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The Information Environment and its Effects on Individuals and Groups

An Interdisciplinary Literature Review



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1 Introduction

Over the past two decades, digital technologies have fundamentally altered how people are exposed to and engage with information. The internet has enabled content to be created and shared with large audiences at marginal cost, social media have blurred the lines between personal and mass communication and search engines have made vast amounts of information widely, instantly and freely accessible.

More recently, the optimism about the positive transformative potential of digital technologies has given way to an acute sense of its risks: a risk, for instance, of filter bubbles and echo chambers, polarising society along ideological lines and fragmenting the political discourse; or a risk of nefarious actors spreading misinformation online, wielding undue influence and undermining democratic processes.

However, researchers can now learn how people interact with their information environment at an unprecedented scale and level of detail by analysing massive amounts of data about who sees, reads or writes what, when and where. This allows them to evaluate the benefits and risks of digital transformations. It also enables them to reassess more fundamental cognitive mechanisms of engaging with information and to develop new hypotheses about the operation of these mechanisms in the digital age. Going forward, good research will have to understand these transformations and how they recontextualise a long history of literature in the field. This makes a review both timely and necessary.

This literature review aggregates research on today's information environment and its effects on individuals and groups, with a particular emphasis on the digital sphere but without a narrow focus on the impact of digital technologies. This is an inherently interdisciplinary task. In our view, emerging fields of research in the computational social and communication sciences do not replace but complement established streams of literature from the cognitive and behavioural sciences. Just like smaller-scale, more controlled experimental studies, the now popular big data approaches come with their own set of strengths and limitations. A comprehensive understanding of today's information environment and its effects on individuals and groups needs to incorporate both perspectives.

Review Structure

The relationship between individuals and their information environment can be examined along two key dimensions: exposure and engagement. We use this distinction to structure our review as follows: (I) Exposure characterises the encounters between individuals and information content. (II) Engagement refers to the interaction between the individual and the information they are exposed to. (III) Digital technologies have blurred the lines between these concepts and dramatically changed the information environment by enabling individuals to generate, seek out or share information content with unprecedented ease. Accordingly, our review is divided into three main sections, which follow this introduction.

Section 2 brings together relevant literature on the state of the information environment in 2020, with a particular focus on its varied composition across individuals and key

trends that will continue to shape it in the near future. *Section 3* aggregates evidence on how individuals engage with new information, the cognitive biases that come into play as well as the factors influencing perceived credibility of information content. *Section 4* serves as a synthesis of the preceding sections. It collates research on fundamental changes in the relationship between individuals and their information environment due to digital technologies, highlighting evidence on social dynamics in information sharing, the polarisation of digital information environments as well as increasingly relevant questions of online misinformation, its prevalence and its effectiveness.

1.1 Defining the Information Environment

In the wider literature, the term *information environment* is often used without prior definition and imbued with different meanings depending on the context it is used in. Since this review is concerned with the information environment and its effects on individuals and groups, a precise definition of the term as well as its components is necessary.

The term *information* by itself has eluded a unifying definition. Claude Shannon, who founded the field of information theory, acknowledged that "the word *information* has been given many different meanings by various writers in the general field of information theory. It is likely that at least a number of these will prove sufficiently useful in certain applications to deserve further study and permanent recognition. It is hardly to be expected that a single concept of information would satisfactorily account for the numerous possible applications of this general field." (Shannon, 1953, p. 105). A full discussion of the manifold concepts of information is well beyond the scope of this review (see instead Machlup, 1983; McCreddie and Rice, 1999; Madden, 2000; Nauta, 2019). One relevant conceptualisation for our review comes from the field of semiotics, which is concerned with signs and signalling across a broad range of biological, engineered, and social systems (Morris, 1938). Semioticians understand information as the unexpected, novel content of a sign (Machlup, 1983; Nauta, 2019). This implies that there are two sides to the concept of information, as it refers both to an object serving as a sign, and a cognitive process of recognizing novelty in that sign (Raber and Budd, 2003). In this review, we recognise the importance of both sides by separating our discussion of exposure to and engagement with information.

For the purpose of this review, we adopt a widely-used general definition of information proposed by Floridi (2005, 2010), which builds on the semiotic concept of information as *text + content* (Raber and Budd, 2003) by conceptualising information as *data + meaning*. More specifically, Floridi considers information content to consist of data that is well-formed, i.e. syntactically valid, and meaningful, i.e. semantically valid. *Data*, in turn, can be understood as an uninterpreted lack of uniformity in the real world, between between signals or between symbols (Floridi, 2005). A news article, for instance, constitutes information as it consists of data (letters), follows grammatical rules and conveys meaning to the reader. More straightforwardly, we can define *environment* as

the physical, social and digital surroundings of an individual, particularly the aspects of those surroundings that can influence the individual's behavior.

Following Floridi (2010), we can then define the *information environment* as "constituted by all informational processes, services, and entities, thus including informational agents as well as their properties, interactions, and mutual relations" (p. 9). Notably, the term *agent* encompasses individuals as well as organisations. Individuals can process and interact with the information they are exposed to through social transmission or media. They can also shape and contribute to their information environment by generating or sharing information content themselves. They can act alone or as a group, coordinated or uncoordinated. Organisations, on the other hand, include news outlets and other institutions, which compose and disseminate information, as well as digital platforms and social networks in particular, which facilitate the exchange of information among individuals as well as between individuals and organisations.

The information environment is dynamic, changing with technological innovation as well as social and political circumstances (Floridi, 2010). To review the effects of the information environment on individuals and groups means to review the evidence regarding how this environment influences individual and collective behaviour as well as how individuals and groups interact with it and with each other while embedded in it (Steinberg, 1999; Habermas, 2015).

Compared to the wider literature, the definition of the information environment that we adopt in this review is closest to that used in political and communication science. However, we expand its common usage as a synonym for the news media environment, particularly print and television (e.g. Jerit et al., 2006; Banducci et al., 2017) to encompass social information transmission as well as digital information platforms and social media. In contrast to broader definitions of the information environment from this field (e.g. Williams and Carpini, 2011), we also do not restrict the information we consider to politically relevant information. We explicitly do not use the term to describe information in financial markets that enables corporations to make decisions (e.g. Frankel and Li, 2004; Fernandes and Ferreira, 2008; Shroff et al., 2017) or information used within corporations to guide management and organisational structure (e.g. Ashford and Cummings, 1985; Orlikowski, 1991).

2 Exposure: The Information Environment in 2020

Before individuals engage with information content, they must encounter it, that is, be exposed to it. Figuratively speaking, this section is concerned with describing the stage for these encounters.

Subsection 2.1 provides an overview of geographic and demographic divides in the information environment today. *Subsection 2.2* then describes key trends that will continue to shape the information environment in the near future.

2.1 Composition of the Information Environment

The information environment is far from an internally cohesive, universal domain. In order to contextualise research into the relationship between individuals and their information environment and to delineate the scope of this literature review, an understanding of the vast differences in the makeup of information environments across individuals in different settings is essential.

Geographic Divides in the Information Environment

Deep economic and social divides between the Global North and South are reflected in clear differences in how people are exposed to information across the globe. Internet access, for instance, which drastically changed the information environment by offering access to online news sites and social media, is expanding globally but has not yet fully covered the Global South. For 2018, the United Nations' International Telecommunication Union (2019b) reported that internet use in the Global North was nearing saturation levels, with 80.1% and 74.6% of individuals online in Europe and the Americas. In Africa, on the other hand, only 26.3% of individuals were using the internet, while in the Arab states and the Asia & Pacific region 49.5% and 46.2% of individuals, respectively, were online.

Granular data on media consumption habits in the Global South is difficult to obtain, with some commercial providers offering limited insights at high costs. For 2016, the *Africa's Prospects Report* by Nielsen (2016), for instance, indicated that television and radio were widely adopted across African countries at a penetration rate of 84% and 77% respectively, but both internet and print media were much less common at 45% and 39% penetration rate. Countries such as Botswana, Nigeria and Kenya had the highest proportion of internet users, while Angola, South Africa and Namibia had the highest proportion of overall media users, which suggests national differences in the composition of information environments in Africa.

More generally and perhaps partially as a consequence of this data scarcity, the vast majority of academic research into media consumption habits and the wider information environment has been concerned with the Global North. Even within the Global North,

strong differences between countries emerge. Dutton et al. (2017), for instance, report results from a representative 2017 survey of the online population across seven countries: Britain, France, Germany, Italy, Poland, Spain, and the US. For political information, they find television and online sources to be the most common across countries, followed by family and friends, print news and radio. However, 21% of German respondents said they *very often* relied on television for political information while in Poland only 9% did. In France, 27% of respondents *never* used online sources for information about politics while in Italy only 9% selected this answer. These differences in media use demonstrate a diversity in information environments across countries.

