Echo Chambers, Filter Bubbles, and Polarisation: a Literature Review

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Executive summary

Terms like echo chambers, filter bubbles, and polarisation are widely used in public and political debate but not in ways that are always aligned with, or based on, scientific work. And even among academic researchers, there is not always a clear consensus on exact definitions of these concepts.

In this literature review we examine, specifically, social science work presenting evidence concerning the existence, causes, and effect of online echo chambers and consider what related research can tell us about scientific discussions online and how they might shape public understanding of science and the role of science in society.

Echo chambers, filter bubbles, and the relationship between news and media use and various forms of polarisation has to be understood in the context of increasingly digital, mobile, and platform-dominated media environments where most people spend a limited amount of time with news and many internet users do not regularly actively seek out online news, leading to significant inequalities in news use.

When defined as a bounded, enclosed media space that has the potential to both magnify the messages delivered within it and insulate them from rebuttal, studies in the UK estimate that between six and eight percent of the public inhabit politically partisan online news echo chambers.

More generally, studies both in the UK and several other countries, including the highly polarised US, have found that most people have relatively diverse media diets, that those who rely on only one source typically converge on widely used sources with politically diverse audiences (such as commercial or public service broadcasters) and that only small minorities, often only a few percent, exclusively get news from partisan sources.

Studies in the UK and several other countries show that the forms of algorithmic selection offered by search engines, social media, and other digital platforms generally lead to slightly more diverse news use – the opposite of what the "filter bubble" hypothesis posits – but that self-selection, primarily among a small minority of highly partisan individuals, can lead people to opt in to echo chambers, even as the vast majority do not.

Research on polarisation offers a complex picture both in terms of overall developments and the main drivers and there is in many cases limited empirical work done outside the United States. Overall, ideological polarisation has, in the long run, declined in many countries but affective polarisation has in some, but not all, cases increased. News audience polarisation is much lower in most European countries, including the United Kingdom. Much depends on the specifics of

individual countries and what point in time one measures change from and there are no universal patterns.

There is limited research outside the United States systematically examining the possible role of news and media use in contributing to various kinds of polarisation and the work done does not always find the same patterns as those identified in the US. In the specific context of the United States where there is more research, it seems that exposure to like-minded political content can potentially polarise people or strengthen the attitudes of people with existing partisan attitudes and that cross-cutting exposure can potentially do the same for political partisans.

Public discussions around science online may exhibit some of the same dynamics as those observed around politics and in news and media use broadly, but fundamentally there is at this stage limited empirical research on the possible existence, size, and drivers of echo chambers in public discussions around science. More broadly, existing research on science communication, mainly from the United States, documents the important role of self-selection, elite cues, and small, highly active communities with strong views in shaping these debates and highlights the role especially political elites play in shaping both news coverage and public opinion on these issues.

In summary, the work reviewed here suggests echo chambers are much less widespread than is commonly assumed, finds no support for the filter bubble hypothesis and offers a very mixed picture on polarisation and the role of news and media use in contributing to polarisation.

1. Introduction

In this literature review, we examine evidence concerning the existence, causes, and effect of online echo chambers and consider what related research can tell us about scientific discussions online and how they might shape public understanding of science and the role of science in society.

We discuss online echo chambers in the context of a set of related concerns around the possible links between the rise of the internet and various digital platforms (search engines, social media, messaging applications, news aggregators, etc.) and polarisation in our societies.

Much of the existing research is focused on the United States, which is in many ways an extreme outlier among high income democracies, as political elites, the media system, and public opinion is more polarised there than in otherwise similar countries.

Thus, while we consider findings from the United States, these insights are not universally applicable. We therefore pay particular attention to comparative studies that can help capture differences and similarities across various national contexts and the situation in the United Kingdom specifically.

We seek to identify (a) areas where we believe there is a clear majority view in academic research, (b) areas where there are some empirical studies but not necessarily convergent interpretations, and (c) areas where there is at this point little evidence to help us understand a situation that is rapidly evolving in terms of both media structure and media substance (as the constant evolution of the digital media environment as well as communications around the coronavirus pandemic has shown).

Research in this area is extensive in some respects, almost non-existent in others. To avoid an overlong review, we focus our efforts on recent studies primarily in the social sciences that have a direct bearing on the possible links between media use and how the public understands the world around them. Most of the work we summarise has been peer reviewed. To be able to present an up-to-date review including work done during the coronavirus pandemic, we also draw on some empirical reports and preprints from academics working at universities and with established social science methods.

In the literature review we aim to summarise relevant empirical research and clarify the meaning of terms that are used both in public and policy debate and in more specialised scientific research, and not always in the same way. Terms like “echo chamber” and “filter bubble” have exploded into public discourse in recent years and the Hansard official record shows how these terms are increasingly used by

elected officials in UK Parliamentary debates. Needless to say, public and political use of these terms are not always aligned with, or based on, scientific work. And even among academic researchers, there is not always a clear consensus on exact definitions of these concepts.

Some of the issues we discuss – around echo chambers, polarisation, and inequality – for example, raise moral and political questions and sometimes capture serious societal challenges. Our purpose here is not to outline normative positions on these but to summarise the relevant evidence. This is important to keep in mind because analytical terms such as echo chambers and polarisation often have a negative ring, but their implications of course depend on the substantive nature of the information echoed or the issues that polarise opinion.

2. Basic descriptive facts about media use

For context, it is important to recognise some basic, often overlooked, descriptive features of contemporary media use.

