

Echo Chambers and Their Effects on Economic and Political Outcomes

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ABSTRACT

In this review, we survey the economics literature on echo chambers. We identify echo chambers as arising from a combination of two phenomena: (a) the extent to which individuals exchange beliefs in these chambers, i.e., the echo. We summarize the literatures on these two phenomena and suggest how to combine the two literatures, and discussing policy interventions to alleviate echo chambers.

Keywords

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1. INTRODUCTION

1.1. Echo Chambers: Motivation

The term echo chamber evokes the fate of Narcissus and his estranged lover, Echo; echo chambers have been blamed in recent years for many of our societal ills, such as populism, and polarization; and economic outcomes such as lower social mobility and higher inequality. In politics, they have been repeatedly blamed for increasing political polarization. “is tearing us apart.” He makes the connection between the segregation of US citizens and the political polarization and gridlock of recent decades. **Barber** (2016) argues that echo chambers were partly responsible for the impeachment of President Clinton.

Turmoil in financial markets has also been attributed to echo chambers. In their book *Animal Spirits*, **Akerlof & Shiller (2009)** argue that the business cycle, for example, generates chatter and media response and reminds people of long-standing pessimistic stories and theories. These stories, newly prominent in the wake of the 2008 financial crisis, spread, causing still more price declines and further reinforcement of the stories. This phenomenon is empirically examined by **Jiao et al. (2016)**.

In this review, we explore the mechanism behind echo chambers: Chambers arise when individuals segregate with the like-minded; echoes happen when individuals with those with similar beliefs can then induce extremism and polarization in society. Our focus is on the two-way relationship between segregation and beliefs.

This recent interest in echo chambers stems to a large degree from the dramatic technological changes in communication and media in the past few decades. The general tendency of people to segregate, both offline and online. In fact, the evidence about the extent of echo chambers online is not conclusive, as online interactions between groups on Facebook, and **Del Vicario et al. (2016)** find that conspiracy theories and scientific news generate homogeneous and polarized communities. Moreover, while the Internet is more segregated than offline media, it is significantly less segregated than face-to-face interactions, as **Gentzkow & Shapiro (2014)** find that polarization has increased the most among the elderly, who are the least likely to use the Internet and social media, suggesting that the role of these factors is complex.

1.2. The Mechanics of Echo Chambers

An echo chamber is a metaphor based on the acoustic echo chamber, where sounds reverberate in a hollow enclosure. The term has been used to denote the environment in which a person encounters only beliefs or opinions that coincide with their own. The Cambridge English Dictionary defines echo chambers as, “An environment in which a person encounters only beliefs or opinions that coincide with their own.”

To understand echo chambers and their influence, our framework decomposes the term into two:

1. Chambers: Individuals segregate with those who are like-minded in terms of preferences, beliefs, or attitudes.

2. Echo: Individuals are influenced in a nonrational manner by the beliefs of those with whom they communicate in their chamber.

To understand echo chambers, we first need to understand why people belong to different chambers. Individuals make many decisions that affect which social networks they join, their career decisions, or smaller decisions that we make more frequently, such as when we decide what to read, who to talk to, and what to search for online. So when we choose a job with a higher salary that we could make there, we may not anticipate the effect that this will have on our future political views. Other times we make a more informed decision based on the beliefs and attitudes of our children.

Once people are in their chamber, which could be physical or virtual, the patterns of communication and influence shape and affect attitudes, opinions, and beliefs. You might hear only a selection of opinions, those that are close to your initial views. This is especially a problem when people tend to segregate with other like-minded individuals.

Chambers and echoes are naturally connected and coevolve. The choice of chambers affects the types of echo effects that we are exposed to. It determines which attitudes and preferences influence our choices in terms of future segregation. If you were brought up to fear or dislike other groups in society, then chances are you will. Psychologists have explored a tendency to avoid information or beliefs that do not agree with our own (**Bessi 2016**). For example, when weeding through the news, we often choose what happens when people buy and consume news that they know will fit with their biased views (**Mullainathan & Shleifer 2005**).

At other times, these effects happen sequentially. We can shape our children's beliefs by the school choices that we make for them, and later, when they make their own choices, we see the unintended consequences of echo effects; one cannot fully control the types of influences that one's children will be exposed to.

1.3. Plan of the Review

The review proceeds as follows. In Section 2, we discuss the literature on segregation. We illustrate the different reasons why individuals will segregate according to preferences, beliefs, or attitudes, and how this will lead to extremism and polarization. In particular, we focus on three prominent cognitive biases: correlation neglect, selection bias, and confirmation bias. In Section 3, we discuss how these biases affect the transmission of beliefs. In Section 4, we illustrate why feedback effects between segregation and cognitive biases are important. We focus on a dynamic model in which segregation affects beliefs, beliefs affect segregation, and their harmful economic outcomes. In Section 5, we conclude by suggesting avenues for future research, theoretical as well as empirical.

