Governance by and of Algorithms on the Internet: Impact and Consequences

Michael Latzer and Natascha Just

Subject: Communication and Technology, Communication Theory, Communication and Social Change, Media and Communication Policy
Online Publication Date: Feb 2020 DOI: 10.1093/acrefore/9780190228613.013.904

Summary and Keywords

Internet-based services that build on automated algorithmic selection processes, for example search engines, computational advertising, and recommender systems, are booming and platform companies that provide such services are among the most valuable corporations worldwide. Algorithms on and beyond the Internet are increasingly influencing, aiding, or replacing human decision-making in many life domains. Their far-reaching, multifaceted economic and social impact, which results from the governance *by* algorithms, is widely acknowledged. However, suitable policy reactions, that is, the governance *of* algorithms, are the subject of controversy in academia, politics, industry, and civil society. This governance by and of algorithms is to be understood in the wider context of current technical and societal change, and in connection with other emerging trends. In particular, expanding algorithmizing of life domains is closely interrelated with and dependent on growing datafication and big data on the one hand, and rising automation and artificial intelligence in modern, digitized societies on the other. Consequently, the assessments and debates of these central developmental trends in digitized societies overlap extensively.

Research on the governance by and of algorithms is highly interdisciplinary. Communication studies contributes to the formation of so-called “critical algorithms studies” with its wide set of sub-fields and approaches and by applying qualitative and quantitative methods. Its contributions focus both on the impact of algorithmic systems on traditional media, journalism, and the public sphere, and also cover effect analyses and risk assessments of algorithmic-selection applications in many domains of everyday life. The latter includes the whole range of public and private governance options to counter or reduce these risks or to safeguard ethical standards and human rights, including communication rights in a digital age.

Keywords: algorithms, Internet, governance, automation, artificial intelligence, algorithmic decision-making, personalization

Introduction

In the past decade, "algorithm" has become one of the central buzzwords in academic and public debates on digitalization and the Internet. Internet-based services that build on automated algorithmic-selection processes for searches, predictions, recommendations, and scoring are booming, pervading more and more life domains (Latzer, Hollnbuchner, Just, & Saurwein, 2016). This growing societal importance is reflected in terms such as algorithmic age (Danaher et al., 2017), algocracy (Aneesh, 2009; Danaher, 2016), and algorithmic culture (Striphas, 2015). Markets for algorithmic services, among other things, search, dating, film and music recommendations, and computational advertising, are often highly concentrated on a global level. Service providers of algorithm-based applications such as Alphabet, Apple, Amazon, and Facebook are among the most valuable and powerful companies worldwide. Risk-awareness about the possible impact of rising algorithmizing in everyday life is growing. It is fueled by scandalized algorithmic applications, and discussions about adequate regulatory reactions are intensifying accordingly. Multidisciplinary research on various aspects of algorithms is also growing and forms the emerging field of "critical algorithms studies."

There are many different definitions and meanings of algorithm. Some authors refrain from using the term algorithm, and rather stick to "code" or "computer systems" (Kroll et al., 2017) in order to grasp the phenomenon analytically. The respective terminology often reflects disciplinary perspectives and is dependent on specific research questions and goals in the field of algorithm studies. For the purpose of an overview of these studies, a broad definition of algorithms as "problem-solving mechanisms" seems appropriate. A common feature of such problem-solving mechanisms on the Internet are automated algorithmic selection (AS) processes, which can be defined as the automated assignment of relevance to selected pieces of information (Latzer et al., 2016). Further, these algorithmic selection systems, which are constituents of various different Internet services, can be described as input–throughput–output systems. Small or big data form the input of such systems, and various algorithms (e.g., for search, filter, prognosis) form the core of the throughput phase. Altogether, input–throughput–output models can form the basis for a systematic understanding of Internet-based services that rely on AS processes (Latzer et al., 2016). A definition of algorithms according to an input–output model is, for example, provided by Gillespie: "encoded procedures for transforming input data into a desired output, based on specified calculations" (Gillespie, 2014, p. 167).

In order to grasp the resulting large and fragmented body of research, an initial analytical distinction in governance *by* and *of* algorithms (Latzer et al., 2016) proves helpful. In general, a governance perspective focuses on institutional steering. Governance *by* algorithms directs the attention towards the steering mechanisms by specific software systems and consequently towards the economic and social effects of algorithms on individuals and the society, that is, on all the opportunities and risks involved. Governance *of* algorithms builds on these results and focuses on the need, options, and actual policy reactions to shape and control algorithms and their use.

Further, algorithm studies differ with regard to their *units of analyses* and can be divided into two groups: the first group focuses on (single) algorithms per se as their unit of analysis, and the second group on the socio-technical context of applications that operate on algorithmic selection. Studies that research the algorithm itself aim to show its capabilities and to detect its inner workings, typically by reverse engineering the code (Diakopoulos, 2015), experimental settings (Jürgens, Stark, & Magin, 2015), or code review/auditing (Sandvig, Hamilton, Karahalios, & Langbort, 2014). In these studies, the overall social power that algorithms exert is widely discounted, because algorithms are studied in isolation, following a mere quest to uncover the workings of the algorithm. Consequently, algorithms remain "meaningless machines" (Gillespie, 2014) or "mathematical fiction" (Constantiou & Kallinikos, 2015) as the risks associated with the use of applications that operate on algorithmic selection and their wider social implications are unaccounted for. This is remedied in studies that focus on the socio-technical context of applications that integrate algorithmic selection. Here algorithms are viewed as situated artifacts and generative processes embedded in a complex ecosystem (Beer, 2017; Willson, 2017). Algorithms are considered as only one component in a broader socio-technical assemblage (Kitchin, 2017) that comprises technical (e.g., software) and human (e.g., uses) components (Willson, 2017).