First, in high income democracies, we live in increasingly **digital, mobile, and platform-dominated media environments**. Digital media use accounts for more than half of time spent with media, mobile accounts for more than half of time spent with digital media, and the most popular products offered by a few large US-based platform companies, most importantly Google (through e.g., Google Search and YouTube) and Facebook (through the eponymous social network, Instagram, and WhatsApp) account for a large share of time spent with digital media (Hindman 2018; Nielsen and Fletcher 2020).

Second, there is an abundant supply of news online, but on average, **people spend a limited amount of time with it and many internet users do not regularly actively seek out online news**. Estimates based on web tracking – where representative panels of internet users voluntarily agree to have their internet use passively recorded – show that the share of time spent online with UK news media ranges from about three percent to about six percent (see e.g., Fletcher et al. 2020c; Hindman 2018). In addition, evidence from survey data – where representative samples are asked to describe their media use – shows that just half of UK internet users in 2021 reported they had gone directly to a news website or app (e.g., BBC News, Guardian, Mail Online, HuffPost) in the past week, with the rest relying on offline sources and/or news accessed via platforms such as search or social media (Newman et al. 2021).

Third, given the ease of accessing news online and the abundant supply, differences in individuals' active choices and regular habits play a defining role in the **overall distribution of news use, tending towards greater inequalities**, with a large minority of news lovers, about 22% of UK internet users, engaging with many different news sources on a regular basis across many different offline and online platforms, a majority of daily briefers (55%) who use a few different sources of news and a large minority of more casual users (23%) who often do not access news daily. Differences in news use are partially aligned with differences in age, gender, education, and income, both in general (Kalogeropoulos and Nielsen 2018) and around, for example, coronavirus information (Fletcher et al. 2020b).

These descriptive features are documented through a combination of surveys relying on nationally representative samples (e.g., Newman et al. 2021) and passive tracking of large parts of the online behaviour of large samples of internet users (e.g., Fletcher et al. 2021a). Though many studies are based on quantitative data from nationally representative samples, it is important to recognise that (a) there is no

single-source ground truth that captures all media use (online tracking data struggles to capture behaviour inside apps such as Facebook, does not capture offline use, and can have a hard time separating meaningful from superficial engagement), (b) surveys in particular are dependent on respondents accurately remembering and describing their media use (something many people struggle to do), and (c) news and information involve an irreducibly subjective component, as there is no objective standard for what does or does not constitute, for example, news as opposed to opinion or impartiality as opposed to partisan news, and sometimes no broad-based inter-subjective consensus either, complicating measurements. (Fox News is the single most widely used source of news in the United States, and relatively highly trusted by many on the political right – at the same time, research reported in, for example, the *New York Times* and *Wired* have treated it as if everything it publishes is misinformation or "fake news".)[1]

[1] See e.g. https://www.nytimes.com/2020/10/12/technology/on-facebook-misinformation-is-more-popular-now-than-in-2016.html and https://www.wired.com/story/right-wing-fake-news-more-engagement-facebook/.

3. Echo chambers, filter bubbles, and polarisation

Social scientists use the term **echo chamber** to describe a particular situation some people are in as a result of media supply, distribution, and/or their own demand – namely one where they occupy what Jamieson and Capella in their influential book *Echo Chamber* defined as "a bounded, enclosed media space that has the potential to both magnify the messages delivered within it and insulate them from rebuttal" (2008, p. 76). The magnification part is typically taken to be a preponderance of attitude-consistent information (e.g., people on the left seeking out information that reinforces their pre-existing views) and the insulation part about the absence of cross-cutting exposure (e.g., people on the right not coming across centrist or left-wing perspectives that challenge their pre-existing views).

Because echo chambers are about the media space a given individual or a group occupies, echo chambers necessarily cannot be identified by analysing behaviour on or data from a single platform. In the UK, one might read exclusively partisan newspapers, which might magnify some messages, while also watching the BBC or ITV, which would mean these messages would be unlikely to be insulated from rebuttal. Or one might primarily engage with a very partisan community on Twitter, which might magnify some messages, while also coming across news from Sky News and the local newspaper on Facebook, meaning that these messages were unlikely to be insulated. To establish whether people are truly inside echo chambers – enclosed media spaces – we have to consider all the different media and sources of news they rely on, offline and online, and across different online means of discovery (direct access, social, search, etc.).

In principle, echo chambers could concern any topic and could magnify any messages one can think of – ambiguous, benign, or malign; widely accepted or controversial; evidence-based or demonstrably false, and anything in between. In practice, social scientists have primarily researched one specific type of echo chamber, namely politically partisan news echo chambers where some people exclusively get news and information from sources that are very clearly on one side of the political spectrum.

In public and policy debate the term echo chamber is sometimes used interchangeably with the term **filter bubble**, but it is important to distinguish between the two.

The term filter bubble was coined by the activist and entrepreneur Eli Pariser in his book of the same name, to capture his concern that the increasing use of personalisation in the ranking of search engine results and social media feeds would create "a unique universe of information for each of us" (2011, p. 10) eroding the possibility of a relatively shared common ground – as we might be shown more and

more of things we like, while things we are not prone to like are hidden from us – on the basis of data-driven display decisions dictated by platform companies' commercial interests rather than our own active choices.

The difference between the two terms is important.[2] An echo chamber is a form of bubble, but the term does not prejudge why some people might live in such bubbles – it is possible, for example, that some actively chose to, that the situation is a result of demand more than distribution or supply. A filter bubble, on the other hand, is an echo chamber primarily produced by ranking algorithms engaged in passive personalisation without any active choice on our part, a possible outcome of specific aspects of how news and information is distributed online.

Thus, there are distinct questions of *outcomes* (how many people live in echo chambers versus more diverse media spaces?) and *contributing causes* (what is the relative importance of active users' choices versus algorithmic filtering in determining the diversity of sources people access?). Supply, distribution, and demand can all contribute to the formation of echo chambers.