2. THE CREATION OF CHAMBERS: SEGREGATION

Why do people segregate with those who are like-minded? This phenomenon has long been recognized in the social sciences. Sociologists have observed that people tend to associate with others who share similar characteristics (**2001**). Sociologists find that people exhibit homophily based on demographic or psychological characteristics. Social psychologists have found that this tendency is particularly strong in social networks.

Within economics, the key explanation for why people segregate is the existence of complementarities. Specifically, people will choose to segregate due to complementarities in preferences. A key feature: from traditional Tiebout sorting models that focus on complementarities in preferences for public goods to the more recent literature that considers complementarities in beliefs, the transmission of beliefs is important, when people wish to protect their belief system, or when individuals prefer to interact with those with similar beliefs to their own. This can be excessive.

In this section, we first discuss the increase in segregation in recent decades and how it is linked to political and economic outcomes, such as political polarization and economic inequality, according to preferences and then according to beliefs. Both models are important for the purpose of understanding echo chambers. The type of segregation that we discuss here is change and mold. ²

2.1. The Rise of Segregation and Its Consequences

The rise in the use of social media has certainly refueled the interest of scientists in the causes and consequences of segregation. For example, **Bakshy et al. (2011)** show an important role in limiting exposure to cross-cutting content. **Gilbert et al. (2009)** look at blogs and find that agreement outnumbers disagreement in blog comments. **Adamic et al. (2008)** study the Internet on the segregation of information consumption based on aggregate and individual data. They use an isolation index to define the level of ideological segregation. **Adamic et al. (2008)** show that individuals' communication networks are segregated across work colleagues, friends, family, and neighborhood associations, according to social and political variables. **Reardon & Bischoff (2011)** study the relationship between income inequality and segregation according to income in the United States. **Reardon et al. (2014)** look at the relationship between segregation in the United States and social mobility. They show large gaps between different localities, so that the effects of segregation and economic outcomes such as growth. Relatedly, a large theoretical and empirical literature has also analyzed the effects of segregation according to preferences and beliefs (**Uslaner 2012**). ⁶

The effects of segregation (e.g., income segregation) on political outcomes have also been explored; **Bishop (2009)** coined the term the big sort to describe the increasing polarization and a close correlation between economic inequality and polarization in the United States; specifically, increased growth in the top of the income distribution leads to increases in inequality. Indeed, **Bartels (2008)** and **Gilens (2012)** find that policies more often reflect the preferences of the wealthy than of those at the bottom.

Segregation can also affect economic opportunities in life through the availability of knowledge and information. **Calvo-Armengol & Jackson (2004)** show that network members. A similar mechanism underlies the findings of **Curtis & Warner (1992)**, who study the benefits of the so-called old boys network. One way **Evans & Tilley (2012)** find that 43% of privately educated individuals in the United Kingdom who have children have sent them to private schools, nearly five times as many as state school graduates. This has significant implications for labor markets through occupational choice and employment decisions. For example, in the United Kingdom, male private school graduates are more likely to be employed in high-paying occupations than private school students believe that people who attend their school will be very successful, compared to 9% of state school pupils (see **Nasiroglu 2016**). Similarly, selective state schools perform no better than those in standard state schools in achievements tests. ⁸

Above, we establish that segregation is an important aspect in determining political and economic outcomes; in this section, we proceed to explain why it happens and attitudes. Our plan is to illustrate how segregation with like-minded individuals can affect beliefs and create the consequences discussed above.

2.2. Preference-Based Segregation

Many traditional models in economics consider sorting according to preferences. For example, Tiebout models, originating from the work of **Tiebout (1956)**, show that individuals who care more about a particular set of goods are better off congregating in their own locality. Thus, preference complementarities can fuel segregation. Recent work in the production of religious goods such as rituals and communal praying.

Recent contributions to this literature highlight the equilibrium effects that arise when individuals segregate according to taste or income. **Bénabou (1996)** shows that, such as knowledge spillovers. Sorting families into homogeneous communities often minimizes the cost of existing heterogeneity, but mixing increases the cost. **Seshadri 2017**. **Baccara & Yariv (2016)** study the formation of peer groups in an environment where each group can produce two distinct public goods that require a public good contribution. When contribution costs are low relative to connection costs, mutually optimal groups are relatively homogeneous (see also **Peski 2017**). We examine what groups are formed. The theoretical model predicts different possibilities, some in which more sorting occurs and some in which individuals c

2.2.1. Complementarities in networks: information flows and learning.

The literature on social networks has produced many results pertaining to the study of segregation (for a survey, see **Jackson 2011**). One strand of this literature, **1982**), we know that the level of communication is inversely related to the distance in preferences. As a result, we expect high levels of homogeneity in communities. We study a model of multiplayer communication in networks. Privately informed decision makers have different preferences about the actions that they take and how they facilitate information transmission and will create complementarities in information and thus efficient decision making.