Only some of the algorithmic systems that are applied in various Internet services can be classified as *artificial intelligence* (AI), or as machine learning, which forms a major part within AI and follows earlier expert-system approaches. Algorithmic systems that, for example, include deep learning via neural networks, image recognition (e.g., generative adversarial networks for the generation of images without training data), and speech recognition/generation (e.g., natural language processing and generation for algorithmic/robotic journalism, or conversational user interfaces such as chat- and voice-bots) are prime examples of AI-based applications. Conventionally programmed applications do not fit this category. Hence the specific risks and challenges of AI (Larus et al., 2018; OSTP, 2016) only apply for a (growing) subgroup of algorithmic systems, basically for different kinds of supervised and unsupervised learning systems. It should be noted that all current AI applications in algorithmic selection systems on the Internet under discussion here are part of so-called "weak/narrow AI," which basically refers to rule-based systems that simulate human intelligence in order to solve well-defined application problems.

Applications of algorithmic systems can be found in Internet-based services (purely software based) and embedded in hardware devices such as self-driving cars, automated weapons such as drones, all sorts of robots, and Internet of Things (IoT) applications. This entry focuses on Internet-based algorithmic services. They are taking over many functions or tasks that arise in daily life. Latzer et al. (2016) provide a functional classification—derived from an analysis of more than 80 services—that comprises nine areas of application: search, aggregation, observation/surveillance, prognosis/forecast, filtering, recommendation, scoring, content production, and allocation applications. A categorization according to these now partially automated daily tasks provides an overview of the scope of algorithmic selection applications and can form the basis for systematic analyses. Initially, most research was carried out on search and recommender systems, as the most wide-spread algorithmic services with great economic significance; more recently, filtering in the form of content moderation has attracted growing attention in academia and politics (Gillespie, 2018; Langvardt, 2018). It must be pointed out that most of the services integrate more than one of these algorithmically automated functions and perform them either as a *core* task, where the products demanded are the results of algorithmic selection, for example search services, or as an *ancillary* task, where the results of AS support core services in order to gain competitive advantages, for example recommendations in e-commerce services.

Governance by Algorithms

The operating modes and mechanisms of how algorithmic systems influence social and economic processes, and their multifaceted effects on societies, can analytically be conceived of as governance by algorithms. Algorithms are software technologies and their institutional steering is therefore an example of governance by technology, raising similar questions and asking for the same, well-tried analytical distinctions employed in technology studies (e.g., Dolata & Werle, 2007; Rammert, 2008) Are these algorithmic applications designed to augment or to replace human decision-making? Are algorithms used by humans purely as fully controlled tools to govern, or are they designed to govern autonomously as agents, and if so to what extent? What are the unintentional effects of algorithmic governance? In-depth insights into and due consideration of these distinctions are a prerequisite for better informed, nuanced public policy decisions, that is, for the governance of algorithms.

The heavy focus on and use of the term *algorithmic decision-making* in academic and public debates stems from the AI perspective and may be misleading in the current context of many Internet-based applications. It implies the (wide-scale) replacement of delicate human decision-making by technology, which is not the case for many Internet-based applications, which are rather designed to augment human decision-making (e.g., search engines, content aggregators, scoring and recommender systems). This is different for automated hardware devices such as self-driving cars, where the focus on autonomy and controllability and the division of labor between human and non-human actors is far more accentuated. Nevertheless, for studies of Internet-based AS applications the distinctions between different degrees of autonomy (e.g., as established for self-driving cars in five degrees; see Bagloee, Tavana, Asadi, & Oliver, 2016) or in categories where humans are *in*, *on*, or *out of the loop* (as already discussed for weapons systems; see Citron & Pasquale, 2014) can also prove helpful.

Literature on the *benefits* and positive effects of algorithmic systems—which include increased efficiency, falling transaction cost, scalability, and adaptability as general purpose technology (Bresnahan, 2010)—is rather scarce and general in nature as compared with the work on the *risks*, harms, and negative effects of algorithms, which form the basis for the governance of algorithms (see “GOVERNANCE OF ALGORITHMS”).

In communications, discussions about the governance by algorithms often focus on the influence on opinion formation and consequently the potential for its manipulation during polls and elections by way of personalization, which is executed via biased filter bubbles (decreasing variety of content), microtargeting (e.g., political microtargeting, see Zuiderveen Borgesius et al., 2018; or online behavioral advertising, see Boerman, Kruikemeier, & Zuiderveen Borgesius, 2017), social bots (Ferrara, Varol, Davis, Menczer, & Flammini, 2016), and automatically produced content (algorithmic journalism, see Dörr, 2016). These examples are predominantly discussed as implications of algorithms for the traditional news/media sector.