Demographic Divides in the Information Environment

Beyond geographic divides, demographic characteristics are a key determinant of individual information environments. Age in particular stands out as highly relevant. The Reuters Institute's comprehensive 2019 *Digital News Report* (Newman et al., 2019), which is primarily concerned with news consumption rather than information more generally, provides digital survey results across 38 countries, mostly in the Global North. It highlights that younger generations overwhelmingly consume news on their smartphone, particularly through social media, while older generations rely more heavily on TV, radio and print. Notably, there are generational divides even among younger social media users, with Facebook being more popular among those aged 25 to 34 years, while Twitter, Instagram and Snapchat are used significantly more by 18- to 24-year-olds.

For individual countries, some national surveys provide more detailed insights into the composition of the information environment. For the UK, for instance, the 2019 *Oxford Internet Survey* (Blank et al., 2019) reports that nearly all respondents under the age of 50 used the internet, while only 47% of those aged 65 years and above did so. Mobile-only users made up 15% of the sample, while 63% used both a computer and mobile phone to access the internet. Similarly, the 2019 UK *Media Use and Attitudes Report* by Ofcom (2019) shows that 93% of 16- to 24-year-olds had a social media profile, while only 58% of 55- to 64-year-olds and 34% of 65- to 74-year olds did so. Compared to demographic differences, Ofcom (2019) finds socioeconomic divides to generally be less pronounced.

Lack of Representativeness of Social Media Users

The vast differences in individual information environments across geographic and demographic dimensions should instill caution when seeking wider implications in the kinds of empirical research which will be discussed in the later sections of this review.

Internet and social media users in particular, which are the focus of much recent research into exposure to and engagement with information, cannot simply be assumed to be representative of the overall population. Hargittai (2018) reports that American social media users in 2016 had higher socioeconomic status than the general population and thus warns that data from social media tends to oversample views of the more privileged. Mellon and Prosser (2017) find similar results and further show that UK Facebook and

Twitter users in 2015 were also more politically engaged and ideologically liberal than the general population. However, they also find that these apparent differences mostly arise due to the demographic differences between users and non-users.

Furthermore, there are stark differences in user characteristics by platform. Blank and Lutz (2017) analyse the socioeconomic attributes of British social media users in 2013 across several social media sites. Facebook, for example, was more likely to be adopted by younger and female users, while LinkedIn was favoured by individuals with higher incomes and Twitter by those who were younger and had higher incomes. Hargittai (2015) finds similar results for the US in 2013.

Even for a given platform, user characteristics can vary by country. For Twitter, one of the most prevalent data sources for contemporary computational social science research, Blank (2017) finds British users in 2013 to be younger, wealthier and more educated than other internet users, who are in turn younger, wealthier and more educated than the British offline population. American Twitter users, on the other hand, are found to be younger and wealthier but not better educated than the offline population. Barberá and Rivero (2015) analyse the sociodemographics of Twitter users engaging in political discussion in the US and Spain in 2011/12. They find users in both countries to be mostly male, living in urban areas and having strong ideological preferences. However, this finding is more pronounced in the US, where users also are on average much more active.¹

Key Takeaways

In summary, both geographic and demographic characteristics shape individual information environments. In the Global South, internet access is far from universal and traditional media sources, television and radio in particular still play a dominant role. In the Global North, on the other hand, differences in media consumption across countries remain, despite internet adoption near saturation levels. Among demographic factors, age in particular explains individual differences in the information environment, whereby older generations generally rely more on non-digital media sources. Lastly, across both platforms and countries, social media users are an unrepresentative sample of the general population, especially in terms of age, wealth and education. For this review, the sum total of these findings serves as a note of caution not to overestimate the generalisability of empirical research discussed throughout the following sections, most of which was conducted in the Global North and often concerned with specific social media platforms.

2.2 Key Trends in the Information Environment

The previous section provided a static view, highlighting geographic and demographic differences in the composition of the contemporary information environment. In the following, we give a brief overview of two major developments of the past decade that

¹See the Reuters Institute's *Digital News Report* (Newman et al., 2019) for a more comprehensive overview of social media platform use across 38 countries.

continue to change the information environment: the growing proportion of mobile-first users and the changing role of traditional media in a digital world.

The Rise of Mobile-First Users

Generally, we can expect internet access to continue becoming more widely available across the globe. However, users increasingly access the internet via smartphones rather than desktop computers. In the UK for instance, in 2013 only 15% of people used their smartphone as the main way of reading online news, while this proportion rose to 49% by 2019 (Newman et al., 2019). In the Global South, where broadband infrastructure is lacking and computers are vastly more expensive than smartphones, mobile internet is often the only form of access. For 2018, an industry-funded survey on the *State of Mobile Internet Connectivity* (GSMA, 2019) reports that 57% of internet users across 18 low-to-medium income countries accessed the internet exclusively via a mobile phone. Similarly, the United Nation's International Telecommunication Union (2019a) found that in 2018 18% of African households had internet access at home while only 11% had a computer.

This change in primary access device has facilitated a trend towards an increased relevance of social messaging apps as sources of information. In a 2019 Reuters digital survey, 53% of Brazilian, 49% of South African and 41% of Hong Kong respondents used WhatsApp as their primary news source (Newman et al., 2019). Perhaps the most prominent case study for this trend is India, where another 2019 Reuters digital survey reported 82% of respondents using WhatsApp with 52% of respondents using it for news content (Aneez et al., 2019). Around the 2019 Indian General Election, the largest election the world ever witnessed, both media (Alluri, 2019; Murgia et al., 2019) and academic commentary (Arun, 2019; Narayanan et al., 2019) highlighted the central role of social messaging apps for political communication as well as the spread of (mis-)information, both by individuals and organisations (see Machado et al., 2019, for an analogous discussion of Brazil). In contrast to social media and news sites, messaging apps provide an even more decentralised, personal and social channel for information transmission. As a result of this dual trend towards both mobile internet use and messaging apps as news sources, we can expect the social component of the information environment to continue growing.

Traditional Media in a Digital World

Digital technologies, the internet and social media in particular, have dramatically shifted the role that traditional media, such as television and newspapers, play in the contemporary information environment. Due to competition with free online resources and a shift of advertising revenue to social media and search platforms, the business models that sustained professional journalism for the past century have all but collapsed (Westlund, 2013; McChesney, 2016; Allern and Pollack, 2019). Publishers are experimenting with alternative approaches, such as paywalls, donations and digital subscriptions, but with limited evidence for success at the time of writing this review. The Reuters Institute's *Digital News Report 2019* finds no increase in the proportion of people spending any

money on online news content since 2013, which remains constant at 11% across a digital survey sample of 9 countries in the Global North (Newman et al., 2019).

Local journalism has been particularly affected by this trend. In the US, more than one in five news outlets closed since 2004, leaving almost 200 of 3,143 US counties without any news outlet and more than 2,000 without any daily newspaper. In 2018, the top 25 news companies in the US owned roughly a third of all newspapers, up from 20% in 2004 (Abernathy, 2018). Among those who pay for online news content at all, the vast majority pay only for one subscription, which suggests further consolidation of the industry going forward (Newman et al., 2019). As a consequence, the information environment for many stands to become less local, lacking coverage of community issues, which many researchers consider a vital public service (Waldman, 2011; R. K. Nielsen, 2015; Abernathy, 2018).

The larger players that remain in this consolidated media industry have embraced technological change, which has impacted information content, style and delivery. Usher (2018), for instance, reports that US media outlets are increasingly adopting breaking news strategies, whereby large amounts of resources are committed to instantaneous and continuously updated coverage of news events rather than more in-depth reporting. Diakopoulos and Koliska (2017) highlight the growing use of algorithmic content curation as well as automated writing and how it erodes journalistic norms of transparency and accountability. More generally, the shift to online news has weakened the relationship between readers and publishers, with more than half of respondents in a 2019 survey across 38 countries accessing news through search engines, social media or news aggregators (Newman et al., 2019). Social media and search platforms now act as gatekeepers between journalists and their audience (Bro and Wallberg, 2014; Tandoc Jr and Vos, 2016) and media outlets have to optimise their content for audience engagement rather than pursuing more traditional curatorial goals (Zamith, 2018; Ferrer-Conill and Tandoc Jr, 2018).

