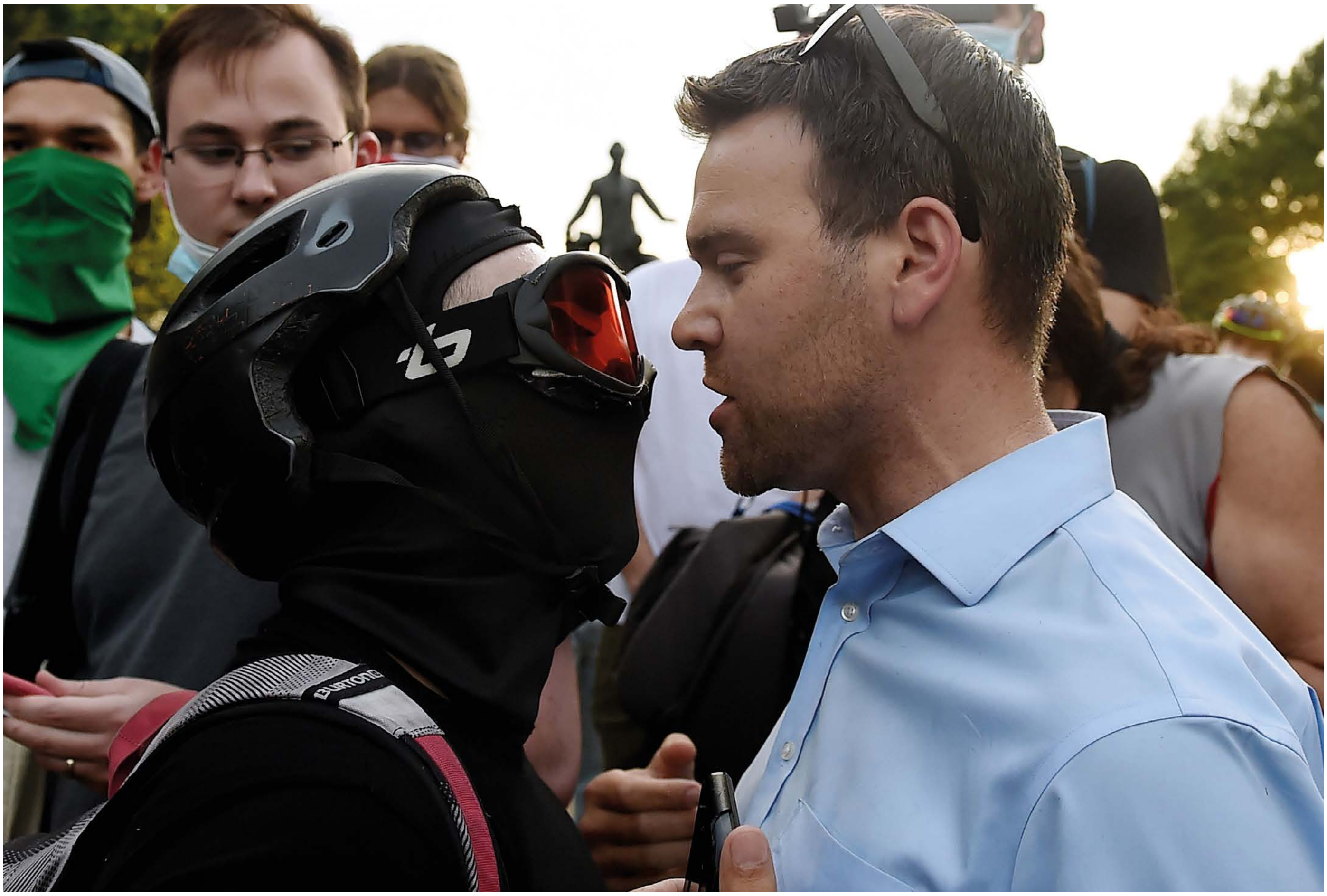
News & views



OLIVIER DOULIERY/AFP VIA GETTY

Figure 1 | A face-off between an anti-racism protester and a conservative activist in Washington DC in June 2020.