Altogether, algorithmic governance and its implications have received the most attention in research on *social and political orientation*. Search applications, content scoring, and news aggregators are understood as intermediaries (Bui, 2010; Newman, Fletcher, Kalogeropoulos, Levy, & Nielsen, 2018) between traditional mass media and individual news consumption. Empirical research suggests that algorithmic selection applications will become more important for information retrieval in the future (Newman et al., 2018; Shearer & Matsa, 2018). This is accompanied by fears of misinformation online (Lazer et al., 2018; Vosoughi, Roy, & Aral, 2018), where deliberately disseminated false news is perceived as a threat to opinion formation, for example in the context of elections (Allcott & Gentzkow, 2017), or by fears of echo chambers (Sunstein, 2001) or personalized filter bubbles (Pariser, 2012), leading to fragmented, biased perceptions of society (Dylko, 2016). Empirical studies are inconclusive: there is evidence of clear patterns of algorithmically induced, homogeneous opinion networks (Bakshy, Messing, & Adamic, 2015; Dylko et al., 2018), but other studies indicate more opinion diversity despite algorithmic selection, and therefore give empirical evidence of a lower risk of echo chambers and filter bubbles (Barberá, Jost, Nagler, Tucker, & Bonneau, 2015; Dubois & Blank, 2018; Fletcher & Nielsen, 2017; Möller, Trilling, Helberger, & Es, 2018; Zuiderveen Borgesius et al., 2016).

However, governance by algorithms extends beyond political orientation and opinion formation in everyday life (Bucher, 2018; Latzer & Festic, 2019; Willson, 2017). Many other life domains are affected, most importantly areas such as recreation, commercial transactions, and socializing.

Recommendation applications have been shown to play a predominant role in daily *recreation* (i.e., entertainment and fitness/health). Here too one of the main concerns is the possibility of diminished diversity (Nguyen, Hui, Harper, Terveen, & Konstan, 2014) and the general algorithmic shaping of culture (Beer, 2013; Hallinan & Striphas, 2016). Thus far clear empirical evidence is similarly wanting, and existing studies once more cast doubt on this risk (Nguyen et al., 2014; Nowak, 2016). Attention has also shifted to wearables—networked devices equipped with sensors. These have become an important way in which algorithms govern the perception of the self (Williamson, 2015) and everyday life in general. Empirical studies, for example, investigate the perception, use, and modes of self-tracking (Lupton, 2016; Rapp & Cena, 2016), and its social and institutional context (Gilmore, 2016).

With regard to *commercial transactions* and how they are affected by algorithmic selection applications, a focus has been on recommender systems and the performance of algorithms (Li & Karahanna, 2015; Ur Rehman, Hussain, & Hussain, 2013), as well as on the implementation of new features (Hervas-Drane, 2015). Furthermore, allocation algorithms in the form of online behavioral advertising have attracted attention (Boerman et al., 2017), revealing inconsistent results on users' perceptions of personalized advertisements (McDonald & Cranor, 2010; Smit, Noort, & Voorveld, 2014; Ur, Leon, Cranor, Shay, & Wang, 2012). Concerns have been raised, for example, regarding the social implications of behavioral targeting resulting from research that shows how behaviorally targeted ads can act as social labels and how these ads lead consumers to make adjustments to their self-perceptions and consequently to their (buying) behavior (Summers, Smith, & Reczek, 2016).

Research on *socializing* scrutinizes how algorithms curate user interactions on social networking sites and dating platforms (Bucher, 2012, 2017; Hitsch, Hortaçsu, & Ariely, 2010) and associated concerns such as social distortion or how social connections are adapting to an algorithmically controlled model (Dijck, 2013; Eslami et al., 2015; Rader, 2017; Rader & Gray, 2015). Research also shows, however, how users consciously interact with algorithms and how they try to instrumentalize algorithmic rules to their own ends (Cotter, 2019).

In all these areas of daily life, empirical research on factually experienced risks is scarce, leading to calls for comprehensive and systematic empirical investigation of risks in various life domains as a basis for more evidence-based policymaking (Latzer & Festic, 2019).

Overall, because of the wide scope and diffusion of algorithmic Internet applications, the effects of governance by algorithms can be framed as shaping and influencing individuals' reality construction in everyday life (Berger & Luckmann, 1967), and consequently the formation of social order in digital societies, which results from a shared social reality. This algorithmically co-shaped reality construction (Just & Latzer, 2017) differs widely from the conventional reality construction by mass media (Luhmann, 1996), in particular regarding personalization and the constellation of the actors involved.

The insights into the governance by algorithms, that is, the acknowledgement of their governing powers as institutions (Napoli, 2014), ideologies (Mager, 2012), gatekeepers (Gillespie, 2018), and agents/actants (Rammert, 2008; Tufekci, 2015), and consequently their contribution to reality construction and the formation of social order (Just & Latzer, 2017), lead to discussions about the adequate handling of these powers, that is, the governance of algorithms.