Key Takeaways

The emergence and adoption of new technologies keeps the way that individuals are exposed to information in constant flux. A growing proportion of mobile-first internet users across the globe fosters decentralised information exposure via social transmission, through messaging apps or social media. At the same time, traditional media outlets have had their business models undermined, their journalistic priorities shifted and their editorial power diminished by the internet and social media in particular. As a result, personal and mass communication in the information environment are increasingly blurred in terms of both information content and delivery (Stacks et al., 2019).

This section has outlined the state of the information environment in 2020, both through a static view of its current composition and a dynamic view on the changes it is undergoing. In the following section we move away from this descriptive and contemporary perspective and shift our focus to how individuals engage with information more generally.

3 Engagement: Interacting with New Information

Extensive empirical research from the cognitive sciences on how humans process and interpret information provides a foundation for explaining individual and collective engagement with information in any information environment. In the following, we focus on literature that sheds light on general cognitive processes in the engagement with information (e.g. "*how do people adjust their beliefs when confronted with new information?*") rather than investigating specific interactions with information content in specific settings, especially in the digital sphere (e.g. "*how do people adjust their political beliefs when confronted with political misinformation on social media?*"). The latter will be discussed in section 4.

Subsection 3.1 gives a brief overview of foundational theories of cognition and how they build on each other to form a basis for understanding individual interactions with information. *Subsection 3.2* focuses on research regarding the confirmation bias, the most relevant bias for engagement with new information. Lastly, *subsection 3.3* outlines evidence regarding factors that influence the perceived credibility of information.

3.1 Foundations of Cognition and Information Processing

A comprehensive survey of research on human cognition in the context of information processing is well beyond the scope of this review (instead, see for example Lindsay and Norman, 2013; Lachman et al., 2015). In the following, we restrict our attention to three foundational theories of cognition that combine into a framework for understanding how people engage with information, often in normatively dysfunctional ways.

Cognitive Heuristics and Biases

In the early 1970s, the so-called *Heuristics and Biases* programme established by the psychologists Amos Tversky and Daniel Kahneman challenged the idea of human beings as rational actors. In a series of articles (e.g. Kahneman and Tversky, 1973; Tversky and Kahneman, 1974; Kahneman and Tversky, 1981), they highlighted the use of heuristics in human judgment and decision-making. *Heuristics* provide highly effective shortcuts, which are essential for fast decision-making but not guaranteed to succeed. They will occasionally and systematically be wrong and thus induce *biases*, which Tversky and Kahneman (1974) define as systematic deviations from rationality as described by the normative standards of probability and expected utility theory. The *availability heuristic*, for instance, judges the frequency of an event by the ease with which instances come to mind rather than its true determinants. People consistently overestimate the probability of a plane crash because they can easily recall news coverage of previous crashes (see Kahneman, 2011, for a review of common heuristics).

Kahneman and Tversky's program has overwhelmingly been received as an indictment of human rationality. Its findings were hugely influential beyond the field of psychology as

they directly called into question fundamental assumptions of other disciplines, in particular that of utility-maximising agents in finance and economics, and thus propagated the notion of human cognition as fundamentally biased and flawed (Hahn and Harris, 2014). Gigerenzer and Todd (1999) provide a contrasting interpretation of heuristics and associated biases as adaptively rational rather than irrational, given their overall effectiveness in obtaining correct responses in computationally simple fashion.

Dual Process Theory

Much of the literature in the tradition of Kahneman and Tversky is primarily concerned with identifying individual heuristics and biases. However, prominent authors have argued that the motivation for studying biases should be their use as a means of understanding underlying cognitive mechanisms (e.g. Gigerenzer, 1996; Krueger and Funder, 2004; Stanovich, 2011). The ultimate goal of such research should be to expand the knowledge of human cognition by assessing how heuristics and biases factor into human cognitive processes, especially in regards to the interpretation of new information. For this, a more comprehensive framework of human cognition is needed.

Dual process theory provides such a framework for human reasoning and related higher cognitive processes, such as judgment and decision-making (Evans and Stanovich, 2013). Originating in the 1970s and 1980s (Wason and Evans, 1974; Evans, 1989) but dominant in the literature until today (Chaiken et al., 1996b; Kahneman, 2011; Evans, 2019), dual process theory posits that cognitive tasks evoke two distinct types of processing, one intuitive, the other reflective.² Type 1 processes are generally fast, which they achieve by relying on prior expectations and heuristics. Their defining characteristic is their autonomy and activation in response to stimuli, which puts minimal demands on mental effort. Type 2 processes, on the other hand, are slower, more deliberate and analytical. Their defining feature is hypothetical thinking, which requires relatively more mental effort (Evans and Stanovich, 2013).

The relationship between the two types of processes is subject of ongoing debate. Evans and Stanovich (2013) propose a *default-interventionalist* account, by which type 1 processes provide a default response, which type 2 processes can then intervene on. This is based on the social psychology concept of humans as *cognitive misers*, which seek to minimise their use of scarce cognitive resources (e.g. Fiske and Taylor, 1991; De Neys et al., 2013; Toplak et al., 2014). Evans and Curtis-Holmes (2005) and Neys (2006) provide experimental evidence in support of this account, showing that belief bias and logical inaccuracies associated with type 1 processes increase with time pressure and concurrent memory load. The *parallel-processing* account, on the other hand, suggests that type 1 and type 2 processes are initiated simultaneously (Pennycook et al., 2014; Handley and

²We adopt the terminology from Evans (2019). Kahneman (2011), for instance, uses the term *dual systems* to describe the same theory. Some literature expands dual process theory by suggesting two evolutionary distinct brain systems are responsible for different types of processing (e.g. Evans, 2010). An in-depth discussion of these alternative theories is beyond the scope of this review.

Trippas, 2015). More recent evidence, which suggests that simple logical arguments may be processed intuitively and autonomously (e.g. Bago and De Neys, 2017; Trippas et al., 2017), favours the parallel-processing account.

Importantly, while type 2 processes would generally be associated with normatively correct responses, both types of processes can suffer from biases and yield incorrect conclusions. For instance, analytical thinking based on a biased selection of information can produce flawed results (Thompson et al., 2011; Evans, 2012).

While widely accepted as a framework for understanding reasoning, judgment and decision-making, dual process theory remains an active and contested area of research (Evans, 2019). Prominent criticism regarding its coherence as well as lack of falsifiability and evidence (Keren and Schul, 2009; Kruglanski and Gigerenzer, 2011; Melnikoff and Bargh, 2018) has provoked direct responses claiming that critics have misinterpreted or misrepresented the theories and failed to consider strong empirical support in the literature (Evans and Stanovich, 2013; Pennycook et al., 2018b)

Motivated Reasoning

Each of the two types of cognition stipulated by dual process theory encompasses a multitude of cognitive processes. The theory of *motivated reasoning* suggests that motivations in terms of desired conclusions play a role in determining which of these will be used on a given occasion (Kunda, 1990). Modern motivated reasoning theory originated in psychological research in the 1980s and 1990s as an attempt to bridge the gap between general process theories of reasoning and concrete biased empirical outcomes (Kunda, 1987; Kruglanski, 1989; Chen et al., 1999). More recently, it has been taken up by political scientists to explain public conflict over policy-relevant facts (e.g. Taber and Lodge, 2006; Bolsen et al., 2014; Kahan, 2015; Baekgaard et al., 2019).

While the definition of motivations, desired end-states that individuals want to achieve, remains somewhat contested (Fishbach and Ferguson, 2007; Kruglanski et al., 2018), the literature is mostly concerned with three broad categories of motivations: the *defense motive*, introduced by Kunda (1990), also referred to as the directional motive (Druckman, 2012), according to which individuals defend their attitudes, beliefs or behaviours by avoiding or engaging in a biased manner with information likely to challenge them, favouring instead information likely to support them; the *accuracy motive*, introduced by Kruglanski (1989), according to which individuals select and engage with information in an objective, open-minded fashion in their attempt to reach a normatively correct conclusion; and the *impression motive*, introduced by Chaiken et al. (1996a), according to which individuals select and engage with information in order to satisfy social goals. The relative strength of these motives shapes the use of cognitive processes and heuristics, which makes cognitive outcomes dependent on individual context. Cognitive processes thus provide the mechanism through which motivation affects reasoning (Kunda, 1990; Chen et al., 1999).

Key Takeaways

In this subsection, we have outlined three major fields of research, mostly from psychology, and how they build on each other to form a more comprehensive account of human cognition and information processing. Dual process theory assigns heuristics and other cognitive processes to two types of thinking, one intuitive, the other reflective. Motivations affect reasoning by guiding the selection of cognitive processes within the two types. Individual context, social and physical, shapes motivations and thus influences cognitive outcomes.