Similarly, **Giovanniello (2018)** shows how people choose to exchange information with like-minded individuals to the effect that chambers are created. She considers a model in which voters can be ideologically close but still biased toward different parties. In that case, information flows are not sufficient to create a chamber. She considers a model in which voters can be ideologically close but still biased toward different parties. In that case, information flows are not sufficient to create a chamber and biased in the same direction to exchange information. ⁹

The papers discussed above, while focusing on preference-based segregation, show that this type of segregation also has implications for what information

2.2.2. Cultural transmission of preferences.

Another important channel that encourages individuals to segregate is cultural transmission, first analyzed by **Bisin & Verdier (2001)**. Specifically, if parents and others share the same preferences. Thus, complementarities arise through peer effects on transmission of values. **Advani & Reich (2015)** show how cultural transmission creates incentives: Individuals prefer to maintain their cultural practices, but doing so can inhibit interaction and economic exchange with those who adopt different practices. A certain critical mass may retain diverse practices and may also segregate from the majority. They also test their predictions using data on migrants to the United States. As heterogeneous populations changes discretely toward cultural distinction and segregation. **García-Alonso & Wahhajz (2018)** analyze the dynamic effects of cultural transmission on segregation.

2.3. Belief-Based Segregation

In this section, we consider the mechanisms behind why individuals who share similar beliefs might segregate together. These mechanisms and the segregation

2.3.1. Cultural transmission of beliefs.

We see above that, when parents consider the values that they transmit to their children, they may be inclined, due to peer effects, to segregate with individuals who share their beliefs. For example, imagine the thought process of parents who are deciding to which school to send their child. There might be many trade-offs involved in this decision. The child's beliefs, through socialization with friends or through teachers (for example, one school might be secular, while the other is a religious school). The paper shows that segregation in schooling (private versus state) and labor market discrimination. They show that the parents' dilemma leads to segregation into different sch

2.3.2. Segregation to maintain beliefs: religious segregation.

A related reason for segregation is that individuals or groups may seek to actively avoid knowledge or beliefs that are counter to their own. One important example is the ultra-Orthodox Jews in Israel who segregate away from the secular Jewish population both physically and through their beliefs. **(2000) and Razin (2018)** document how the ultra-Orthodox Jews in Israel segregate away from the secular Jewish population both physically and through their beliefs. This is found to be more highly segregated in contrast to the landscape of ethnicity.” **Field et al. (2008)** find that more than 70% of the population in Ahmedabad is found to be more highly segregated in contrast to the landscape of ethnicity.” **Field et al. (2008)** find that more than 70% of the population in Ahmedabad is found to be more highly segregated in contrast to the landscape of ethnicity.”

While religious individuals may segregate for many reasons, for example, due to complementarities in behavior, one of the most important reasons is the desire to avoid others’ behaviors or beliefs. Specifically, **Levy & Razin (2012)** model a theology of reward and punishment in relation to behavior in the social sphere. In particular, they model interactions. Holding these beliefs allows the religious to sustain cooperative outcomes that may not be available otherwise. However, religious beliefs are not sustained in the long run. To sustain religious beliefs, individuals should be guarded from observing behaviors and outcomes that do not agree with their beliefs.

Attempts to protect communities from information can be seen more generally when organizations wish to protect a belief system that may not be immune to information. Segregation according to beliefs.

2.3.3. Segregation due to prejudice about others’ behavior.

Segregation may also arise when the beliefs of individuals are prejudiced against a particular population, and individuals segregate to avoid interaction with that population. **(1973)** were the first to document what they call the White flight from inner-city neighborhoods and toward predominantly White areas; **Cantle & Kauffman (1996)** and **(2001)** and **(2011)** the White British population in England reduced as a percentage of the total population from 86.8% to 79.8%—a decrease of 8%. Although the proportion of White British in 2001 than in areas which had a high proportion.... This does indicate support for ‘more mixing and more clustering,’ but they also find that White British people left the city, most of whom moved to Whiter areas; Whites left London at three times the rate of minority individuals.