Governance of Algorithms

Discussions about the governance *by* algorithms are thus accompanied by discussions about the governance *of* algorithms. This refers to the various practices to control, shape, and regulate algorithms and the effects that result from their processing, learning/adaptation, and/or decision-making powers (D'Agostino & Durante, 2018; Latzer et al., 2016; Mager, 2018; Saurwein, Just, & Latzer, 2015). With few exceptions, there is only little conceptual clarification as to what types of algorithms are the focus of regulatory concern and whether AI is implicated or not.

Within the broad body of literature on the governance of algorithms, different approaches that somehow tackle the same concerns and problems about algorithmic selections can be identified, although in various constellations and to differing extents. Despite the lack of precise delineations, four approaches can be distinguished. The first three are (1) risk-based approaches, (2) human-rights-based approaches, and (3) ethics-based approaches. In addition, a myriad of general principles (as opposed to specific or detailed rules) are commonly highlighted throughout this literature. Among these are principles such as fairness, transparency, accountability, liability, and explainability, which should be taken into consideration in the governance of algorithms. This strand of literature could be grouped as (4) a fourth category, as four principles-based approaches.

(1) Risk-based approaches (Baldwin, Cave, & Lodge, 2012; Black, 2010; OECD, 2010) focus on the control of risks associated with certain types of algorithmic applications from a public-interest perspective—instead of the compliance with rules. Such approaches call for systematic risk identification and risk assessments as well as the appropriate choice of governance modes to counter or cope with these risks in order to maximize economic and social welfare (Latzer, 2007; Latzer et al., 2016; Latzer, Saurwein, & Just, 2019; Saurwein et al., 2015). The many examples of risks debated in the context of algorithmic systems on the Internet are classified and summarized by Latzer et al. (2016). They distinguish between: manipulation (Bar-Ilan, 2007); diminishing variety, the creation of biases and distortions of reality (Bozdag, 2013; Rieder & Sire, 2014; Vaughan & Thelwall, 2004); constraints on the freedom of communication and expression (Pasquale, 2016; Zittrain & Palfrey, 2008); threats to data protection and privacy (Pasquale, 2015); social discrimination (Barocas & Selbst, 2016; Chander, 2017; O'Neil, 2016); violation of intellectual property rights (Colangelo & Torti, 2019); abuse of market power (Geradin, 2019; Patterson, 2013); possible transformations and adaptations of the human brain; and the uncertain effects of the power of algorithms on humans, for example growing independence of human control and growing human dependence on algorithms (Carr, 2010, 2016; Danaher, 2018; Frischmann, 2014).

(2) Human-rights-based approaches discuss the power and impact of algorithms in light of specific human rights that may be affected by their operations (McGregor, Murray, & Ng, 2019; Raso, Hilligoss, Krishnamurthy, Bavitz, & Kim, 2018; Risse, 2019). Essentially, arguments are grounded in the principles and normative justifications that underlie respective legal frameworks and constitutionally granted rights such as those afforded through the Convention for the Protection of Human Rights and Fundamental Freedoms. Unlike the risk-based approaches, which focus more on public-interest aspects, human-rights-based approaches center more on the individual and his/her rights that may be violated or harmed by the results of automated algorithmic decision-making, such as credit scoring (Bruckner, 2018), health diagnostics (Kraemer, van Overveld, & Peterson, 2011), or criminal-risk assessments (Kehl, Guo, & Kessler, 2017). Essentially along the lines of constitutionally protected rights, the Committee of Experts on Internet Intermediaries (2018), for example, discusses the relevant topics and areas where concerns regarding violations of human rights may occur. Among these they identify issues such as fair trial and due process, privacy and data protection, freedoms of expression, assembly, and association, effective remedies in cases of violations, the enjoyment of human rights and freedoms without discrimination, and the right to free elections.

(3) Ethics-based approaches to algorithms—which pertain to a larger and/or newly claimed branch of digital ethics (Floridi, 2018; Floridi & Taddeo, 2016)—focus in a nutshell on epistemic and normative concerns (Mittelstadt, Allo, Taddeo, Wachter, & Floridi, 2016). Epistemic concerns focus on the *quality of evidence* generated by algorithms, which may be *inconclusive*, *inscrutable*, and *misguided* and accompanied by problems such as unjustified actions, opacity, and bias. Normative concerns refer solely to the *action* of the algorithms, with the focus on *unfair outcomes* that may lead to discrimination, and *transformative effects*, where attention is paid to how algorithmic activities re-ontologize reality in new and unexpected ways, and the attendant challenges of these effects for autonomy, informational privacy, and moral responsibility. Finally, *traceability* is considered an overarching ethical concern and emphasizes the need for traceability of both cause and responsibility for harm.

There have been further attempts at structuring current ethics issues in general, for example in terms of digital media ethics (Ess, 2009), as well as specifically with relation to algorithms (Ananny, 2016) and associated concepts, most notably big data and its related collection and processing. The latter also includes questions of whether and how (big) data ethics differs from information or computer ethics and attendant branches and how and if it needs adaptation, for example the need to establish an independent research strand of big data ethics (Floridi & Taddeo, 2016; O'Leary, 2016; Richards & King, 2014; Zwitter, 2014). In their work on ethics and big data, Herschel and Miori (2017) furthermore highlight the importance of the different theoretical ethical approaches and their underpinnings in order to better understand why and how ethics can inform big-data issues. Related to the discussion of increasing autonomy, the general question of the moral status of technical artifacts in general (Kroes & Verbeek, 2014) and of AI in particular (Bostrom & Yudkowsky, 2014) has emerged as well.