In sum, this literature provides a framework for understanding how individuals interact with information in specific contexts. In the following, we build on this framework by summarising evidence for the confirmation bias, which warrants a more extensive discussion given its relevance for engagement with new information.

3.2 Confirmation Bias and Engagement with New Information

The term *confirmation bias* typically denotes the tendency to seek or interpret information in a way that conforms with existing beliefs or hypotheses at hand, unwittingly rather than deliberately (Oswald and Grosjean, 2004). It is a well-established phenomenon, first popularised in the 1960s in experimental studies by Wason (1960, 1968) but recognised by philosophers as a fundamental determinant of thought and behaviour in engagement with information for centuries (see Nickerson, 1998, for a review). This makes it uniquely relevant to our review of the information environment and its effects on individuals and groups. In the following, we therefore examine evidence for three of the most prominent types of confirmation bias relating to engagement with new information.

Selective Exposure: Confirmation Bias in Seeking Information

The phenomenon of *selective exposure*, synonymously known as congeniality bias, describes the extent to which individuals choose to examine information they expect to or have been told will align with their attitudes or beliefs, as opposed to information that runs counter to it (Hart et al., 2009). Like all types of confirmation bias, selective exposure is intimately linked to motivated reasoning, whereby motivation shapes the use of cognitive processes and biased heuristics.

Generally, factors that increase the anticipation or experience of cognitive dissonance, the mental discomfort arising from the heightened presence of inconsistent or conflicting mental cognitions (Festinger, 1962), have been found to strengthen the defense motive and thus amplify selective exposure to congenial information. For instance, confirmation bias has been demonstrated to be stronger when uncongenial information challenges a recently expressed belief, attitude or behaviour (Frey, 1981, 1986). Accuracy considerations, on the other hand, can motivate people to select uncongenial information if they believe that information to be helpful for drawing correct conclusions, and thus lead them to exhibit

relatively less confirmation bias (Kunda, 1990; Chaiken et al., 1996a). Outcome-relevant involvement, for instance, which refers to attitudes, beliefs or behaviour linked to an important outcome, has consistently been shown to reduce confirmation bias in favour of objective processing of available information (Lowe and Steiner, 1968; Johnson, 1994; Jonas and Frey, 2003).

In sum, the literature suggests that individuals exhibit larger confirmation bias in settings which accentuate the defense motive over the accuracy motive, while the converse holds when the accuracy motive is dominant. In other words, when accuracy is more important, individuals tend to exhibit less bias in selecting which information they are exposed to.

Hart et al. (2009) provide the most recent meta-analysis of 67 published reports of selective exposure. They find individuals to be almost twice as likely to select information that is congenial rather than uncongenial to their attitudes, beliefs or behaviours. Confirmation bias increased with factors associated with a strong defense motive, demonstrating its significant influence in selective exposure. The accuracy motive on the other hand was validated in the sense that participants generally selected the information that was most relevant to the goal they were pursuing in the experiment, but factors regarding outcome relevance proved insignificant.

Selective exposure has recently gained new relevance in light of research into hyper-personalised digital information environments, so-called *filter bubbles* (Pariser, 2011) governed by algorithmic design. This more specific stream of literature, which is strongly tied to digital technologies, will be discussed in section 4.2

Myside Bias: Preferential Treatment of Evidence Supporting Existing Beliefs

Closely related to the concept of selective exposure is *myside bias*, the tendency not to ignore uncongenial information, but rather to give greater weight to congenial information (Nickerson, 1998). Early experimental evidence (Snyder and Cantor, 1979; Koriat et al., 1980; Pyszczynski et al., 1985) demonstrated this bias in information evaluation, which was then interpreted in the context of motivated reasoning by Pyszczynski and Greenberg (1987) and most prominently by Kunda (1990). The latter argued that the desire to avoid cognitive dissonance, the defense motive, provided motivation for individuals to exhibit myside bias. Furthermore, while defense-motivated preferences for congenial information could influence beliefs, the desire for those beliefs to be justifiable towards the self and others puts a limit on their influence. Building on these arguments, experiments by Ditto and Lopez (1992) and Ditto et al. (1998) showed that participants would examine information inconsistent with a preferred conclusion more critically than information consistent with a preferred conclusion. Similarly, participants in a widely-cited study by Edwards and Smith (1996) scrutinized uncongenial arguments longer, subjected them to more extensive refutational analyses, and consequently judged them to be weaker than congenial arguments.

Myside bias continues to be an active area of research in the cognitive sciences, in particular regarding differences in its prevalence across individuals (Wolfe, 2012; Stanovich

et al., 2013) and ways to mitigate it (Felton et al., 2015; Villarroel et al., 2016), but it has also taken on a central role in social science explanations of polarised opinion dynamics. Myside bias has been demonstrated in relation to contested issues such as climate change (Hart and Nisbet, 2012) and abortion (Baron, 1995; Čavojová et al., 2018). In political science, there is strong evidence for partisan Myside bias in evaluating news and policy (e.g. Petersen et al., 2013; Bolsen et al., 2014; Tappin et al., 2017).

Motivated Perception

The tendency for people to hold a belief and interpret new information in a way that aligns with it, even when it might not actually support the belief, is referred to as *motivated perception* (Nickerson, 1998). Illusory correlations provide a common example for this phenomenon: In the 1980s, broad experimental evidence established that the belief that two variables are related increases the likelihood of finding evidence consistent with that relationship while decreasing the likelihood of finding inconsistent evidence (Hamilton and Rose, 1980; Crocker, 1981; Alloy and Tabachnik, 1984). In alignment with the motivated reasoning literature, judgments tended to be more accurate when participants lacked strong prior beliefs about the relationship between the variables.

Motivated perception, too, has recently played a key role in explaining social phenomena. For instance, a large body of research is concerned with personal perceptions of climate change (e.g. Egan and Mullin, 2012; Akerlof et al., 2013; Sisco et al., 2017). In particular, T. A. Myers et al. (2013) show that prior beliefs mediate the relationship between personal experience and perceptions of climate change. Recent neuroscientific research has provided an additional perspective on this bias. An fMRI study by Leong et al. (2019), in which participants were asked to perform a visual categorisation task, provides a computational account of how motivation influences perception by increasing neural activity selective for the motivationally relevant category.

Beyond selection and interpretation of information, retention and recall are considered fundamental elements of human cognition. The phenomenon of *selective memory* has been studied along the same dimensions as the confirmation biases we discussed in this subsection by psychologists (e.g. Eagly et al., 1999, 2001) and more recently by neuroscientists (e.g. Benoit and Anderson, 2012; Anderson and Hanslmayr, 2014). Given our focus on interaction with new information, further discussion of this subject is beyond the scope of this review.

Key Takeaways

Confirmation bias has come to provide an umbrella term for many distinct ways in which information processing is influenced by prior beliefs or expectations (Hahn and Harris, 2014), a comprehensive overview of which is beyond the scope of this review (see instead Nickerson, 1998). Instead, we focused on three of the most prominent types of confirmation bias relating to engagement with new information.

Myside bias and motivated perception, continue to be highly relevant beyond experimental psychology precisely because of their importance for understanding behaviour, beliefs and opinions in the contemporary information environment. Literature on the former sheds light on how individuals weigh contradictory evidence in information-rich settings. Evidence for the latter helps understand how even stand-alone factual information content can be interpreted in a partisan manner. Selective exposure suggests that both phenomena occur in information environments that are already biased towards prior opinions and beliefs.

3.3 Credibility, Information Content and Context

Judgments about the credibility or trustworthiness of information content provide an additional, important dimension for understanding how individuals engage with their information environment. Public and regulatory concerns around misinformation on the internet and social media in particular have spurred academic interest in this area over the past decade. In the context of this review, credibility matters because individuals tend to favour information sources they find more believable (Wanta and Hu, 1994) and because they revise their beliefs more when engaging with information they consider more credible (Birnbaum and Stegner, 1979; Chaiken and Maheswaran, 1994; Pornpitakpan, 2004; Corner et al., 2010).³ In this subsection, we thus discuss a wide range of current literature on the factors that shape perceptions of information credibility. We structure our discussion around the four components of the influential *source-message-channel-receiver* (SMCR) model of information transmission devised by Berlo (1960), which is still prevalent today (Self and Roberts, 2019). Evidence that is specific to online misinformation and its influence is subject of section 4.3.