Commentators and analysts typically worry about echo chambers and filter bubbles because they fear they will fuel **polarisation**, diminish mutual understanding, and ultimately lead to a situation where people are so far apart that they have no common ground – effectively inhabiting different realities. Polarisation can take substantially different forms. The most important forms for the purposes of this review are the following. First, ideological polarisation, which refers to the degree to which people disagree about political issues. Second, affective polarisation, which refers to people's feelings about the 'other side' – those they disagree with on a given issue. Third, news audience polarisation, which refers to the degree to which audiences for news outlets in a given country are generally more politically partisan or politically mixed.

Beyond this, the classical focus of much political science research is elite polarisation (which in turn can have very significant consequences for other forms of polarisation, an issue we return to below), and it is important to remember that while news and media use may contribute to relative increases or decreases in polarisation, many other factors are often seen by social scientists as more important – including the role of political parties in providing partisans with various cues to navigate public issues, as well as degrees of social homophily shaped by changing patterns in how and where we live, including how diverse our primary

[2] Beyond the definitions we rely on here, the terms "echo chamber" and "filter bubble" are used in a variety of other often broad and ambiguous ways, both by academics and in public debate, and there is limited consensus on singular clear definitions.

social groups are (Guess et al. 2018; Tucker et al. 2018; McPherson et al. 2001; Mason 2015).

4. Evidence of the existence and prevalence of echo chambers

Social scientists have primarily relied on surveys, passive tracking data, and social media data to analyse the existence and prevalence of echo chambers. Of these sources of data, only surveys and tracking data can give a broader sense of what media space people occupy, as findings based on data from a single social media platform – virtually never used in isolation – cannot establish whether people inhabit a bounded, enclosed media space that magnifies messages while insulating them from rebuttal. Twitter data, for example, is often used for analysis because it is easier to access but is necessarily limited to Twitter specifically and says nothing about individuals' wider media use, let alone anything about the large majority of the population that does not use Twitter.[3] In the UK, just 31% say that they use Twitter, with only around half of these saying they use it for news (Newman et al. 2021).

Across a range of different countries, including the highly polarised United States, several cross-platform studies – both those reliant on survey data and those reliant on passive tracking data – have found that few people occupy politically partisan online news echo chambers.

One recent study (Fletcher et al. 2021b), that includes the UK, used survey data from 2020 to assess the number of people in politically partisan online news echo chambers in Austria, Denmark, Germany, Norway, Spain, the UK, and the US by looking at how many people only use news sources with left- or right-leaning slants (measured in terms of the overall ideological slant of each outlet's audience).

In the UK, the proportion of people estimated to be in a left-leaning echo chamber is around 2% and the proportion in a right-leaning echo chamber is around 5% (Fletcher et al. 2021b). This is slightly lower than in most of the other countries covered in the study. In most other cases, a minority of around 5% of people only use news sources with ideological slants in one direction. The US is the main outlier among the seven and the only one where more than 10% of the respondents are estimated to rely only on partisan news sources. In every country covered by this study, many more internet users consume no online news at all on a regular basis than inhabit politically partisan echo chambers.

The UK results from this study are broadly similar to a previous analysis, also based on survey data, that, using a more indirect measure of diversity of news use, found

[3] And indeed, evidence from the US has shown that some who experience little or no cross-cutting exposure on Twitter still encounter opposing views via television news – suggesting that analysis of echo chambers based on Twitter data alone will overestimate their size (Eady et al. 2019).

that around 10% in the UK said they almost never see political content on social media that they disagree with (Dubois and Blank 2018).

These findings are consistent with several other studies of other European countries. In Sweden, for instance, Dahlgren et al. (2019, p. 170) found that while some people did engage in selective exposure to partisan news sources, rates were low overall, "suggesting a pattern of cross-cutting exposure more than isolated echo chambers." The authors note that "citizens who are frequent users of online news from one side of the ideological spectrum also tend to be more frequent users of news from the other side" (p. 170). Similarly, in Spain, Masip et al. (2020) did not find strong evidence for widespread news echo chambers and observed that most people accessed "non-like-minded media" at least sometimes. In the Netherlands, Bos et al. (2016) found some evidence of partisan selective exposure to news but noted that the formation of echo chambers was largely undercut by people's common use of relatively impartial public service broadcasting. This is also an important factor in the UK, where the BBC News website is by far the most widely used online news source (Fletcher et al. 2021b).

Even in the United States, researchers have long found that echo chambers are smaller and less prevalent than commonly assumed. Gentzkow and Shapiro (2011, p. 1831) observe that "internet news consumers with homogeneous news diets are rare," and Garrett (2013, p. 248) similarly argues that the notion that large numbers of people are cocooned in pure ideological news echo chambers, cut off from other points of view, is exaggerated and wrong.

Studies based on passive tracking that automatically log people's behaviour on one or more platforms have similar findings to analyses of survey data from nationally representative samples, though there are fewer such studies from outside the United States.

In the UK, Fletcher et al. (2020c) find a relative dearth of partisan online news echo chambers in the UK, using web tracking data collected during the 2019 General Election and show that the proportion of people in like-minded echo chambers in the UK during the election was 2% among Labour voters and 4% among Conservative voters – very similar to the results of survey-based work in the UK cited above.

Similarly, in Israel, Dvir-Gvirsman et al. (2016), using web tracking data collected around the time of the 2013 election, estimate that 3% of people were in an entirely one-sided partisan media echo chamber and that, in most cases, people in Israel had either relatively diverse media diets or did not consume online news at all.