For communication studies, ethical questions have particularly emerged with the rise of automated journalism (Dörr, 2016), which brings about new challenges for professional journalistic practices and the media in general (e.g., Diakopoulos, 2019; Dörr & Hollnbuchner, 2017; Fairfield & Shtein, 2014; Lewis & Westlund, 2015; McBride & Rosenstiel, 2013).

(4) Within the three approaches and also within the overall literature that raises questions within the wider realm of governance, the need for adherence to certain overarching principles repeatedly emerges and resonates. This strand of research can be summarized as principles-based approaches. The principles that are most often voiced are accountability and transparency, among others such as fairness, liability, and justification. Such principles are also reflected in policy discourses among policymakers and other stakeholders as well as in regulations such as the EU General Data Protection Regulation (Regulation (EU) 2016/679; GDPR). While these principles are often upheld, there is no systematic taxonomy that orders them in terms of clarifying, for example, whether they are means or ends or both. Essentially, the debate centers on making how systems work *transparent*, for example clarifying what data are collected or how they are processed, and guaranteeing that this is done in a *fair*, *non-discriminatory* way, defining who is *accountable* or *liable* for the operations and effects of algorithmic decision-making, including provisions that *explain*, *justify*, and possibly *remedy* these effects. Altogether, this research is very varied and focuses on different, often overlapping aspects such as legal protections of accountability and transparency (Blacklaws, 2018), the contribution of transparency to accountability (de Laat, 2018), the addressees of accountability (Binns, 2018; Martin, 2018), the technical solutions and tools available to enhance principles of fairness, accountability, and transparency (Kroll et al., 2017; Lepri, Oliver, Letouzé, Pentland, & Vinck, 2018), or methods of algorithmic accountability reporting that investigate algorithms and their powers, biases, and mistakes, among other things by reverse engineering (Diakopoulos, 2015).

Especially for policymaking, the resort to such general principles can be seen within a wider framework or trend of principles-based regulation (Baldwin et al., 2012; Black, 2007). Principles-based regulation refrains from detailed prescriptive rules and instead relies on broadly stated principles, which are definable and adaptable during policy implementation. It can also be seen as a commitment to alternative governance arrangements such as self- and co-regulation (Just & Latzer, 2004; Latzer, Just, & Saurwein, 2013; Latzer, Just, Saurwein, & Slominski, 2003).

Finally, this leads to the question of how to choose between the possible modes of governance located on a continuum ranging from market mechanisms and self-restrictions to command-and-control regulation by state authorities, and of finding the right mix of public and private governance contributions for existing and newly emerging challenges. Here, a governance-choice method may prove useful (Latzer et al., 2019). In practice, the risks of algorithms are being addressed by diverse governance arrangements, from self-regulation to statutory regulation (Saurwein et al., 2015). For example, the GDPR (in force since May 2018) is an example of a statutory provision that provides safeguards with regard to the (automated) processing of personal data and includes, among other things, compulsory data protection impact assessments in cases of high risk, data-breach notifications, and the encouragement of codes of conduct, as well as the rights to object to data processing and not to be subject to a decision based solely on automated processing. The EU regulation on promoting fairness and transparency for business users of online intermediation services (Regulation (EU) 2019/1150), which will apply from July 12, 2020, introduces transparency requirements regarding the main parameters that determine online rankings and the reasons for their relative importance. Market solutions against potential risks are the various privacy-enhancing technologies (PETs) that users can employ, or supply-side applications that focus on technological design, for example widgets that encourage people to consider diverse opinions (Munson, Lee, & Resnick, 2013). Typical instruments of industry self-regulation are codes of conduct or ethics committees. Alongside various regulatory responses, policymakers are also developing national strategies to cope with AI, for example developing guidelines such as the Ethics Guidelines for Trustworthy AI of the European Commission's High Level Group on Artificial Intelligence, or establishing committees and centers, including the UK Centre for Data Ethics and Innovation and the German Inquiry Committee on Artificial Intelligence. The task of these institutions is to inform governments on challenges arising from algorithms, big data, and AI and to identify the public need for action, to monitor developments, and to make recommendations to the government.

Conclusion

In the past decade, the multifaceted use, social impact, and control of algorithms on the Internet has led to booming, highly interdisciplinary and methodologically manifold research activities. This article proposes and applies various analytical distinctions in order to structure the large and highly fragmented body of research.

From an institutional governance perspective, research either focuses on (a) the governance *by* algorithms, that is, on the steering and governing capacities of technology and on the economic and social effects of services that apply algorithmic selection mechanisms in various life domains, or on (b) the governance *of* algorithms, that is, the need, options, and policy reactions to shape, control, and regulate these AS applications.

In order to understand the governance by algorithms, further distinctions are elaborated that consider the degree of autonomy of algorithms in various applications and their relationship with human decision-making (augmentation or replacement). Most of this research focuses on risks, harms, and negative effects of algorithms, among other things, on manipulation, bias, constraints on freedom of communication, or threats to data protection and privacy. Given fears of disinformation and false news, research has focused on political orientation and opinion formation, while other affected areas of daily life ranging from entertainment and health to commercial transactions and socializing have received less attention.