Source: Author Characteristics and Social Information

Early research into source credibility from psychology and marketing science was mostly concerned with source characteristics associated with trustworthiness as perceived by the message recipient. Motivated by results from Hovland and Weiss (1951) suggesting that effectiveness of communication is primarily determined by source credibility, it considered favourable attributes such as qualification and dynamism (Berlo et al., 1969) or independence (Meyer, 1988). Eisend (2006) provides a comprehensive overview summarising three decades of research and encompassing 50 distinct attributes, a full discussion of which is beyond the scope of this review.

Much recent research has also focused on social means of credibility assessment afforded by digital technologies. Shan (2016), for instance, isolates a positive effect of perceived similarity of reviewers on the credibility of online product reviews. For online marketplaces, Xu (2014) shows that personal profile characteristics, in particular endorsements

³Conversely, individuals tend to find the media they use the most to be the most credible (Johnson and Kaye, 2004)

by other users and having a profile picture, increase the credibility of consumer reviews. Metzger et al. (2010) demonstrate that individuals were more inclined to trust sources that displayed many positive testimonials. Moe and Schweidel (2012) provide a potential explanation for such behaviour, suggesting that individuals evaluate credibility using a bandwagon heuristic, where the number of prior endorsements positively relates to perceived source credibility.

Message: Content, Topic and Other Factors

Source and message credibility are somewhat congruent concepts: Message credibility has been shown to boost source credibility (Slater and Rouner, 1996) while message errors reduce it (Maier, 2005). Hahn et al. (2009) further demonstrate that source and message credibility have non-additive effects on information credibility in relation to how persuasive an argument is perceived to be.

In the absence of source cues, message content has been shown to affect credibility. Technical quality (Sundar, 1999) and grammatical correctness (Maier, 2005) positively relate to credibility. Fischer et al. (2008) suggest that quantity of information induces credibility and thus reduces the likelihood of seeking out further evidence. Fico et al. (2004) show that balanced message structure increases credibility. Furthermore, it is well documented that familiarity with a message through repeated exposure can increase credibility (see Dechêne et al., 2010, for a review). Westerman et al. (2014) show that on Twitter, the recency of updates increases the credibility of information content. Lucassen et al. (2013) also consider receiver attributes in relation to message content. They report that source domain expertise shapes individual criteria for assessing information credibility. In their experiment, novices relied mostly on surface features while experts focused on accuracy of the content.

Channel: Platform Characteristics and Media Attitudes

The relative credibility of different media sources has been the focus of survey research since radio emerged as an alternative to newspapers in the 1930s (Self and Roberts, 2019). As the media landscape evolves, relative credibility changes, which makes historical evidence less relevant for this review. In the early days of the internet, Johnson and Kaye (1998) found online media to be judged as more credible than traditional counterparts, although it should be noted they were surveying internet users only. Flanagin and Metzger (2000), on the other hand, found newspapers to have the highest perceived credibility, followed by online and television news among a more general sample. Kioussis (2001) produced results aligned with Flanagin and Metzger (2000). This early survey research, conducted at a time when the internet was not nearly as widely used as today, suffered from a lack of generalisability and representativeness. More recent evidence corrects for this and paints a different picture of media credibility. In a representative survey of the online population across seven countries in the Global North, Dutton et al. (2017) report that respondents trust social media significantly less than any other information channel.

Online search results, however, along with online news are perceived as approximately equally credible as radio, newspapers or television. Their survey's more granular view underlines the importance of national differences in information environments discussed in section 2.1. Respondents from Germany and France, for example, perceived social media as much less credible than those from Poland or Spain.

Receiver: Audience Attributes, Beliefs and Attitudes

Credibility of information ultimately lies in the mind of its recipient and is thus specific to them. The recipient's attributes, beliefs and attitudes therefore influence their perception of the credibility of information content. Early studies were concerned with demographic attributes such as gender and education (Westley and Severin, 1964; Greenberg, 1966). More recent studies from political and communication science focus more on the impact of beliefs and attitudes, which relates to our discussion of confirmation bias in section 3.2 above. Stroud and Lee (2013) and Metzger et al. (2015) for instance show that people judge attitude-consistent and neutral news sources as more credible than attitude-challenging news sources. These results are complemented by evidence for the *hostile media effect*, first established by Vallone et al. (1985), which describes the tendency for individuals to perceive news coverage of partisan issues as biased against their own side and thus less credible. Since both sides of a partisan issue can perceive a given news source as biased in opposite directions, these judgments must emanate from the characteristics of the recipient (Goldman and Mutz, 2011). The hostile media effect has been replicated in dozens of studies, summarised in the most recent meta-analysis by Hansen and Kim (2011), who find the effect to be stronger when individuals are more deeply involved with the topic covered (see Perloff, 2015, for a more extensive discussion).

Key Takeaways

Assessing the credibility of information content is a complex task, since every component of the information transmission channel can exert an influence on a concept defined only in the mind of the recipient. Information sources can imbue credibility through their own attributes and social signals. Familiarity and semantic quality in message content also increase credibility. Different channels are perceived as more or less trustworthy, with online social media being among the least trusted. Lastly, individual attributes of the recipient, in particular ideological congeniality, can instill trust. In sum, credibility is highly context-dependent, but the literature provides insights into the dimensions along which to evaluate it.

4 Transformations in Digital Information Environments

Sections 2 and 3 outlined the state of the information environment in 2020 as well as how individuals engage with information more generally. In this section we synthesise these findings by discussing transformations in the information environment due to digital technologies, which alter the way individuals and groups are exposed to and engage with information. These transformations have motivated a vast and diverse literature across disciplines. In the following, we focus on three of the most prominent and active streams of research.

Subsection 4.1 reviews literature on the collective dynamics of information sharing in online social networks. *Subsection 4.2* outlines current research on the polarisation of digital information environments. Lastly, *subsection 4.3* discusses evidence regarding the prevalence of online misinformation as well as its effects.

4.1 Social Dynamics and the Diffusion of Information

Online social networks like Facebook or Twitter were devised with the express purpose of facilitating information to be spread via likes, shares, comments or retweets. Such social media create new dynamics of interaction between individuals, the communities they belong to and the information environment they are embedded in. Most of this review so far has focused on individual exposure to and interaction with information. In the following, we outline evidence regarding the collective dynamics of information diffusion in online social networks.

Mechanisms of Information Diffusion in Online Social Networks

There is a large body of social networks research concerned with the diffusion of information, which is formalised by, for instance, observing link sharing behaviour on Facebook (Bakshy et al., 2012) or hashtag propagation on Twitter (Lehmann et al., 2012). However, while observed behaviours may be influenced by the social network in question, they could also arise from the individuals' own characteristics or activities outside the network. Thus, there are three mechanisms which can explain why individuals that are connected in a network, such as two friends on Facebook, would share the same information content: *Social influence*, also referred to as *social contagion*, whereby an individual shares information with another, causing them to re-share that information themselves; *homophily*, whereby two linked individuals share the same information independently but because of traits they have in common; and, lastly, *external influence*, where two linked individuals share the same information because of a common external cause.

Anagnostopoulos et al. (2008) were among the first to highlight the importance and complexity of disentangling these mechanisms, in particular homophily and contagion, when studying online social networks (see also Shalizi and Thomas, 2011). This motivated

a wave of empirical research in the early 2010s, which produced somewhat diverging results across different settings. Aral et al. (2009), for instance, find that homophily explained more than 50% of perceived contagion in the adoption of a mobile service application in a large instant messaging network. Bakshy et al. (2012) on the other hand show that most information diffusion on Facebook is driven by social influence. S. A. Myers et al. (2012) compare social to external influence in Twitter URL mentions, finding that 71% of information volume can be attributed to the former. By contrast, Lehmann et al. (2012) report that social influence plays only a minor role in Twitter hashtag popularity, which they suggest is mostly driven by external influence.

Similar results originate from closely related research into information cascades, which model the spread of information as sequential tree-like networks (e.g. Goel et al., 2012; Cheng et al., 2014; Zhao et al., 2015). Goel et al. (2016) highlight the structural diversity of online information cascades, showing that some information on Twitter spread widely because of social influence while other information spread because of media broadcasts. They find popularity in general to be mostly driven by the size of the largest broadcast.

In sum, there is clear evidence for strong social influence facilitated by online social networks, but perceived contagion has also been shown to stem from homophily and external influence. The relative importance of individual mechanisms appears highly context-dependent.