In addition to people's common use of relatively impartial public service broadcasting undercutting the existence of partisan echo chambers, we should keep in mind that – at least online – their potential size is limited by the fact that many people do not consume much online news in the first place. In the UK, around 25% of internet users say they access no online news at all each week (Newman et al. 2021).

Related research – often not specifically aiming to measure the size of echo chambers – often arrives at broadly similar conclusions by analysing patterns of media use. Again, even in the polarised United States, the results are largely similar. Using network analysis and combining TV and internet tracking data, Webster and Ksiazek (2012) find high degrees of audience overlap across news sources and concentration of audiences on large mainstream outlets. Guess (2016, pp. 17-18) observes, based on analysis of tracking data, that there is a "remarkable degree of balance in respondents' overall media diets regardless of partisan affiliation. Whether Democrat, Republican, or independent, the large bulk of these individuals' media diets cluster around the center of the ideological spectrum." Similarly, Nelson and Webster (2017) find that audiences are concentrated on a few popular political news sites and that, in general, political news sites, irrespective of popularity, have ideologically diverse audiences.

Yang et al. (2020), working with desktop and mobile data from Comscore's panels, also observe that ideologically diverse US audiences converge on mainstream news outlets online, find little evidence of ideological selective exposure and, contrary to what some have suggested, find increasing co-exposure to news sources over time. Reinforcing the results from survey data, the authors also note that many more internet users consume no online news at all than rely solely on partisan sources.

Single-platform studies are, as noted, of limited value in identifying echo chambers, but there are several important studies that identify like-minded communities formed on individual social media platforms – whether through algorithmic selection, self-selection, or some combination thereof (Bakshy et al. 2015; Barberá et al. 2015; Kaiser and Rauchfleisch 2020; Vaccari et al. 2016). Even these, however, often conclude, like Barberá (2015, p. 28), that "most social media users receive information from a diversity of viewpoints." And in the absence of evidence on what other media the individuals involved use in addition to the social media platform in question, these studies simply cannot establish whether people inhabit a bounded, enclosed media space where specific messages are magnified and insulated from rebuttal.

In summary, studies in the UK and several other countries, including the highly polarised US, have found very similar results whether relying on survey data or

passive tracking data. Most people have diverse media diets, those who rely on only one source typically converge on large sources with politically diverse audiences such as commercial or public service broadcasters, and only small minorities, often only a few percent, exclusively get news from partisan sources.

5. Who might end up in echo chambers and why?

Though a large number of empirical studies from different countries and relying on various kinds of data find that echo chambers are smaller and less prevalent than often assumed, it is still important to consider who might end up in echo chambers and why.

To understand what news and information people see, media researchers typically seek to consider the interplay between media **supply**, media **distribution**, and media **demand** (Webster 2014).

While the term "echo chamber" has sometimes been used to describe the news institution as a whole as "the media echo chamber" (Bennett et al. 2007), in a liberal democracy with a diverse media system and a multitude of independent voices expressed online, it is hard to see how, on most issues of importance, **supply** alone could lead to the formation of echo chambers. Information supply has grown enormously in recent years thanks to the growth of the internet. The data and analytics company Comscore tracks more than one thousand news and information providers online in the UK alone, and that is without counting the variety of information people can access from activists, authorities, educational institutions, political parties, scientists, and many, many other sources available online.

This leaves distribution and demand as the main possible causes for the formation of echo chambers.

In terms of **distribution**, algorithmic selection by digital platforms such as search engines and social media that make personalised display decisions for countless users using automated systems might, some fear, generate filter bubbles by reducing the diversity of information people come across, serving them more attitude-consistent news and resulting in less cross-cutting exposure.

But empirical studies, whether based on survey data or passive tracking data, have generally found the opposite. They demonstrate that reliance on secondary gatekeepers such as search engines and social media – whatever other problems might be associated with them – is in most cases associated with more diverse news use.

This is a consistent finding across a growing number of survey-based studies (DuBois and Blank 2018; Fletcher and Nielsen 2018a; Fletcher and Nielsen 2018b; Beam et al. 2018) and studies based on various forms of passive tracking data (Flaxman et al. 2016; Cardenal et al. 2019; Fletcher et al. 2021a; Sharkow et al. 2020; Wojcieszak et al. 2021). These findings also hold across different countries (including the United Kingdom and the United States), across different digital platforms (search engines, different social media platforms, and news aggregators),

and across different methods and modes of analysis. These avenues particularly increase exposure for people who are less likely to otherwise visit news sites directly (Fletcher and Nielsen 2018a; Wojcieszak et al. 2021). We are not aware of any comparable studies that have found support for the filter bubble hypothesis that algorithmic ranking leads to echo chambers (see Bruns 2019 for a more detailed overview).

To understand why algorithmic selection is consistently found to lead to more diverse news diets, not narrower diets (let alone echo chambers), it is important to remember that the median number of different sources of news that people in the UK use on a weekly basis offline is two, and just one online (Newman et al. 2021). Search engines and social media do not vastly expand this number and it is not the case that people who use these platforms have very diverse and balanced news diets. Rather, they lead people to slightly more, and slightly more diverse, sources of news than what they seek out of their own volition.

The two main drivers of this are automated serendipity, where ranking algorithms may return a result in, for example, a search query from a source that people might not normally access directly (Fletcher and Nielsen 2018b), and incidental exposure, where people come across and read news articles while on, for example, a social media site they primarily use for other purposes (Fletcher and Nielsen 2018a). (Both effects are broadly aligned with the commercial self-interest of platform companies – automated serendipity creates an experience of variety, and incidental exposure can increase time spent on social media as people come across the occasional interesting article.)