Based on insights from the governance by algorithms, research on the governance of algorithms discusses practices to control the effects of applications that use automated AS systems. This article analytically distinguishes and sorts this research according to four approaches: risk-based, human-rights-based, ethics-based, and principles-based approaches: (1) risk-based approaches focus on the systematic identification of specific risks from a public-interest perspective, together with risk assessments and the appraisal of appropriate governance modes; (2) human-rights-based approaches center more on the individual and pay attention to the human, mostly constitutionally granted rights that may be affected; (3) ethics-based approaches scrutinize epistemic and normative concerns associated with the overall employment of algorithmic-selection applications and attendant issues of responsibility; and (4) principles-based approaches focus on broadly stated principles such as accountability and transparency that align well with the generally observable trend towards principles-based regulation, which is less prescriptive and more amenable to adaptation during policy implementation.

This finally brings up the question of how to decide on possible governance mechanisms. In this regard, a governance-choice method proves useful to support the suitable choice of different modes of governance located on a continuum ranging from market mechanisms and self-restrictions to command-and-control regulations by state authorities. At present, the risks of algorithms are being addressed by diverse governance arrangements, from self-regulation to statutory regulation.

Digital Resources

Critical Algorithm Studies: a Reading List. Tarleton Gillespie and Nick Seaver of the Social Media Collective (SMC), 2016.

Further Reading

Beer, D. (2017). **The social power of algorithms**. *Information, Communication & Society*, *20*(1), 1–13.

Bucher, T. (2018). *If…then: Algorithmic power and politics*. Oxford, U.K.: Oxford University Press.

Cheney-Lippold, J. (2017). *We are data: Algorithms and the making of our digital selves*. New York: NYU Press.

Committee of Experts on Internet Intermediaries. (2018). *Algorithms and human rights: Study on the human rights dimensions of automated data processing techniques possible regulatory implications*. Strasbourg: Council of Europe.

Diakopoulos, N. (2019). *Automating the news: How algorithms are rewriting the media*. Cambridge and London: Harvard University Press.

Fry, H. (2018). *Hello world: How to be human in the age of the machine*. New York: Random House.

Gillespie, T. (2018). *Custodians of the Internet: Platforms, content moderation, and the hidden decisions that shape social media*. New Haven and London: Yale University Press.

Just, N., & Latzer, M. (2017). **Governance by algorithms: Reality construction by algorithmic selection on the Internet**. *Media, Culture & Society*, *39*(2), 238–258.

Kitchin, R. (2017). **Thinking critically about and researching algorithms**. *Information, Communication & Society*, *20*(1), 14–29.

Saurwein, F., Just, N., & Latzer, M. (2015). **Governance of algorithms: Options and limitations**. *info*, *17*(6), 35–49.

Yeung, K. (2017). **“Hypernudge”: Big data as a mode of regulation by design**. *Information, Communication & Society*, *20*(1), 118–136.

References

Allcott, H., & Gentzkow, M. (2017). **Social media and fake news in the 2016 election**. *Journal of Economic Perspectives*, *31*(2), 211–236.

Ananny, M. (2016). **Toward an ethics of algorithms: Convening, observation, probability, and timeliness**. *Science, Technology, & Human Values*, *41*(1), 93–117.

Aneesh, A. (2009). **Global labor: Algocratic modes of organization**. *Sociological Theory*, *27*(4), 347–370.

Bagloee, S. A., Tavana, M., Asadi, M., & Oliver, T. (2016). **Autonomous vehicles: Challenges, opportunities, and future implications for transportation policies**. *Journal of Modern Transportation*, *24*(4), 284–303.

Bakshy, E., Messing, S., & Adamic, L. A. (2015). **Exposure to ideologically diverse news and opinion on Facebook**. *Science*, *348*(6239), 1130–1132.

Baldwin, R., Cave, M., & Lodge, M. (2012). *Understanding regulation: Theory, strategy, and practice*. 2nd ed. New York: Oxford University Press.

Barberá, P., Jost, J. T., Nagler, J., Tucker, J. A., & Bonneau, R. (2015). **Tweeting from left to right: Is online political communication more than an echo chamber?***Psychological Science*, *26*(10), 1531–1542.

Bar-Ilan, J. (2007). **Google bombing from a time perspective**. *Journal of Computer-Mediated Communication*, *12*(3), 910–938.

Barocas, S., & Selbst, A. D. (2016). **Big Data’s Disparate Impact**. *California Law Review*, *104*, 671–732.

Beer, D. (2013). *Popular culture and new media: The politics of circulation* (1st ed.). New York: Palgrave Macmillan.

Beer, D. (2017). **The social power of algorithms**. *Information, Communication & Society*, *20*(1), 1–13.

Berger, P. L., & Luckmann, T. (1967). *The social construction of reality: A treatise in the sociology of knowledge*. New York: Anchor Books.

Binns, R. (2018). **Algorithmic accountability and public reason**. *Philosophy & Technology*, *31*(4), 543–556.

Black, J. (2007). ***Principles based regulation: Risks, challenges and opportunities***.