More recent work in this area has focused on detecting external influence (Varol et al., 2017) as well as influence by social bots, i.e. automated users (Kudugunta and Ferrara, 2018; Shao et al., 2018), a discussion of which falls within the scope of subsection 4.3 regarding online misinformation below.

Determinants of Information Diffusion in Online Social Networks

The diversity in findings regarding the efficacy of social influence has motivated a more granular empirical literature on the determinants of information diffusion in online social networks. In general, this literature is concerned with two main factors: *information content* and *network context*.

For information content, Romero et al. (2011) show that on Twitter different kinds of content spread differently, with hashtags for politically controversial topics proving particularly persistent in their repeated use and social diffusion. Coscia (2014) finds that memes which are more similar to other memes are less likely to be popular. Del Vicario et al. (2016) report distinct diffusion dynamics for conspiracy and science news on Facebook, whereby more popular conspiracy rumors are shared more persistently. Vosoughi et al. (2018) show that false rumours on Twitter spread more widely and faster than the truth. The effects of information content on information diffusion are closely related to individual-level attributes, which influence how content is interpreted. Bakshy et al. (2015), for instance, show that US Facebook users were substantially less likely to share

content from sources that did not align with their own ideology.⁴

For considering the effects of network context on information diffusion, Centola and Macy (2007) introduced a distinction between *simple* and *complex contagions* in social settings, where for the former a single source can be sufficient for transmission while for the latter contact with multiple sources of activation is required. Thus, network topology is relevant for both types of contagion but particularly influential for complex contagions.

The structure of the community that individuals are embedded in has been shown to be a powerful predictor of information diffusion. For complex contagions, the spread within highly clustered communities is enhanced, while diffusion across communities is hampered (Centola and Macy, 2007). Weng et al. (2013) show that this result holds for information flow on Twitter, where most information in retweet networks spreads via complex contagion. Similarly, Harrigan et al. (2012) report increased social contagion in more clustered communities on Twitter. Locally, greater tie strength facilitates information diffusion (Zhang et al., 2013; Arnaboldi et al., 2016). Furthermore, Mønsted et al. (2017) establish that diffusion of hashtags on Twitter also increases with the number of sources of exposure, which aligns with the complex contagion model.

Rather than investigating the role of local network structures and communities, another prominent stream of research is concerned with identifying *influentials* (Merton, 1968), the users in the network that play a central role in the diffusion of information. This research lacks a uniform definition and measurement of influence in online social networks, with individual articles often factoring multiple metrics into their models. For the many analyses using Twitter data, follower and retweet counts are a popular choice, while other commonly used measures include centrality measures such as closeness centrality, link topological ranking and entropy measures (see Peng et al., 2018, for a review). The generalisability of individual measures is also contested. For instance, Cha et al. (2010) show that the number of Twitter followers does not provide a reliable measure of influence as measured by retweets in the network (see also Harrigan et al., 2012). Bakshy et al. (2011) on the other hand find that the largest information cascades for link sharing on Twitter tend to be generated by users with many followers. Dubois and Gaffney (2014) highlight the multiple facets of influence in their analysis of Canadian political Twitter communities, which finds that centrality measures identify traditional political elites as influential, while measures taking into account the quality of messages and interactions yield a different set of influentials, which includes political bloggers and commentators. In computer science, the closely related problem of *influence maximisation*, which entails finding the set of nodes whose activation yields the largest influence over the rest of the network (Kempe et al., 2003), continues to be an active area of research (see Li et al., 2018, for a recent review).

⁴Such findings motivate the literature on polarisation in the information environment, which will be discussed in subsection 4.2 below.

Key Takeaways

The internet and social networks in particular have facilitated collective dynamics of social information diffusion at an unprecedented scale. However, perceived contagion can arise not only from social influence but also from homophily of connected users as well as external influences, such as other media sources. For social influence, both information content and network context, including local network topologies as well as influential nodes in the larger network, determine the diffusion of information across social networks.

4.2 Polarisation of Digital Information Environments

The interaction of social dynamics and algorithmic design on digital platforms has created new concerns regarding a polarisation of digital information environments, whereby access to information content systematically differs across individuals and is tailored to them, their ideology and other attributes, rather than being universal and unfettered. Such a development could threaten democratic norms of political discourse as people grow unaccustomed to engaging with information they disagree with (Sunstein, 2001; Taber and Lodge, 2006) and thus increase social and political polarisation (Barberá et al., 2015).⁵

Two concepts in particular have received much attention in the public and academic discourse. Firstly, the concept of *echo chambers*, popularised for the digital sphere by Sunstein (2001), which describes homogeneous and closed-off information environments, in which individuals associate with like-minded others and reinforce their pre-existing beliefs, attitudes and behaviours. Secondly, the distinct but closely related concept of *filter bubbles*, coined by Pariser (2011), in which algorithms select which content individuals are exposed to on the internet based on previous behaviours, thus reinforcing them.

In public and media commentary, both echo chambers and filter bubbles have become popular explanations for dramatic political events, such as Brexit or the 2016 election of Donald Trump. In the academic literature, however, the evidence regarding their importance or even their very existence is much less clear. In the following, we highlight recent research into both concepts, which provides a more nuanced picture of the relevance of echo chambers and filter bubbles in digital information environments.

Echo Chambers

The concept of echo chambers directly builds on the confirmation bias literature discussed in subsection 3.2 above, which demonstrated a fundamental human tendency to associate with similar others and seek out congenial information. On social media platforms, this

⁵An alternative interpretation, whereby engagement with uncongenial information entrenches polarised views rather than encouraging critical reflection (see e.g. Karlsen et al., 2017; Bail et al., 2018), has only limited empirical and theoretical support and will thus not be discussed further.

tendency would be reflected in network clusters of friendship or followership characterised by homophily, in which users expose each other to congenial information content.

First empirical research efforts, concerned with single social media platforms, mostly found evidence in support of the existence of echo chambers for political discourse in social networks. Colleoni et al. (2014), for instance, establish political homophily in ties between US Twitter users in 2009 (see also Conover et al., 2011; Himelboim et al., 2013). Barberá et al. (2015) find that there is ideological segregation on Twitter, whereby online communication, as measured by retweets, resembles an echo chamber for political issues, such as the 2012 US presidential election, but not for other apolitical news events. On Facebook, Quattrociocchi et al. (2016) find echo chambers for Italian and US users discussing conspiracy theories. Similarly, Del Vicario et al. (2017) suggest that news consumption patterns reflect echo chambers in the Brexit debate on Facebook.

A more recent stream of literature questions the overall relevance of echo chambers given the diversity of media choices in today’s information environment. On the one hand, the high-choice setting created by the internet (Van Aelst et al., 2017), where information can be obtained via search, social transmission, news websites or similar sources, might allow individuals to make biased media choices and thus amplify echo chamber effects. On the other hand, this diversity of choices may result in individual exposure to diverse information content from diverse sources, so that source-specific echo chambers become less consequential. The latter is not generally accounted for by empirical research focusing on echo chambers on single social media platforms. Dubois and Blank (2018) use a representative 2017 survey of adult internet users in the UK to study media choices including but importantly not limited to social media. They show that only a small segment of the population - those that are uninterested in politics and have a uniform media diet - are likely to be caught in an echo chamber. In the same vein, Dutton et al. (2017) argue that concerns over echo chambers in the wider digital sphere are overstated. In their cross-national 2017 digital survey, the majority of respondents regularly encountered content they disagree with and almost half of respondents *often* learned about new information through internet search. Flaxman et al. (2016) also report an increase in exposure to uncongenial political information through search and social media in browsing histories for 50,000 US-located users. Similarly, Scharkow et al. (2020) find that the use of social network sites and other online intermediaries generally leads to more frequent exposure to more diverse information content.

Filter Bubbles

Filter bubbles denote selective exposure to congenial information, as discussed in section 3.2, but based on algorithmic design rather than human cognitive biases. In this context, a central research question is whether algorithms, such as news feed and search rankings, exacerbate pre-existing biases in human information exposure and engagement. Generally, conclusive evidence regarding filter bubbles is difficult to obtain due to the opacity of algorithmic design on social media and search platforms. Research has to rely on privileged

data access provided by the platforms or draw inferences about algorithmic design based on a record of algorithmic outcomes for a large number of users.