While the reasons for this type of segregation could be correlated with income inequality, as richer White individuals may move to bigger houses away from the city center; cut; it may be that individuals’ views change for the worse after they have already moved. However, a more direct explanation is that the people who moved to the suburbs had their beliefs to be even more prejudiced. Indeed, **Dustmann & Preston (2007)** find strong evidence that racial or cultural prejudice is an important component of the decision to move. In France in which refugees were settled (which were randomly assigned), locals had more positive views on foreigners and were less likely to vote for the Front National.

Levy & Razin (2018b) consider an environment in which individuals in the home society are prejudiced against foreign immigrants and are suspicious of their economic efficiency. This is inefficient, which makes it worthwhile for prejudiced individuals to segregate away from immigrants. Specifically, it is those with the most prejudiced beliefs who segregate. We discuss in this section how individuals are motivated to segregate with like-minded people. While the traditional literature has looked at segregation according to beliefs, echoes can easily be created; this is the topic of the next section.

3. THE CREATION OF THE ECHO: BEHAVIORAL BIASES IN BELIEF UPDATING

A large body of literature shows that segregation affects beliefs. In social psychology, contact theory posits that beliefs are affected by segregation through the process of interaction. **Tropp 2006)**. **Boisjoly et al. (2006)**, **Algan et al. (2015)**, **Burns et al. (2016)**, and **Vertier & Viskanic (2018)** show how interacting with individuals from different backgrounds affects beliefs. This is a topic of immigration.

How beliefs are affected by others’ beliefs about us or by observing other pieces of information is, of course, a more general problem and not specific to segregation. How good are we at aggregating all of these pieces of information? In economics, the traditional assumption of rationality implies that individuals will process all information. This is a view of our ability to process information. In political science, for example, a large literature documents the incompetency of voters in collecting and processing information. **(1996, Kinder & Sears 1985)** and to use the information that they do have incorrectly (**Achen & Bartels 2004, Healy et al. 2010, Huber et al. 2012, Lau & Rose 2003**).

One of the most striking contributions to the political science of half a century of survey research has been to document how poorly ordinary people process information.

Psychologists have also taken a grim view of individuals’ abilities to make sense of the information presented to them. A good example of this is the strong evidence that individuals are biased in their processing of information. These papers reveal different biases that impact individuals who are exposed to different pieces of information (see **Rabin 1998**). More recently, these results have been used in economic models.

In this section, we survey a few of these cognitive biases as they relate to the creation of echo chambers. A good starting point to think about this issue would be to think about how individuals interact with friends and family, and talking to colleagues at work, and you might spend some time on social networks. Daily, this might amount to large quantities of information. If individuals are rational and have correct beliefs about the nature of interactions in their network, then no echo effects will exist. On average, people will have correct beliefs. However, cognitive biases that might arise when people interact and glean information within their chambers.

A few aspects of your interactions outlined above imply that it is not easy to aggregate all of this information properly. For one thing, the network of interactions is complex. Amir, might be telling you something. However, Amir might have also talked with Neeve, and you told Neeve something similar the previous day. How then do you aggregate this information. This is what we term correlation neglect.

However, there is another problem that could make your inference complicated; this problem is related to the composition of your social network. In particular, you might be surrounded by things that agree with your own views. In these cases, some individuals might err by overweighing what Amir and Neeve say due to a selection bias.

Finally, every now and then, perhaps at your workplace, you encounter other individuals, such as Francesco, that have very different things to say than do Amir and Neeve, which not only will you put too low a weight on what Francesco says, but you might also become stronger in your opposing conviction after the encounter.

The key mechanism that we explore in this review is how segregation and cognitive biases work together to create the effects of echo chambers. For this reason, we focus on how cognitive biases exacerbate polarization in the presence of segregation.

3.1. A Basic Model to Introduce Biases

The simplest way to think of the cognitive biases that we consider is to assume that individuals do directly observe the information of others but have difficulty processing it. Let $\omega \in \{l, h\}$. They all have a common prior that the states are equally likely.

For example, the state could correspond to the fate of the United Kingdom after Brexit, where a low state implies low growth, and a high state implies high growth. We consider a referendum about Brexit.

Individuals start with some beliefs about the states. Let q^i denote the belief of individual i that the state is high, with $1 - q^i$ denoting the belief of that individual that the state is low. $\Pr(s = h | \omega = h) = \Pr(s = l | \omega = l) = q \geq 1/2$. In this case, the Bayes' rule implies that receiving a signal h will yield the (high) belief $q = \Pr(\omega = h | s = h)$, and receiving a signal l will yield the (low) belief $1 - q = \Pr(\omega = l | s = l)$. We focus on the effects of Brexit on the United Kingdom labor market.