Black, J. (2010). **Risk-based regulation: Choices, practices and lessons being learnt**. In *OECD reviews of regulatory reform. Risk and regulatory policy: Improving the governance of risk* (pp. 185–224). Paris: OECD.

Blacklaws, C. (2018). **Algorithms: Transparency and accountability**. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, *376*(2128), 20170351.

Boerman, S. C., Kruikemeier, S., & Zuiderveen Borgesius, F. J. (2017). **Online behavioral advertising: A literature review and research agenda**. *Journal of Advertising*, *46*(3), 363–376.

Bostrom, N., & Yudkowsky, E. (2014). The ethics of artificial intelligence. In K. Frankish & W. M. Ramsey (Eds.), *The Cambridge handbook of artificial intelligence* (pp. 316–334). Cambridge, U.K.: Cambridge University Press.

Bozdag, E. (2013). **Bias in algorithmic filtering and personalization**. *Ethics and Information Technology*, *15*(3), 209–227.

Bresnahan, T. (2010). **General purpose technologies**. In B. H. Hall & N. Rosenberg (Eds.), *Handbook of the economics of innovation* (Vol. 2, pp. 761–791). Amsterdam, The Netherland: Elsevier/North Holland.

Bruckner, M. A. (2018). The promise and perils of algorithmic lenders' use of big data. *Chicago-Kent Law Review*, *93*(1), 3–60.

Bucher, T. (2012). **Want to be on the top? Algorithmic power and the threat of invisibility on Facebook**. *New Media & Society*, *14*(7), 1164–1180.

Bucher, T. (2017). **The algorithmic imaginary: Exploring the ordinary affects of Facebook algorithms**. *Information, Communication & Society*, *20*(1), 30–44.

Bucher, T. (2018). *If...then: Algorithmic power and politics*. New York: Oxford University Press.

Bui, C. (2010). How online gatekeepers guard our view. *Global Media Journal: American Edition*, *9*(16), 1–41.

Carr, N. (2010). *The shallows: What the Internet is doing to our brains*. New York: Norton.

Carr, N. (2016). *The glass cage: Automation and us*. London: Vintage.

Chander, A. (2017). The racist algorithm? *Michigan Law Review*, *115*(6), 1023–1045.

Citron, D. K., & Pasquale, F. A. (2014). The Scored Society: Due Process for Automated Predictions. *Washington Law Review*, *89*, 1–33.

Colangelo, G., & Torti, V. (2019). **Copyright, online news publishing and aggregators: A law and economics analysis of the EU reform**. *International Journal of Law and Information Technology*, *27*(1), 75–90.

Committee of Experts on Internet Intermediaries. (2018). *Algorithms and human rights: Study on the human rights dimensions of automated data processing techniques possible regulatory implications*. Strasbourg: Council of Europe.

Constantiou, I., & Kallinikos, J. (2015). **New games, new rules: Big data and the changing context of strategy**. *Journal of Information Technology*, *30*, 44–57.

Cotter, K. (2019). **Playing the visibility game: How digital influencers and algorithms negotiate influence on Instagram**. *New Media & Society*, *21*(4), 895–913.

D'Agostino, M., & Durante, M. (2018). **Introduction: The governance of algorithms**. *Philosophy & Technology*, *31*(4), 499–505.

Danaher, J. (2016). **The threat of algocracy: Reality, resistance and accommodation**. *Philosophy and Technology*, *29*(3), 245–268.

Danaher, J. (2018). **Toward an ethics of AI assistants: An initial framework**. *Philosophy & Technology*, *31*(4), 629–653.

Danaher, J., Hogan, M. J., Noone, C., Kennedy, R., Behan, A., De Paor, A., . . . Shankar, K. (2017). **Algorithmic governance: Developing a research agenda through the power of collective intelligence**. *Big Data & Society*, *4*(2), 2053951717726554.

de Laat, P. B. (2018). **Algorithmic decision-making based on machine learning from big data: Can transparency restore accountability?***Philosophy & Technology*, *31*(4), 525–541.

Diakopoulos, N. (2015). **Algorithmic accountability: Journalistic investigation of computational power structures**. *Digital Journalism*, *3*(3), 398–415.

Diakopoulos, N. (2019). *Automating the news: How algorithms are rewriting the media*. Cambridge and London: Harvard University Press.

Dijck, J. van. (2013). *The culture of connectivity: A critical history of social media*. Oxford, U.K.: Oxford University Press.

Dolata, U., & Werle, R. (2007). 'Bringing Technology Back In': Technik als Einflussfaktor sozioökonomischen und institutionellen Wandels. In U. Dolata & R. Werle (Eds.), *Gesellschaft und die Macht der Technik: Sozioökonomischer und institutioneller Wandel durch Technisierung* (pp. 15–43). Frankfurt and New York: Campus Verlag.

Dörr, K. N. (2016). **Mapping the field of algorithmic journalism**. *Digital Journalism*, *4*(6), 700–722.

Dörr, K. N., & Hollnbuchner, K. (2017). **Ethical challenges of algorithmic journalism**. *Digital Journalism*, *5*(4), 404–419.

Dubois, E., & Blank, G. (2018). **The echo chamber is overstated: The moderating effect of political interest and diverse media**. *Information, Communication & Society*, *21*(5), 729–745.