These effects are not equally strong for everyone. Passive personalisation based on past behaviour may well make algorithms more likely to recommend more news to those who already engage with a lot of news (Thorson 2020), but they are particularly important – and arguably more beneficial – for those least likely to actively seek out a lot of news on their own, such as younger people and those with lower interest in news (Fletcher and Nielsen 2018a; Wojcieszak et al. 2021).

The role of interest leads us to **demand**, the final factor we will consider in this section. The main possible causal mechanism here is self-selection: that some people actively opt into echo chambers because they prefer news that aligns with and reinforces their pre-existing views (selective exposure to attitude-consistent information) or actively seek to avoid counter-attitudinal information (selective avoidance of cross-cutting exposure).

Research on self-selection is predominantly a mix of survey and passive tracking studies akin to those discussed above, which often have high external validity but can have limited internal validity, and experimental studies that have higher

internal validity but often limited external validity because of the difficulties of creating a situation akin to what media users face outside the experiment.

Broadly, a number of studies find that while many people do engage in some degree of selective exposure, they do not necessarily engage in selective avoidance (Bos et al. 2016; Garrett 2009; 2013; Garrett and Stroud 2014; Jang 2014; Johnson et al. 2011; Kim and Lu 2020; Trilling and Schoenbach 2015). As Weeks et al. (2016, p. 263) write of the US context, "although partisans exhibit some preference for like-minded sources, we find no evidence that they avoid disagreeable information but rather continue to rely mostly on a common set of mainstream, general interest news outlets. These more mainstream sources provide information that at times challenges both Republicans' and Democrats' positions, yet neither make an attempt to avoid them."

This means, for example, that while those with highly partisan political views are significantly *more* likely to use partisan news media with a similar orientation, they are not necessarily *less* likely to use other news media with a different orientation.

Evidence from selective exposure experiments – which show different people's *tendencies* to select content they agree or disagree with – has indicated that the people most likely to choose pro-attitudinal content are those who have stronger partisan/ideological beliefs, are more certain about their beliefs, or who are more politically interested/engaged (Iyengar and Hahn 2009; Knobloch-Westerwick and Meng 2009; Kim and Lu 2020). Similarly, studies focused on specific social media also find that people most likely to be deep into like-minded communities are strong partisans (Barberá 2015; Boutyline and Willer 2017).

But, importantly, many people do not have particularly strongly held political views and do not primarily approach news and media through a political lens (Bos et al. 2016; Yang et al. 2020). Often, basic interest, in turn partly aligned with levels of education and income, is a more important factor.

In Europe, public service media often help bridge these gaps, with differences between those with low interest and high interest being smaller in countries like the UK that have widely used public service media (Castro-Herrero et al. 2018). But many people self-select away from politics and news, choosing entertainment content instead (Prior 2005), and people with more limited levels of formal education and lower levels of income generally use less news than more privileged parts of the population (Kalogeropoulos and Nielsen 2018).

This is a reminder that, while of great interest to politicians and political scientists, politics is not the only, or even main determinant of news and media use. Media use is often more shaped by habits that in turn reflect a mix of instrumental uses and

preferences anchored in social contexts that often exhibit more significant homophily in terms of social class than in terms of politics (Bos et al. 2016; Dahlgren 2019; Dubois and Blank 2018; Garrett et al. 2013; Johnson et al. 2011; Skovsgaard et al. 2016; Van Aelst et al. 2017; Yang et al. 2020).

In summary, studies in the UK and several other countries, have found that algorithmic selection generally leads to slightly more diverse news use – the opposite of what the filter bubble hypothesis posits – but that self-selection, primarily among a small minority of highly partisan individuals, can lead people to opt in to echo chambers, even as the vast majority do not, and document that limited news use remains far more prevalent than echo chambers are.

6. Media use and polarisation

Polarisation, in social science, refers to divisions between groups. It can be used to describe a situation where divisions are already sufficiently large to be considered polarised, or a process whereby divisions are becoming larger over time (even though they may still be quite small). Polarisation can take many forms and is not always intrinsically problematic (some things are worth disagreeing over, see Kreiss 2019).

Just as many assume that echo chambers are pervasive and filter bubbles are real – despite evidence to the contrary – there is widespread public and political concern over polarisation in many countries. Some surveys which aim to measure perceived polarisation suggest much of the public *feel* that the UK is more divided today than in the past.[4]

Social scientists examine a range of different kinds of polarisation of the public, including **ideological polarisation**, **affective polarisation**, and **news audience polarisation**. As with any attempt to measure a change over time, decisions about what time frame to consider will influence conclusions, and often, there is little consistent data allowing for rigorous longitudinal analysis.

Ideological polarisation, sometimes termed issue polarisation, has been a long-standing focus of political science and focuses on divisions in public opinion on a range of different policy issues. Looking back several decades, comparative research based on the World Values Survey has found some support for the idea that Left/Right polarisation has *decreased* in many high-income democracies and electoral volatility increased, even as other divisions, sometimes over so-called "post-material" issues, have become more important (Dalton 2006; Ingelhart 2017). However, divisive elections in the last two decades have led to a resurgence of interest in whether political partisans' views have become more polarised again (Abramowitz 2010; Fiorina and Abrams 2008; Iyengar et al. 2012), with one summary in the United States concluding that while public opinion overall on many issues has not become markedly more polarised in recent years *on average*, it *has* increased among the most politically engaged (Prior 2013; see also Mason 2013). In the UK, in the longer term, the polarisation of party supporters has declined since the 1970s, as have both perceived polarisation and expert evaluations of polarisation (Rehm and Reilly 2010). Other analyses have also found declines in polarisation in the UK (Adams et al. 2012a; Adams et al. 2012b), but many of these studies are from before Brexit and other recent divisive political discussions.