Computational social science

Effect of Facebook's feed algorithm put to the test

David Garcia

A landmark collaboration shows that Facebook's news feed filters partisan political news to users with the same views. But changing the feed algorithm to reduce exposure to like-minded content does not reduce political polarization. **See p.137**

Voters are polarized in many countries to the point at which they feel greater aversion to people with different political views than affection for like-minded people[1]. A common concern is that news-feed algorithms on social media could have a role in generating polarization by exposing individuals to more information from politically like-minded sources than they would otherwise see, thus creating 'echo chambers' and 'filter bubbles'[2]. An often-proposed solution to this is to change these algorithms to reduce exposure to content from sources that agree with the users' political views. Four papers, one[3] from Nyhan *et al.* in *Nature* (see page 137) and three[4–6] in *Science*, now describe the findings of the U.S. 2020 Facebook and Instagram Election Study, a remarkable collaboration between researchers at Meta (the company that owns Facebook and Instagram) and independent academics. The results cast light on the influence of social media on polarization, and expose the limits of making changes to news-feed algorithms in efforts to depolarize political attitudes.

The collaboration tested the consequences of making three substantial changes to Facebook's news-feed algorithm. Nyhan *et al.* report what happens when all content from like-minded sources is down-ranked; and Guess *et al.* examine the effects of removing re-shared content from the feed[4], and of disabling all ranking calculations to show social content on Facebook and Instagram in reverse chronological order[5] (that is, so that the most recent items are displayed first). None of these changes had any effect on affective polarization, the phenomenon in which people become more positive towards supporters of their own political party, but more negative towards supporters of opposing parties. The changes also failed to affect opinion polarization, including ideological extremity[3] and issue polarization[4,5] (a measure of how close someone is to the position adopted by the party they support across a battery of issues).

Although the changes did not influence these self-reported attitudes and opinions, they did have other observable effects. Down-ranking content from like-minded sources in the algorithm reduced exposure to misinformation, hateful speech and uncivil content. Removing re-shares also reduced exposure to untrustworthy sources, but increased exposure to uncivil content. By contrast, using reverse chronological order on Facebook and Instagram feeds had the concerning effect of increasing exposure to untrustworthy sources.

Why did the changes to the news-feed algorithm, especially those that reduced exposure to like-minded sources, not reduce polarization? One possibility is that the study took place around the time of the 2020 US presidential election — it might be hard to change opinions and attitudes during polarized elections. However, the interventions lasted three months, which is potentially long enough for people to change their political opinions, as a previous social-media experiment has shown[7]. During elections, there is also more political communication that can be influenced by social-media algorithms than normal. Another consideration is that US media and society outside Facebook are highly polarized (Fig. 1); similar changes in algorithms might have altered opinions in countries where mass media is less partisan and where citizens are not as polarized.

If we think about polarization as a collective behaviour that we would like to moderate[8], the absence of an algorithmic effect on attitudes and opinions in these studies is not that surprising. Let's consider an analogy with climate change: imagine a policy that reduces carbon emissions in a few towns. Compared with a control group of towns, we are unlikely to find an effect on temperature anomalies, but the absence of an effect would not be evidence that carbon emissions did not cause climate change. Similarly, these social-media experiments do not rule out the possibility that news-feed algorithms contributed to rising polarization. Still, both examples show that there is a limit to the effectiveness of solutions that work at the level of individuals when trying to alter collective behaviour. These limits must be overcome by using coordinated approaches, such as regulation or collective action.

Nyhan *et al.* also report a large-scale observational analysis of exposure of all US Facebook users to content on that platform. When analysing all content, and not just political news, they find that the 'depth' of echo chambers differs widely between people — ranging from the deepest chambers, in which 20.6% of Facebook users get more than 75% of their exposures from like-minded sources, to virtual spaces that cannot be considered to be echo chambers at all, in which 23.1% of the users receive 25% or less of their content from such sources. This contradicts the common assumption that all interaction on social media happens in echo chambers.

However, things look different when considering how Facebook drives exposure and engagement with political news. González-Bailón *et al.*[6] analysed whether political news was segregated by ideology as it passes through the Facebook 'funnel of engagement' — from the potential full audience of subscribers to pages, groups and friends, to the actual exposure influenced by Facebook's feed algorithm, to the final engagement of users, taking into account actions such as likes, shares and comments. This analysis is an important update of a previous study of Facebook data[9], which included only users who self-disclosed their political ideas and only exposure through friends (ignoring exposure through subscriptions to groups and pages). González-Bailón and colleagues found that ideological segregation of news on Facebook is higher than was previously thought and increases as content goes through the funnel: segregation is higher after the Facebook algorithm filters content, and is even higher when final engagement is considered.