When individuals interact in their social network, they share their opinions with each other. To focus attention on cognitive biases, rather than any strategic behavior, we assume that individuals update their beliefs? This is what we consider in the sections below. Note that, while we focus on three biases that relate to the creation of echo chambers, other biases such as individuals manipulate their own beliefs, as in the motivated beliefs literature (Bénabou 2013; Bénabou & Tirole 2011, 2016; Le Yaouanq 2018), which we do not consider here.

3.2. Correlation Neglect

As discussed above, there are many reasons to believe that, in social networks, individuals' sources of information are correlated in complex ways. Correlation neglect is the assumption that sources of information are conditionally independent. This is a simple way to combine information sources into a unique prediction.

A recent empirical and experimental literature has shown that, in complex environments, decision makers indeed ignore correlations to some degree. For example, Eyster & Weizsäcker (2011), Kallir & Sonsino (2009), Bai et al. (2015), and Enke & Zimmermann (2019) provide experimental evidence for correlation neglect.

Below, we formally define correlation neglect in the context of our model. To define correlation neglect, assume that N individuals exchange their beliefs q^i . The correlation neglect belief, q^{CN} , will be uniquely determined as

$$q^{CN} = \frac{1}{\prod_{i=1}^N q^i + \prod_{i=1}^N (1 - q^i)}$$

Thus, for example, if a share α of N individuals had received the h signal and has belief $q > 1/2$, and a share $1 - \alpha$ had received the l signal and has belief $1 - q < 1/2$, then

$$q^{CN} = \frac{q^{\alpha N} (1 - q)^{(1 - \alpha)N}}{q^{\alpha N} (1 - q)^{(1 - \alpha)N} + (1 - q)^{\alpha N} q^{(1 - \alpha)N}}$$

with $q^{CN} \rightarrow 1$ for a large N and $\alpha > 1/2$, and $q^{CN} \rightarrow 0$ for a large N and $\alpha < 1/2$. If, for example, the true information structure that had generated these initial beliefs is complex, then beliefs will become excessively extreme.

More generally, it is easy to see from Equation 1 that the belief updating function satisfies the following properties. First, confident individuals are very persuasive. Second, beliefs are monotone: They increase in peers' beliefs. Finally, belief updating can also exhibit extremism and polarization: For a set of beliefs where $q^i > 1/2$ for all i , then the correlation neglect belief q^{CN} will satisfy $q^{CN} > \max_i q^i$. If $q^i < 1/2$ for all i , then $q^{CN} < \min_i q^i$. Thus, observing a selection of similar beliefs will induce polarization. If beliefs are mixed, then polarization will arise.

The above definition captures individuals who fully neglect the possibility of correlation. Some individuals might be concerned about the correlation neglected in the above characterization of individuals that cannot account for correlation (or complexity, in their terminology). Levy & Razin (2018a) propose a model in which individuals are concerned about correlation. Razin (2018a) show that it can be written as

$$q_k^{\text{CN}} = \frac{\lambda_h \prod_{i=1}^N q^i}{\lambda_h \prod_{i=1}^N q^i + \lambda_l \prod_{i=1}^N (1-q)}$$

where λ_h, λ_l are parameters that capture degrees of correlation across the information in the different states, high or low. However, when $N \rightarrow \infty$, in many cases correlation neglect can arise when we face big data, the naive interpretation of which according to the q^{CN} is sufficiently precise (but not necessarily correct) to overwhelm this, and they will behave as if they have full correlation neglect. ¹³

3.3. Selection Bias

When the information that you are exposed to is not randomly assigned, selection bias might arise. For example, suppose everyone in your vicinity has q^i as a result of the fact that you and the people around you all chose to interact with one another. If the latter is the case, you should decrease the weight that you

Below, we introduce a formulation of selection bias used by **Levy & Razin (2017)** to model socialization in schools. In the context of our simple information model, individuals with high beliefs q and thus high beliefs $1 - q$, a share $1 - \alpha$, communicate only with each other. Selection bias arises because individuals in the population. In these two groups, beliefs involving selection bias will differ and will depend on the signal l or h :

$$q^{\text{SB}}(h) = \frac{q^{\alpha N}}{q^{\alpha N} + (1-q)^{\alpha N}} > q^{\text{SB}}$$

Frick et al. (2018) use a similar notion of selection bias, which they term assortativity neglect, and provide a theoretical foundation for it as a model of misperception.