[4] See e.g. https://www.britainschoice.uk/media/x2mhxg1z/britain-s-choice-chapter-5.pdf

Affective polarisation refers to how much opposing partisans dislike one another. Most research on affective polarisation has been conducted in the United States and, in contrast to ideological polarisation, affective polarisation clearly seems to be on the rise – as one team of researchers find that ordinary Americans increasingly dislike and distrust those from the other party (Iyengar et al. 2019; see also Mason 2013). In the UK, there is evidence that affective polarisation exists between Labour and Conservative voters and also around opinion-based groups that either support or oppose Brexit (Hobolt et al. 2021). Comparative work on affective polarisation is in its infancy, but a few studies have been published recently. They find that levels of affective polarisation vary greatly by country (complicating the notion that polarisation is pronounced everywhere) and document considerable variation in patterns over time (belying the notion that a single universal cause – for example the spread of the internet – is driving polarisation everywhere) (Gidron et al. 2019; Boxell et al. 2020; Reiljan 2020). In several of these studies, Britain is found to have higher levels of affective polarisation than multiparty political systems in other parts of Northern and Western Europe, though one of these studies actually suggests affective polarisation in the UK may have declined since the 1980s (Boxell et al. 2020).

News audience polarisation, finally, refers to the structure of aggregate public attention to news media, to whether a country is home to large news outlets with both strongly left- and strongly right-leaning audiences, as opposed to outlets with mostly mixed or centrist audiences (Fletcher et al. 2020a). Again, the situation in the United States – where highly partisan news brands including, most importantly, Fox News play an important role – has led some to suggest that news media use is increasingly fragmented and polarised. Despite the very real importance of some highly partisan brands (Benkler et al. 2018), even in the United States, Nelson and Webster's (2017) analysis of Comscore tracking data found that, despite huge choice, most people tend to congregate around a few popular news outlets and that all news sites – including partisan ones – attract reasonably ideologically diverse audiences. Comparative work based on survey data from a sample of 12 high-income democracies suggests that cross-platform (online and offline) news audience polarisation is highest in the United States but lower within Europe. The UK has relatively high levels of news audience polarisation by European standards – largely thanks to widely used partisan newspapers – but overall levels are still low (Fletcher et al. 2020a).

There is an extensive literature in political science and sociology about the drivers of polarisation, with considerable attention to elite cues from politicians (Rogowski and Sutherland 2016; Iyengar et al. 2012) and to social dynamics including social homophily and various kinds of social sorting – all predominantly rooted in our

offline lives, where we work, who we spend time with, where we live (see e.g., Guess et al. 2018; McPherson et al. 2001; Mason 2015).

There is also some work on media, including media reporting about polarisation. US studies find that exposure to like-minded partisan media under experimental conditions can strengthen the views of already partisan individuals (Levendusky 2013). Panel survey work, which measures the same people's media use and attitudes at different points in time, has also found that using like-minded partisan media in the US can increase anger toward the 'other side' and make people more willing to share political information on social media (Hasell and Weeks 2016). At the same time, cross-cutting exposure, at least on social media, also seems to be able to increase polarisation, at least among political partisans (Bail et al. 2018). Furthermore, experimental work finds that exposing people to media coverage about political polarisation may in itself increase perceptions of polarisation and contribute to increased dislike for the opposition (Levendusky and Malhotra 2016).

Work in the United States stresses that these factors are sometimes asymmetrical, in terms of the degree to which individual political leaders actively seek to polarise the public, and in terms of the role of individual news media – there is a growing literature documenting the impact of Fox News specifically (DellaVigna and Kaplan 2007; Hopkins and Ladd 2013). Furthermore, broader changes in both news supply and media use, suggesting a relative decline in coverage of and attention to local politics and more focus on often more divisive national politics, also seems to be a possible contributor to polarisation in the United States (Martin and McCrain 2019).

There is much less work from outside the United States and no clear overall set of convergent findings. Experimental work from the Netherlands, for example, has found that while people might have a tendency to engage in selective exposure, this does not necessarily polarise people's attitudes (Trilling et al. 2017). Yet Wojcieszak et al. (2018), analysing panel survey data in the Netherlands, found that people with strong opinions about the EU polarised in their views after being exposed to news about the EU.

In summary, the picture on polarisation is complex and research is often limited outside the United States. Overall, ideological polarisation has, in the long run, declined in many countries, but affective polarisation has in some cases, but not all, increased. News audience polarisation is much lower in most European countries, including the United Kingdom. Much depends on the specifics of individual countries and what point in time one measures change from, and there are no universal patterns, suggesting country-specific factors drive national developments, including most importantly the behaviour of political elites and social dynamics. When it comes to media, there is limited research outside the US and this work does

not always find the same patterns as those identified in the US but, at least in the specific context of the United States, it seems that exposure to like-minded political content can potentially polarise people or strengthen the attitudes of people with existing partisan attitudes, and that cross-cutting exposure can potentially do the same for political partisans.

7. Digital media and public discussions around science

Virtually all the studies reviewed above on echo chambers, filter bubbles, and polarisation are concerned with the interplay between politics, news, and media use.

This work provides a set of basic findings about the dynamics of contemporary news media use, the relative importance of algorithmic ranking versus self-selection in shaping it, and how engagement with some forms of information can further strengthen already strongly held beliefs.