For digital information environments and social media platforms in particular, where information content is socially transmitted but curated by algorithms, echo chamber and filter bubble effects cannot easily be distinguished between, even though they originate from distinct mechanisms - cognitive biases and algorithmic design. In a rare study addressing this issue, Bakshy et al. (2015) use privileged Facebook data access to investigate these two mechanisms for exposure to ideologically diverse news and opinion. They find that on Facebook's news feed users are generally exposed less to political content that is uncongenial. However, this is driven primarily by user choices in terms of who they are friends with than by algorithmic design, which suggests a limited relevance of filter bubbles. Similarly, Möller et al. (2018) test several recommender algorithms for articles on a news website, which they find to make news recommendations that are on par with human editors in terms of content diversity.

Beyond social media, search algorithms pose a risk of creating filter bubbles. However, Krafft et al. (2019) find the degree of personalisation of Google search results to be very limited, based on a record of search results for political keywords during the 2017 German general election. This is aligned with results from Haim et al. (2018), who find almost no personalisation of news content on Google.

Similarly to echo chambers, the evidence for which is mostly limited to individual social media platforms, the overall relevance of filter bubbles is also mitigated by diverse media choices. Dutton et al. (2017) suggest that filter bubbles have attracted disproportionate levels of concern since they find that most respondents in a 2017 cross-national digital survey used multiple media sources and thus encountered a diversity of information, even if individual platforms might constitute filter bubbles.

Key Takeaways

The existence of online echo chambers is mostly supported by the empirical literature for individual social media platforms, particularly for political issues. However, more recent research suggests that their overall relevance is overstated, since most individuals have a diverse media diet, leading to diversity in the information they are exposed to. For filter bubbles created by algorithmic design, a growing body of evidence suggests that concerns might be exaggerated. In theory, search engines and social media platforms have the potential to create filter bubbles, but in practice evidence for their existence is limited and even then their relevance is questionable, given that for most people each platform is only one component of individual information environments characterised by a diversity in media choices.

4.3 Online Misinformation

Concerns over false or misleading information on the internet used for purposes of political influence gained prominence in the public and academic discourse after Brexit and the 2016 US Presidential Election. *Fake news* has become a buzzword in media commentary and even in the academic literature, there is little consensus on what it encompasses. A review by Tandoc Jr et al. (2018) locates six distinct types of fake news in a two-dimensional typology based on their level of facticity, meaning the degree to which they rely on facts, and their author's immediate intention to deceive. They include news parodies and satire, which intend to entertain, as well as native advertising, which intends to sell a product. By contrast, the literature discussed in this section is concerned with types of misinformation which are characterised by a strong intent to deceive for social or political purposes: propaganda, i.e. state-backed and selective or misleading dissemination of information, manipulation and outright fabrication of information content.

To this day, supposed Russian election interference through social media is a major talking point in US politics. Investigating the validity of such a claim and similar others is a complex task. In order to establish the influence of online misinformation, researchers not only need to demonstrate that individuals were exposed to misinformation and engaged with it, but also that they changed their behaviour, for example their voting intention, in response to it. We use this distinction to structure our discussion of the evidence regarding the prevalence of misinformation in the digital sphere as well as its contested effectiveness in achieving political or social influence. Lastly, research on potential countermeasures is briefly outlined.

Prevalence: Exposure to and Engagement with Online Misinformation

A large body of recent empirical literature on the prevalence of online misinformation is concerned specifically with the 2016 US Presidential Election. Guess et al. (2018), for instance use survey and browser history data to assess exposure to misinformation online. They estimate that one in four voting age Americans visited a fake news website in the run-up to the election, where a small subset of Americans with the most conservative information diets were disproportionately likely to visit fake news websites, which mostly produced pro-Trump content. Grinberg et al. (2019) produce matching results for Twitter, where they find that fake news accounted for nearly 6% of all news consumption in the months before the election, but this consumption was heavily concentrated with only 1% of users exposed to 80% of fake news. They, too, report that fake news exposure was most concentrated among conservative voters. Similarly, Allcott and Gentzkow (2017) estimate that the average adult in the US only saw on the order of one or several fake news articles during the election period, with higher exposure to pro-Trump articles than pro-Clinton articles. For engagement with misinformation content, analogous patterns emerge. Grinberg et al. (2019) show that 0.1% of users were responsible for sharing 80% of fake news on Twitter around the election. Survey evidence by Guess et al. (2019) mirrors these results, finding that the sharing of misinformation content was rare, with

older and more conservative users generally sharing more such content (see also Narayanan et al., 2018).

In sum, for the 2016 US Presidential Election, the evidence suggests that concerns over wide-spread exposure to and engagement with misinformation on social media are overstated. Instead, misinformation constituted a deep but narrow issue, with only a small, mostly conservative portion of the population being exposed to and actively engaging with mostly pro-Trump misinformation content. This also implies that tendencies toward selective exposure to politically congenial content extend to misinformation.

Empirical literature which is so specific to a single national election cannot easily be generalised to other settings, but it provides a theoretical and methodological foundation for further research. Bradshaw and Howard (2019) provide an inventory of organised social media manipulation campaigns across 70 countries, most of which have received much less academic attention than those around the 2016 US elections. The Oxford Internet Institute's *Computational Propaganda Research Project* has addressed some of these research gaps through technical reports on the 2016 Brexit referendum (Narayanan et al., 2017), the 2017 French presidential election (Howard et al., 2017) or the 2017 German parliamentary elections (Neudert et al., 2017), among others. However, the literature remains incomplete, especially for countries in the Global South. Furthermore, the prevalence of online misinformation is not a static issue, but subject to dynamic social and political circumstance as well as changing platform regulations. Allcott et al. (2019), for instance, find that, between the end of 2016 and July 2018, user interactions with content produced by fake news sites have fallen sharply on Facebook while continuing to rise on Twitter. For the UK, Marchal et al. (2020) report that only 2% of links shared on Twitter in the lead-up to the 2019 UK General Election were junk news, compared to circa 20% in 2017. This highlights the importance of current and cross-platform research for informing the debate about the issue of misinformation on the internet.

Another stream of research focuses more explicitly on the role of social media in the spread of online misinformation. Subsection 4.1 aggregated evidence for how social media sites enable the diffusion of information content, factual or false, through social contagion. Vosoughi et al. (2018), provide a particularly relevant result in this context, showing that false rumours on Twitter spread more widely and faster than the truth. The prevalence of social bots, computer algorithms that automatically produce content and interact with humans on social media (Ferrara et al., 2016), provides a potential mechanism for this amplified propagation of misinformation. Bessi and Ferrara (2016) estimate that a fifth of all Twitter messages relating to the 2016 US elections were generated by social bots and Stella et al. (2018) find similar results for the 2017 Catalan independence referendum, where social bots generated and promoted violent content aimed at Independentists. More generally, Shao et al. (2018) show that social bots played a disproportionate role in spreading articles from low-credibility sources on English language Twitter in 2016 and 2017 (see also Bovet and Makse, 2019). This highlights an orchestrated and inorganic component to exposure and engagement with misinformation on social media.

Effectiveness: Influence of Online Misinformation

Measuring the influence of online misinformation rather than just its prevalence comes with complex challenges of methodology and data availability. Establishing online misinformation as a cause for a change in voting behaviour, for instance, would require an identification strategy that isolates the effect of engagement with misinformation content as well as a record of individual votes. As a consequence, empirical literature that attempts to at least approximate causal influence is extremely rare. Several articles that claim to discuss the influence of misinformation in fact just evaluate how users engaged with it (e.g. Badawy et al., 2018; Bovet and Makse, 2019), and thus fail to acknowledge the underlying intent of misinformation campaigns to exert social or political influence. Bail et al. (2020) provide a potential template for more effective research in this area. Using longitudinal survey data and privileged access to Twitter data, they assess the impact of a Russian Twitter misinformation campaign on the political attitudes and behaviours of American Twitter users in late 2017. They show that those users who were already highly polarised engaged the most with the misinformation content and find no evidence that interacting with accounts linked to the campaign substantially impacted any of the six political attitudes and behaviours they capture in their survey, which calls into question the effectiveness of the misinformation campaign. This is aligned with more general evidence regarding the causal effect of political campaign contact, a meta-analysis of which suggests little to no impact of efforts by political campaigns to persuade individuals (Kalla and Broockman, 2018).

Rather than quantifying its influence, a related stream of research seeks to qualify the relevance of online misinformation by locating it in the context of the wider information environment. Dutton et al. (2017), for instance, suggest that online misinformation has attracted disproportionate levels of concern, given that respondents in their cross-national survey were generally skeptical of information from the internet and used other sources for validating the information they come across. Similarly, Allcott and Gentzkow (2017) argue that social media is an important but not dominant source of election news, with only 14% of respondents in their survey calling social media their *most important* source.