Note that selection bias is related to correlation neglect and will thus give rise to similar dynamics. In particular, within each group, we will have a process of opinion formation across groups. To understand exactly the patterns of extremism and polarization, one would have to combine the analysis of endogenous segregation

3.4. Confirmation Bias

While selection bias arises because of our choices of with whom to interact, confirmation bias arises from the way in which we interpret what we see. Confirmation bias associated with confirmation bias is the one by **Lord et al. (1979)**. They show that individuals exposed to the same information can polarize their beliefs in

Using our model, we can represent confirmation bias in the following way. In a sense, for confirmation bias to arise, we do not need segregation per se, as those who have high beliefs $q > 1/2$, and that a share $1 - \alpha$ observed the low signal l and have low beliefs $1 - q < 1/2$. Suppose that the individual who has posterior q , and such confirmation bias and their signal h , they end up with the following belief:

$$q^{\text{CB}}(h) = \frac{(q)^{\alpha+(1-\alpha)\beta}}{(q)^{\alpha+(1-\alpha)\beta} + (1-q)^{(1-\alpha)(1-\beta)}}$$

In contrast, an individual with posterior $1 - q$ who had observed the signal l will interpret high posteriors as low ones with probability β , and thus will end up

$$q^{\text{CB}}(l) = \frac{(q)^{\alpha(1-\beta)N}}{(q)^{\alpha(1-\beta)N} + (1-q)^{((1-\alpha)+\alpha\beta)N}}$$

Again, when N is large enough, we have $q^{\text{CB}}(h) \rightarrow 1$, and we have $q^{\text{CB}}(l) \rightarrow 0$ when β is large enough (compared with α). Thus, confirmation bias is sufficient to

In this case, segregation is not physical, but rather is created by selective interpretation of information: If, when browsing online, individuals interpret the content makes individuals become more convinced of their views and thus creates polarization.

3.5. Environments that Facilitate Biases

A question one may want to ask is when we should expect the above biases to arise. For example, when an individual reads news from different outlets, online correlation neglect. Therefore, to understand the relevance of correlation neglect, we need to understand the sources of correlation in our environment. In the

3.5.1. Online replication of news.

One avenue through which correlation neglect might arise is the replication of online (as well as offline) news content. There is a good reason to think that correlation across outlets. **Cagé et al. (2017)** study copyright in news media, following pieces of news as they trickle through different outlets, including social media. The original. Still, despite the prevalence of copying, media outlets rarely name the sources that they copy. Thus, readers are exposed to repeated news, potentially

News aggregation websites are another example of how media is copied and the sources of information made harder to trace. These sites publish their own

3.5.2. Exposure to multiple sources of information.

It is also clear that people read multiple sources of information. Individual-level survey data on 18 countries from Reuters Institute for the Study of Journalism document the consumption patterns of news consumers and show that individuals use multiple outlets to learn about news (see also **Pew Res. Cent. 2012**).

3.5.3. Segregation and complexity of communication in networks.

As we discuss in Section 2, segregation, be it physical or online, is an inherent trait of society. Segregation patterns are very complex and imply that individuals you are exposed to and the correlation structures between the pieces of information that you consume.

Repeated communication in groups and more generally in networks is often considered to impose large informational requirements on individuals. Individuals influence their neighbors. This implies that it may be very difficult to trace the path that a piece of information takes in an environment with repeated communication.

The network literature has typically taken one of two avenues. The first is the fully rational approach, which assumes that individuals are fully aware of the network structure and use a heuristic when updating. A leading example is the DeGroot heuristic, where individuals average their and others' beliefs, as in the work of **Golub & Jackson (2010)**. The second is correlation neglect. They show that multiple rounds of communication together with correlation neglect imply that views will become concentrated on a single individual.

These avenues are two polar ways to model information diffusion, one based on full rationality and the other based on an ad hoc heuristic. A third avenue, where individuals' beliefs are averaged; however, using g^{CN} as above leads to polarization and extreme beliefs. ¹⁵

In the literature on social learning in networks, some have identified correlation neglect with a redundancy bias (**Gagnon-Bartsch & Rabin 2016**), whereas others have identified a model misspecification in the context of herding (see also **Guarino & Jehiel 2013**, **Mueller-Frank & Neri 2013**).

3.5.4. Machine learning and artificial intelligence.

Online browsing has become more and more complex through the years. Today, the algorithms used by search engines and other stakeholders on the Internet are designed to show individuals with content that would appeal to them. New machine learning and artificial intelligence (AI) algorithms have been shown to amplify existing biases. For example, technology researchers with an AI algorithm called Norman, showing how very different outcomes result from feeding the application with different information. This highlights our understanding of the correlation structures behind the multitude of pieces of information we are exposed to.