"Facebook still has a problem in terms of how social and algorithmic factors influence the political news."

Crucial insights also emerged from the ideological leanings of the audiences of news sources. News sources that are typically found on Facebook (such as the sites of news companies and individual links within those sites) have more people in their Facebook audiences who have right-wing (conservative, or Republican) political views than people with left-wing (liberal, or Democratic) political views. Moreover, untrustworthy news sources and news that has been fact-checked as false have audiences mostly composed of conservatives. The results also show that Facebook's US audience for false news is predominantly conservative and does not have an equivalent on the left. Taken together, the findings of the current four papers show that reducing exposure to like-minded sources might not be the solution to polarization, but that Facebook still has a problem in terms of how social and algorithmic factors influence the political news that is seen and engaged with by users — especially misinformation.

In Nyhan and colleagues' experiment, algorithmic strong down-ranking of like-minded sources reduced exposure to these sources only from 53.7% in a control group to 36.2%, and also indirectly increased exposure to cross-partisan sources from 20.7% to 27.9%. Users found other ways to read like-minded content, for example through groups and channels or by scrolling far down the Facebook feed. This shows that users have their own agency and that their behaviour is not completely determined by algorithms, at least for social-media forms such as Facebook and Instagram. It echoes results reported this year that compared engagement and exposure to partisan news found using search engines[10]. By contrast, the feed algorithms of newer platforms such as TikTok are much more central to the user experience than are other, more direct kinds of social interaction. If appropriate social values are incorporated into these new 'algorithmic media'[11], they bring the opportunity to promote content with cross-partisan appeal that could help in reducing polarization as a collective phenomenon[12].

The studies reported in the four papers have high ethical standards and scientific quality. The design, analysis and publication of the results were outside the control of Meta (see Section S4.8 of the supplementary information for ref. 3), dispelling concerns that the company would censor findings that were uncomfortable for their private interests but necessary for societal good. A proactive approach to establishing such collaborations is needed in the future, so that the effects of emerging online technologies on political behaviour can be investigated without our first having to endure more than a decade of concern[13].

There is now an urgent need to study the influence of social-media algorithms and interface designs on other topics, such as misinformation spreading, the erosion of democracies, privacy issues (for example, shadow profiling: the collection of user information without consent) and the mental health of young users and other at-risk populations. A global perspective is possible in collaboration with a wider community of scientists beyond US scholars. This is particularly feasible in Europe through the framework of the Digital Services Act — a European Union law that requires large online platforms to share their data with researchers. Meta and other companies must honestly and openly embrace regulated collaborations to scale up studies such as those now reported, and thereby to have a responsible role in our digital society.

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Biogeochemistry

An improved model of the ocean iron cycle

Brandy M. Toner

A revised conceptual model of the chemical and physical forms of iron in the ocean reconciles the mismatch between observations and simulations of the amount of dissolved iron in seawater — and might aid climate predictions. **See p.104**

Marine microorganisms known as phytoplankton use carbon dioxide to build their bodies, and the energy of sunlight to fuel their metabolisms. When they die, they sink to the ocean floor, carrying carbon with them. These organisms therefore act as the primary link between CO_2 in the atmosphere and carbon sequestered in ocean sediments. However, the scarcity of iron — a nutrient required for life — in seawater limits the growth of phytoplankton[1], and therefore the quantity of carbon that can be sequestered. The amount and chemical forms of iron available to phytoplankton are key to how the ocean and atmosphere interact. On page 104, Tagliabue *et al.*[2] report a modelling framework and numerical tool that address some of the intricacies of marine iron chemistry and solve long-standing inconsistencies in simulations of the iron cycle.