Lastly, a range of experimental studies seeks to evaluate the factors that lead individuals to believe in misinformation content, which is a prerequisite for its hypothetical influence. This relates directly to questions of information credibility, discussed in subsection 3.3. In alignment with literature on general repeated exposure and credibility (Dechêne et al., 2010), Pennycook et al. (2018a) show that prior exposure increases perceived accuracy of fake news in an experiment using fake news headlines from Facebook. Turcotte et al. (2015) find a strong social component to credibility of social media content, whereby social media recommendations significantly improve media trust (see also Messing and Westwood, 2014; Weeks et al., 2017). Pennycook and Rand (2019) suggest that the susceptibility to fake news stems from a lack of reasoning more than from partisan motivated reasoning.

Countermeasures to Online Misinformation

Potential measures to curb the spread and impact of misinformation, which constitute targeted interventions in individual information environments, emerge as a direct consequence of the research discussed in this subsection. Two main approaches are common in the relevant literature, one centered around individuals, the other around platforms.

The first is to empower individuals in their ability to question information content and identify misinformation as such through fact checking or improving media literacy. Evidence for the effectiveness of the former is contested. Clayton et al. (2019), for instance, show that Facebook content tagged as *rated false* tended to be perceived as moderately less accurate (see Ecker et al., 2010; Lewandowsky et al., 2012; Chan et al., 2017, for similar results). Pennycook et al. (2020) on the other hand find that attaching warnings to a subset of fake news headlines increases the perceived accuracy of headlines without warnings, which matches similar evidence for a backfire effect of fact checking (Nyhan and Reifler, 2010; Thorson, 2016; Wood and Porter, 2019). Furthermore, Guess et al. (2018) suggest that fact checking content from institutional media sources almost never reaches its intended audience of users who engaged with misinformation content. Efforts to improve media literacy rely on more long-term educational programs and as such have not yet been conclusively assessed in their effectiveness, especially for a social media context (see Bulger and Davison, 2018, for a review).

The second approach encompasses measures to be taken by the platforms, which host or disseminate misinformation content. Given that social bots play a significant role in the spread of such content (Shao et al., 2018), a large body of computer science research is concerned with bot detection to enable platform moderation (e.g. Davis et al., 2016; Varol et al., 2017; Kudugunta and Ferrara, 2018). Furthermore, Facebook (Weedon et al., 2017) and Twitter (Crowell, 2017) reported changing their news feed algorithms to favour credible news sources. Such intransparent measures for prioritising certain information content do, however, pose questions of free speech and censorship (Lazer et al., 2018).

Key Takeaways

The prevalence of misinformation on social media, which has received most academic attention in relation to the 2016 US Presidential Election, appears to be a deep but narrow issue, whereby a small and politically polarised subset of the population is most exposed to and engages the most with misinformation content. Further research is needed to generalise these findings to other contexts. Social bots play a significant role in spreading misinformation on social media. Research into the causal effect of online misinformation is restricted by issues of methodology and data availability. To date, there is no evidence for the effectiveness of misinformation campaigns in achieving social or political influence and their overall relevance is called into question by diverse media consumption habits. Potential countermeasures targeted at individuals include fact checking and improved media literacy, while on the platform side social bot detection and algorithmic design stand to curb the spread of misinformation content.

5 Conclusion and Outlook

This review brought together interdisciplinary perspectives on the contemporary information environment and its effects on individuals and groups. Over the past two decades, digital technologies have redefined modes and dynamics of interaction between individuals and the information they are exposed to, which has motivated new fields of literature in the computational social sciences and media studies but also revived interest in research on human cognition and its biases from the cognitive sciences. Even though the literature is wide, diverse and continues to grow, much work remains to be done. Directions for future research naturally emerge from the key messages of current literature synthesised in this review.

The information environment is not a universal concept, but rather it is characterised by clear geographic and demographic divides. Media consumption habits significantly differ between the Global North and South as well as between individual countries. Older generations across the world generally rely more on non-digital media sources. The young, wealthy and educated are overrepresented on social media across platforms and countries.

The information environment is also not a static concept, but rather it changes with the emergence and adoption of new technologies as well as social and political circumstances. A growing proportion of mobile-first internet users as well as a decline in the editorial power of traditional media will increasingly blur personal and mass communication in terms of both information content and delivery.

On the one hand, these factors make much empirical research on the information environment inherently contemporary and context-dependent. High public trust in newspapers in Germany does not imply the same holds in India, Angola, or even the UK. Discourse dynamics on social media that exist today might be reversed in a few years' time. Today's research is still valuable, but the limits to its generalisability need to be acknowledged. On the other hand, these factors encourage future research, which evaluates the information environment in light of technological changes, such as the emergence of new media. Such research should also devote more attention to countries outside the Global North in order to provide a more comprehensive perspective on the information environment and its effects on individuals and groups across the world. As it stands, both small-scale experimental and big data research concerning the Global South remains woefully under-represented.

Beyond exposure, as characterised by the composition of the information environment, engagement with information is the mechanism through which the information environment affects individuals and groups. Psychological research on dual process theory and motivated reasoning forms a comprehensive account of human cognition and its biases, which in turn provides a framework for evaluating individual engagement with the information environment in different contexts. Confirmation bias in particular, three types of which

were discussed in this review, is highly relevant for understanding individual behaviour, beliefs and opinions when faced with new information. People tend to give greater weight to congenial information in information-rich settings, as shown by research on the myside bias. Even factual content is often interpreted in a partisan manner, as demonstrated by evidence for motivated perception. Both phenomena occur in an information environment that tends to already be biased towards prior opinions and beliefs, as supported by the literature on selective exposure.

The credibility of information content provides another important dimension for understanding how individuals engage with their information environment. Credibility is highly context-dependent, but it can be evaluated in terms of the influence exerted on it by each component of the information transmission channel. The attributes of information sources and social signals about them as well as familiarity and semantic quality in message content can imbue credibility. Different channels are perceived as differently trustworthy, with online social media being among the least trusted. Lastly, individual attributes of the recipient, in particular ideological congeniality, can increase credibility.

This long history of literature on human cognition and engagement with new information in particular has recently gained added momentum due to its relevance for understanding contemporary social challenges, such as political polarisation or online misinformation. Future research will have to continue connecting established results from experimental settings with findings from big data analyses. Conversely, new experimental research is needed to isolate causal effects in otherwise correlational big data research and thus inform targeted policy measures.

Digital technologies have fundamentally transformed the way individuals and groups are exposed to and engage with information. The internet and social networks in particular have facilitated collective dynamics of social information diffusion at an unprecedented scale. Network context, including local network topologies as well as influential nodes in the larger network, and information content determine the degree of social influence. However, homophily of connected users as well as external influences, such as other media sources, have to be considered as alternative explanations for perceived behavioural contagion in social networks.

While the risks of these digital transformation will have to be evaluated further, current evidence suggests they might be overstated. Concerns over echo chambers, driven by cognitive biases, and filter bubbles, driven by algorithmic design, fracturing digital information environments and thus increasing social and political polarisation have only limited support in the literature. On individual platforms, echo chambers appear to exist for political issues, but their relevance fades in light of generally diverse media diets. The same applies for filter bubbles, although algorithmic opacity limits the quality of evidence. Similarly, the prevalence of online misinformation appears a deep but narrow issue, whereby a small and politically polarised subset of the population is most exposed to and engages the most with misinformation content. Its effectiveness in achieving social

or political influence, however, has not been demonstrated.

Future research will need to validate these results for more diverse contexts. An overwhelming majority of the empirical literature uses Twitter data, as it is most freely accessible, and much of it focuses on US politics, both of which severely limits the generalisability of its findings. In order to obtain stronger results on the existence of filter bubbles or the causal influence of online misinformation, researchers will also need to collaborate with platforms to obtain privileged data access, although this is in part limited by public policy and political constraints. Initiatives such as *Social Science One*, which seeks to build industry-academic partnerships for computational social science research, present a strong step in this direction. A better understanding of the extent of the risks thus posed by digital transformations is essential to inform policy responses and countermeasures.

At the time of writing, the COVID-19 pandemic is further highlighting the social and political relevance of many of the issues discussed in this review at a global scale. Digital technologies and social media in particular stand to provide a valuable tool for educating the public and disseminating health advice, leveraging the dynamics of social information diffusion on the internet. At the same time, the prevalence of online misinformation around the virus and the underlying cognitive biases that lead people to find it credible pose a very concrete threat to human lives. While the pandemic presents a uniquely disruptive challenge to society as a whole, it is also an opportunity for the academic community to step up and provide research with very real and immediate impact.

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