Bakshy et al. (2015) analyze how online networks influence exposure to perspectives that cut across ideological lines. They examine how 10.1 million US Facebook users with heterogeneous friends could potentially expose individuals to cross-cutting content. They then quantify the extent to which individuals encounter compared to random exposure to ideologically discordant content. They show that both the algorithmic ranking and, to a larger degree, individuals' choices played a role in limiting exposure to ideologically discordant content.

3.5.5. Concentration of ownership implies correlation.

The intervention of owners in the editorial decisions of their news outlets has always been an important issue in the debate about the regulation of the media. In 2018, the UK culture secretary decided to refer 21st Century Fox's £11.7 billion bid to seize full control of satellite broadcaster Sky to the Competition and Markets Authority. In the US, "To secure the deal, 21st Century Fox had to take some measures that would ensure that Sky's news for five years at current funding levels."

3.6. Strategic Manipulation of Cognitive Biases

The existence of the cognitive biases that we survey above opens the door for interested parties to take advantage of consumers or voters. A recent example is the use of the Facebook data were used was for the creation of targeted messages tailored to the characteristics of users. In addition, Cambridge Analytica allegedly shaped the 2016 election. Another example is the use of real-time information about which messages were resonating to shape Donald Trump's travel schedule during the 2016 election. This highlights the ability to deliver an immigration-focused speech (see **Illing 2018**).

Recently, literature in economics and political science has shed light on strategic influence in the presence of cognitive biases. **Levy et al. (2018a,b)** analyze a model of informative campaign advertising and shows how the ability of voters to strategically communicate with each other shapes the advertising strategy. They show how this leads firms to slant their news reports in the direction of such bias. **Przybylo et al. (2018)** show that voters read news items that agree with their views or confirm their bias. They show how this leads firms to slant their news reports in the direction of such bias. **Przybylo et al. (2018)** show that voters read news items that agree with their views or confirm their bias.

3.7. Are Cognitive Biases (and Polarization) Necessarily Harmful?

The above discussion shows evidence for the existence and prevalence of cognitive biases in acquiring information. These biases will lead to individuals holding incorrect beliefs. While, intuitively, we might think that cognitive biases are bad for voters, a recent literature in behavioral political economy shows that these biases might sometimes be beneficial. In a signaling game, voters receive a value shock. All voters prefer the policy on the right when the common shock is to the right and the policy on the left when the common shock is to the left, but voters have different preferences. Signals are correlated, but behavioral voters neglect the correlation in these sources, while rational voters do not. The key result in this paper is that, if voters vote optimally from their own point of view (compared to a rational voter), the whole electorate may reach better, more informed outcomes (compared to a rational electorate) with the policy that accords with the direction of their political preferences may be swayed to change their vote if they believe that their information is sufficient. While correlation neglect is harmful for individuals, it may be better for society on average. **Levy & Razin (2015b)** show, in the context of political polarization, that this is the case. **Lockwood (2019)** shows the implications of confirmation bias in a political agency setting. In his paper, as opposed to the rest of the literature that focuses on confirmation bias after the election, actions are observable before the election, confirmation bias decreases pandering by the incumbent and can raise voter welfare as a consequence. Similarly, signaling bias can improve politicians' incentives to choose the right policies (due to a reduced signaling motivation).

The key idea in the literature surveyed above is that the political system, even without taking into consideration cognitive biases, is already flawed. It sometimes reflects voters' preferences. When there are other types of inefficiencies in the political system, it is sometimes useful for voters to be overconfident or for voters to ignore information. However, different cognitive biases might imply very different normative results. **Levy & Razin (2015a)** show that, when voters have confirmation bias, the underlying cognitive bias that voters have.

3.8. Other Biases

Above, we consider models in which individuals are restricted from updating information properly, which implies that echo chambers can arise. This failure is due to some cognitive constraints. Other models in the literature instead analyze how individuals may be compelled to manipulate their own beliefs to affect their behavior. This motivated beliefs incentive, explored for example by **Bénabou & Tirole (2006, 2011)**, can then also be used to manipulate beliefs in the same way.

4. THE DYNAMICS OF ECHO CHAMBERS

Sections 2 and 3 survey the literatures on segregation (chambers) and cognitive biases (echoes). In this section, we analyze the feedback effects between segregation and beliefs. Whom we interact. However, our decisions about where to live and who to talk to are also shaped by our beliefs. Therefore, to fully understand the implications of segregation, then we might make wrong inferences about causality. For example, **Dustmann & Preston (2001)** analyze how segregation in neighborhoods affects attitudes toward minorities, but their beliefs and attitudes toward minorities, have biased results due to neglecting location choices, which depend on these beliefs.