Oceanographers have long struggled to capture the complex processes that govern iron's chemical forms, bioavailability and transport in the ocean. Part of the problem is that iron concentrations in seawater are exceedingly low, yet iron is abundant in human environments. This means that specialized handling procedures, laboratory spaces and instruments are needed to prevent seawater samples from being contaminated by non-marine iron. The painstaking efforts involved mean that scientists cannot measure iron throughout the ocean at high enough spatial and temporal resolutions to understand the feedbacks between the ocean, atmosphere and biosphere. Robust conceptual and numerical models are therefore needed to describe the marine iron cycle.

Establishing such models requires knowledge of the chemical and physical forms that iron can take in the ocean. Unfortunately for phytoplankton, the modern ocean surface favours iron in its least water-soluble form — rusty minerals that carry the metal in its +III oxidation state[3]. However, dissolved organic molecules called ligands can bind to iron(III), increasing its solubility in water[4], and therefore its bioavailability to phytoplankton.

For historical reasons, oceanographers group marine iron into different categories according to whether the iron can be separated from seawater using filters with 0.2-micrometre pores. Iron species that pass through such filters are considered to be dissolved, whereas retained iron is classified as particulate[5]. The concentration of dissolved iron is commonly measured and is an important parameter used to relate ocean chemistry to phytoplankton nutrition and the global element cycles in models[6]. More specifically, water-soluble ligand-bound iron is a key component of dissolved iron[7] and a central feature

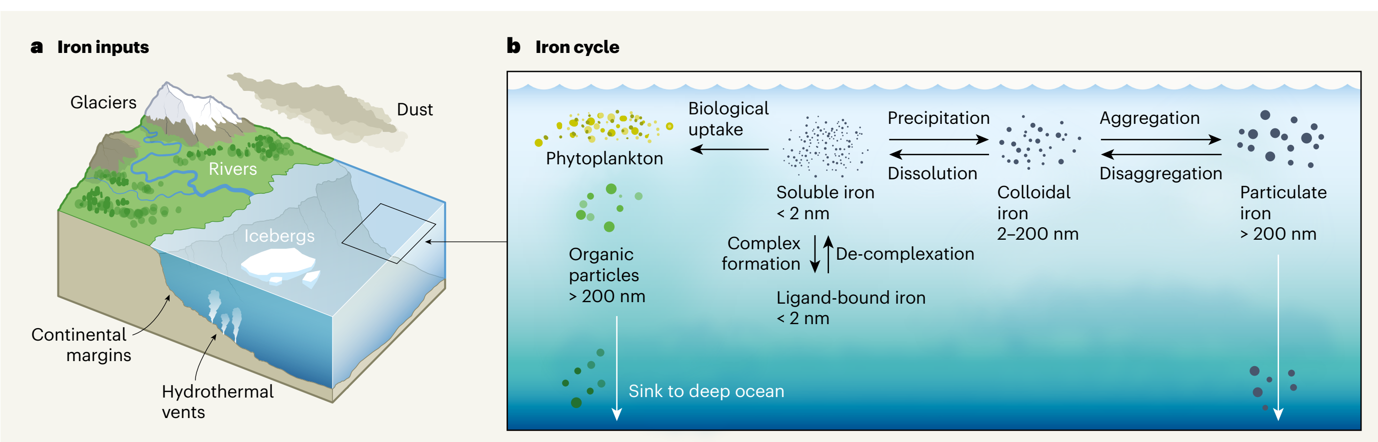

Figure 1 | A revised view of the iron cycle at the ocean surface. a, Iron inputs to the ocean include continental sources (such as rivers, glaciers and wind-blown dust) and hydrothermal vents. **b**, In sunlit seawater, soluble forms of iron are taken up by phytoplankton, which require the element for growth. Organic particles from dead phytoplankton sink to the deep ocean, taking some of the iron with them. The amount of iron available to phytoplankton is boosted by the presence of organic ligand molecules (not shown), which bind to iron in its +III oxidation state, producing soluble complexes. Tagliabue *et al.*[2] propose that another pool of iron at the ocean surface — colloidal iron, which consists of particles about 2–200 nanometres in diameter — is key to describing the spatial and seasonal distribution of iron in seawater. These small particles can aggregate into ones that sink to the deep ocean. An advanced numerical model that includes this process accurately reproduces observed levels of dissolved iron around the globe, resolving a previously persistent mismatch between observations and models.