Many of these dynamics may also be relevant for understanding the role that digital media play in public discussions around science topics. But research in this area is largely separate from the political communication and media research traditions discussed above that have usually focused on politics specifically, or news and media use as a whole, rather than specific topics. And while terms like echo chambers, filter bubbles, and the like are beginning to feature in discussions among scientists and science communication scholars, these discussions, when research-based, are generally based on the research reviewed above (see e.g., Scheufele et al. 2017; Scheufele and Krause 2019; West and Bergstrom 2021). Empirical research specifically on the possibility of echo chambers and the like in online scientific discussions is still very limited.

There are different strengths and weaknesses of either looking at media use as a whole or focusing on discussions around different topics – and this can sometimes lead to different results and interpretations. Scholarship on selective exposure and polarisation around various science issues illustrates how the concepts, theories, and methods the research reviewed so far relies on can also shed light on science discussions but also underlines that dynamics are not always the same with these topics as with, say, party politics.

In the US, some studies have examined selective exposure around various science issues like genetically modified foods, nanotechnologies, stem cell research, and fracking (Jang 2013; Knobloch-Westerwick et al. 2015; Yeo et al. 2015). These studies have found evidence of selective exposure for some topics but, in general, the preference for like-minded information is less clear than it is for partisan political topics, it varies by subject, and sometimes shows opposite patterns in which people seek out opposing views (see Stroud 2017 for a review). Indeed, in the US, "not all science topics cohere with partisan perspectives" (Stroud 2017, p. 379) and it is likely that the strength and direction of these associations varies not only by topic but also from one country to the next.

That said, there are growing concerns about selective exposure in scientific domains that have become politically aligned, emotionally loaded, and more explicitly and actively politically polarised in some countries (e.g., Nisbet et al. 2015).

Elite cues seem critically important here. In making sense of how climate change became a more ideologically polarised issue in the United States over time, even as the scientific consensus grew stronger, Merkley and Stecula (2018) analysed news items over more than three decades and found that while Democratic politicians consistently acknowledged climate change in the media over time, Republican messages were ambiguous – and polarisation increased as more Republican-elected officials began actively and publicly denying climate change. They suggest that Republican voters' rejection of climate science may have been in part a direct response in opposition to cues from Democratic elites these voters regard with scepticism, a proposition they provide further evidence for in a separate study based on more than 200 surveys between 1984 and 2014 (Merkeley and Stecula 2020). Similarly, Brulle et al. (2012, p. 185) argue "the most important factor in influencing public opinion on climate change [is] the elite partisan battle over the issue," and they show how US public opinion on the threat of climate change has been moved more by elite cues – in particular, Republican politicians' opposition to climate change bills – than by media coverage, which by and large mirrored those cues while also presenting the Democrats' position.

Analogous arguments have been made in light of the COVID-19 pandemic, where research in the US has shown polarisation in elite communication about the issue, with Democrats emphasising threats to public health and American workers, and Republicans placing greater emphasis on China and businesses early on in the pandemic (Green et al. 2020; see also Hart et al. 2020). Hamilton and Safford (2021) used survey data to show that trust in science agencies like the CDC declined rapidly among Republicans in the US but not Democrats, following Donald Trump's changing views toward the CDC, views that were in turn amplified by conservative media including Fox News. This further underlines how top-down cues from political elites, including most prominently the President, were crucial to the deep partisan divide that formed around the subject.

The relative absence of similar levels of polarisation in discussions around and public opinion on issues such as climate change and the coronavirus in many countries where political elites have behaved differently is a reminder of how important country-specific factors are, even as wider changes in the media system may be broadly similar. Content-analysis based research has in the past shown how, for example, news coverage of climate change is broadly based on the scientific consensus in countries where most elected officials recognise it but features climate change deniers and their views more prominently in countries where some

politicians or even whole political parties have embraced these views (Painter and Ashe 2012). Work from Canada (Merkley et al. 2020) demonstrates the importance of cross-party consensus elite cues in shaping the public's perception of and response to COVID-19, just as work from Brazil (Gramacho et al. 2021) shows how very differently things developed in Brazil as Jair Bolsonaro's most avid supporters took their cues from the President.

A growing body of research has also sought to better understand the dynamics of public discussions around science online. Much of this work is not concerned with echo chambers, filter bubbles, and polarisation as defined here, but it can help us understand some of the ways in which digital media are used to discuss science.

In general, much of this research has documented a tendency for social media groups that actively discuss scientific issues to be made up of somewhat homogenous, segregated, and often polarised communities of interest with limited intersections between groups holding opposing views, and the vast majority of users on any given platform not taking any active role in any of these discussions of science. This is similar to broader dynamics online where communities of interest tend to coalesce, often around perfectly benign shared interests but sometimes around more ambiguous activities and, of course, in some instances, around shared interest in views that are demonstrably false and activities that are potentially harmful (Philips and Milner 2017).

Some of this research has compared differences between groups that form around science versus conspiracy news (Del Vicario et al. 2016a; Del Vicario et al. 2016b), whereas other research has focused on specific topics like vaccines (Cinelli et al. 2021; Cossard et al. 2020; Dunn et al. 2015; Schmidt et al. 2018), abortion (Cinelli et al. 2021), climate change (Williams et al. 2015), and most recently COVID-19 (Wang and Qian 2021).

In line with studies of political discussions online, people identified as active in these online discussions are often relatively small minorities who have strong attitudes on the subject (Williams et al. 2015), potentially skewing the online debate toward the more extreme attitudes of these active, vocal, opinionated minorities. In their analysis of the Italian vaccination debate on Twitter, Cossard et al. (2020) found differences in the structures of the polarised groups. Vaccine sceptics tended to form smaller but louder groups that were more tightly connected, whereas vaccine advocates tended to organise in a more hierarchical fashion around certain authoritative actors. Elsewhere, scientists have studied alternative media ecosystems involving websites and various other actors who repeatedly share the same disinformation, often across a wide variety of issues and topics, advancing political conspiracies alongside content such as climate science denial, anti-vaccine

pseudoscience, and flat earth theory and trying to promote these on social media platforms such as Twitter to reach beyond those already actively involved in the communities in question (Starbird 2017; Starbird et al. 2019).