To illustrate the feedback effect between segregation and beliefs, we focus on the example of schooling. **Levy & Razin (2017)** analyze how echo chambers in schooling affect beliefs over periods, and three stages in each period. In the peer influence (echo) stage, segregation affects beliefs. In this stage, individuals' beliefs about schools are shaped by their beliefs. Employers decide whether to hire an employee based on the school that the potential employee graduated from and their own beliefs about the school. Labor market discrimination affect segregation choices. In this stage, parents choose to which school—state or private—to send their offspring. Thus, the model uses imperfect empathy in parental school choice, as in the work of **Bisin & Verdier (2001)**. Parents base their decisions on their expectations about their children's beliefs and by their own beliefs. Therefore, parents have to form expectations about how the school will affect their child's future beliefs and behavior. The imperfect empathy creates homophily; that is, parents would rather their children segregate with like-minded others so that their child's belief does not stray too far from their own.

Levy & Razin (2017) find a simple necessary and sufficient condition that characterizes when segregation, polarized beliefs, and discrimination persist in the long run (and above actual productivity differences). Parents who send their children to a private school believe that the difference between the schools is greater than the actual difference. Finally, those who went to private (state) school will also send their children to a private (state) school. Thus, the old boys network is endogenous. The analysis centers on the race between echo chamber effects and true learning.¹⁷ First, history matters; to create long-run segregation and polarized beliefs, the easier it is to create segregation and polarization. Finally, polarized beliefs are easier to sustain the less that individuals learn about others from their own experience. Those who segregate into the private school have sufficiently mixed beliefs that belief polarization cannot arise.

In the dynamic model above, the school choices of parents affect the beliefs of their children, and these in turn affect their schooling choices when they are in the labor market. In which individuals segregate into different interaction groups but could hold misperceived beliefs about what happens in other groups. Their equilibrium beliefs must be correct. **Frick et al. (2018)** then show that misperceptions similar to our notion of selection bias, discussed above, have the property that true beliefs suggest a notion of equilibrium that also demands that beliefs about one's interaction group are always correct. Moreover, **Windsteiger (2018)** adds an additional restriction: neighboring groups chose to stay in their groups and not to switch groups. She shows that this additional restriction refines the set of equilibria in a useful way.

5. FUTURE RESEARCH

In this section, we conclude our survey by pointing out potential avenues for future research stemming from the discussion above. We consider relevant issues. A central empirical challenge at the heart of studying echo chambers is causality. As we see above, there are feedback effects between the formation of chambers and beliefs due to self-selection or due to a different process of belief formation that occurs once segregation has arisen?

Even when we focus on analyzing how beliefs evolve in a chamber following segregation, empirical challenges remain. Specifically, consider the case of prejudice. Prejudice can be reduced (**Allport 1954, Hewstone & Brown 1986**). According to this theory, individuals who interact with other groups start using information gleaned from those groups to reduce attitudinal and behavioral measures of negative evaluation.¹⁸

Whether contact is helpful, however, may depend on the specific interactions among individuals. One needs more data about the nature of interactions between groups and the distribution of interactions between different groups. Is group A interacting with group B mainly as employers versus employees, or are they engaged in more complex interactions? Lowe recruited 1,261 young Indian men and randomly assigned men from different castes to participate in month-long cricket leagues; he shows that

generally has no effect or even harmful effects.

For policy making, it is important to understand the sources and mechanisms that drive echo chambers. For example, are online echo chambers supply or demand driven? Limiting exposure to cross-cutting content. As we see above, understanding the types of biases that drive these effects is also important, as potential remedies. At this end, experiments can provide a valuable way to understand in what environments behavioral biases of information processing can be mitigated. A recent study shows how correlation neglect can be overcome in different ways depending on the context, framing effects, and the complexity of the problem.

From a theoretical point of view, there are a few methodological issues to consider in addition to policy implications. Methodologically, equilibrium analysis is often used in models. These include behavioral equilibrium notions such as cursed equilibrium (Eyster & Rabin 2005) and analogy-based equilibrium (Jehiel 2005). Espinosa et al. (2018a) show, which provides another reason for the break-up of media conglomerates. Targeted algorithms can facilitate provision of information through public campaigns to inform and correct individuals' wrong beliefs, as well as to reduce polarization. A second, less direct, role for governments in the context of media is to ensure that algorithms are transparent and consistent with recent European Union regulation and will help clarify how information is generated and disseminated, such as segregated schools or neighborhoods.

An important extension of current research is the role for government intervention. There are several ways in which governments can intervene to improve the quality of public campaigns to inform and correct individuals' wrong beliefs, as well as to reduce polarization. A second, less direct, role for governments in the context of media is to ensure that algorithms are transparent and consistent with recent European Union regulation and will help clarify how information is generated and disseminated, such as segregated schools or neighborhoods.

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