These studies are important and valuable for understanding online social dynamics and well-suited to provide evidence for self-selection, homophily, and polarisation dynamics between groups that focus on controversial topics (and how they may vary from one platform to another), but they are less helpful in examining the phenomenon of echo chambers as understood here – despite the occasional use of the term "echo chambers" in a broader sense of people being actively engaged in an online community of like-minded people. Because many of these are single-platform studies based on data from one social network, and often deliberately study already highly engaged and therefore unusual communities (rather than nationally representative samples or exhaustive studies of all users), we should be cautious about (a) generalising to the population at large, (b) generalising to discussion of other less divisive topics, and (c) whether they accurately describe the vast majority of social media users who are not engaged in these discussions, or have only the most peripheral contact with them.

In summary, public discussions around science online may exhibit some of the same dynamics as those observed around politics – with an important role for self-selection, elite cues, and small highly active communities with strong views in explaining the dynamics of these debates – but fundamentally, while important studies have been published, mostly from the US, there is at this stage limited empirical research on the possible existence, size, and drivers of echo chambers in public discussions around science. More broadly, years of research document the role political elites play in shaping both news coverage and public opinion around science issues as well.

8. Conclusion

In this review, we have examined evidence concerning the existence, causes, and effects of online echo chambers and have considered what related research can tell us about scientific discussions online and how they might shape public understanding of science and the role of science in society.

There are a number of areas where our review suggests that there is a **clear majority view** in academic research, including most notably:

- Politically partisan online news echo chambers are generally small – much smaller than is often assumed in public and policy debate.
- Automated serendipity and incidental exposure mean that relying on search engines, social media, and other digital platforms using algorithmic ranking leads people to slightly more diverse news – the opposite of what the filter bubble hypothesis posits.
- Self-selection, both along partisan lines and, importantly, in terms of levels of interest, plays a significant role in shaping news and media use.
- There is no single uniform trend towards greater polarisation – ideological polarisation has declined in some countries, affective polarisation has increased, news audience polarisation varies greatly, and in every case, country-specific factors seem decisive, not a single global trend like the rise of the internet.
- Elite cues continue to play an important role in shaping both news coverage and public opinion, with the behaviour of political parties and individual prominent politicians often contributing to polarisation, whether around ideological issues or science issues such as climate change.

Given the amount of research on these issues arriving at broadly similar conclusions, the burden of proof now, in our view, is on those arguing for alternative interpretations to provide systematic evidence.

Furthermore, there are several areas where there are **some empirical studies** but not necessarily convergent interpretations, or only convergent interpretations supported by data from a single or a few countries. These areas include, most notably:

- News audience polarisation is higher online than offline in some but not all countries.
- Engagement with partisan news and media can increase polarisation.
- Cross-cutting exposure may also increase polarisation among partisans.

- Relatively small minorities of unusually active and opinionated individuals often animate online debates, even as the vast majority of internet users pay little or no attention to these partisan discussions.

There is evidence for all these, but it is either mixed or exclusively from one country, so we cannot necessarily assume these findings apply everywhere.

Finally, there are many areas where there is at this point **little empirical research** to help us understand a situation that is rapidly evolving. These include, among other things:

- Whether echo chambers and the like work broadly in the same ways around science issues as around more conventionally political issues.
- How self-selection driven by forms of opinion other than political ones operate and how self-selection based on partisanship and/or interest shapes engagement with news and information around science.
- The extent to which dynamics identified in studies of online news sites/apps and established digital platforms including search engines and social media are similar on less studied but potentially important platforms including messaging applications, video sites, and new social media platforms.

In closing, let us make three final points.

First, a large number of empirical studies documenting that echo chambers are smaller than commonly assumed, and a growing amount of research rejecting the filter bubble hypothesis should not be confused with a Panglossian belief that we live in the best of all possible worlds or that our increasingly digital, mobile, and platform-dominated media environment does not come with any serious societal challenges. There are many, including the frequently overlooked fact of pronounced inequality in news and information use documented by many of the studies reviewed here, as well as a multitude of others, such as widespread online harassment and abuse, various kinds of misinformation, often invasive data collection by dominant platforms, a serious disruption of the established business of news and market concentration, and many more issues beyond the scope of this review.

Second, the risks associated with people primarily seeking out attitude-consistent information, let alone living in bounded media spaces where their pre-existing views are rarely challenged, can be much smaller than many believe while still being present, and it is clearly possible for people to come to hold very polarised views – sometimes views that are contradicted by the best available scientific research – without living in echo chambers or filter bubbles. Sometimes minorities, however small, play an important role in driving public and policy debate and decision

making. (As Guess (2021, p. 12) puts it, in the US context, “even if most Americans do not exist in online echo chambers, they are subject to the political influence of those who do.”) And sometimes confirmation bias, motivated reasoning, and social reinforcement from the communities we spent most of our offline lives with will mean we have very strong views, even as we also see a wide range of different kinds of information via news and media.

Third, research in this area is extensive in some respects, almost non-existent in others. Among other things, there is often a dearth of research outside the United States, much less research on scientific issues specifically than on politics and media use more generally, and little work on several important established platforms and many newer and smaller platforms – and all this work could be greatly facilitated if academic researchers had better access to data in a privacy compliant and secure way from platform companies.

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