Dylko, I. B. (2016). **How technology encourages political selective exposure**. *Communication Theory*, *26*(4), 389–409.

Dylko, I., Dolgov, I., Hoffman, W., Eckhart, N., Molina, M., & Aaziz, O. (2018). **Impact of customizability technology on political polarization**. *Journal of Information Technology & Politics*, *15*(1), 19–33.

Eslami, M., Rickman, A., Vaccaro, K., Aleyasen, A., Vuong, A., Karahalios, K., . . . Sandvig, C. (2015). **"I always assumed that I wasn't really that close to [her]": Reasoning about invisible algorithms in news feeds**. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems* (pp. 153–162). Seoul, Korea: ACM.

Ess, C. (2009). *Digital media ethics*. Cambridge, U.K.: Polity Press.

Fairfield, J., & Shtein, H. (2014). **Big data, big problems: Emerging issues in the ethics of data science and journalism**. *Journal of Mass Media Ethics*, *29*(1), 38–51.

Ferrara, E., Varol, O., Davis, C. A., Menczer, F., & Flammini, A. (2016). **The rise of social bots**. *Communctions of the ACM*, *59*, 96–104.

Fletcher, R., & Nielsen, R. K. (2017). **Are news audiences increasingly fragmented? A cross-national comparative analysis of cross-platform news audience fragmentation and duplication**. *Journal of Communication*, *67*(4), 476–498.

Floridi, L. (2018). **Soft ethics, the governance of the digital and the General Data Protection Regulation**. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, *376*(2133), 20180081.

Floridi, L., & Taddeo, M. (2016). **What is data ethics?***Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, *374*(2083), 1–5.

Frischmann, B. M. (2014). **Human-focused Turing tests: A framework for judging nudging and techno-social engineering of human beings**. Cardozo Legal Studies Research Paper No. 441.

Geradin, D. (2019). ***Complements and/or substitutes? The competitive dynamics between news publishers and digital platforms and what it means for competition policy***. TILEC Discussion Paper No. 2019-003.

Gillespie, T. (2014). **The relevance of algorithms**. In T. Gillespie, P. J. Boczkowski, & K. A. Foot (Eds.), *Media technologies* (pp. 167–194). Cambridge, and London.

Gillespie, T. (2018). *Custodians of the Internet: Platforms, content moderation, and the hidden decisions that shape social media*. New Haven and London: Yale University Press.

Gilmore, J. N. (2016). **Everywear: The quantified self and wearable fitness technologies**. *New Media & Society*, *18*(11), 2524–2539.

Hallinan, B., & Striphas, T. (2016). **Recommended for you: The Netflix Prize and the production of algorithmic culture**. *New Media & Society*, *18*(1), 117–137.

Herschel, R., & Miori, V. M. (2017). **Ethics & big data**. *Technology in Society*, *49*, 31–36.

Hervas-Drane, A. (2015). **Recommended for you: The effect of word of mouth on sales concentration**. *International Journal of Research in Marketing*, *32*(2), 207–218.

Hitsch, G. J., Hortaçsu, A., & Ariely, D. (2010). **Matching and Sorting in Online Dating**. *American Economic Review*, *100*(1), 130–163.

Jürgens, P., Stark, B., & Magin, M. (2015). Messung von Personalisierung in computervermittelter Kommunikation. In A. Maireder, J. Ausserhofer, C. Schumann, & M. Taddicken (Eds.), *Digitale Methoden in der Kommunikationswissenschaft* (pp. 251–270). Berlin, Germany: gesis Leibnitz-Institut für Sozialwissenschaften.

Just, N., & Latzer, M. (2004). Self-and co-regulation in the mediamatics sector: European Community (EC) strategies and contributions towards a transformed statehood. *Knowledge, Technology & Policy*, *17*(2), 38–62.

Just, N., & Latzer, M. (2017). **Governance by algorithms: Reality construction by algorithmic selection on the Internet**. *Media, Culture & Society*, *39*(2), 238–258.

Kehl, D., Guo, P., & Kessler, S. (2017). ***Algorithms in the criminal justice system: Assessing the use of risk assessments in sentencing***.

Kitchin, R. (2017). **Thinking critically about and researching algorithms**. *Information, Communication & Society*, *20*(1), 14–29.

Kraemer, F., van Overveld, K., & Peterson, M. (2011). **Is there an ethics of algorithms? [***Ethics and Information Technology*, *13*(3), 251–260.

Kroes, P., & Verbeek, P.-P. (Eds.). (2014). *The moral status of technical artefacts*. Dordrecht: Springer.

Kroll, J. A., Barocas, S., Felten, E. W., Reidenberg, J. R., Robinson, D. G., & Yu, H. (2017). Accountable algorithms. *University of Pennsylvania Law Review*, *165*, 633–705.

Langvardt, K. (2018). Regulating Online Content Moderation. *Georgetown Law Journal*, *106*, 1353–1388.

Larus, J., Hankin, C., Carson, S. G., Christen, M., Crafa, S., Grau, O., . . . Werthner, H. (2018). ***When computers decide: European recommendations on machine-learned automated decision making***.

Latzer, M. (2007). Regulatory choices in communication governance. *Communications—The European Journal of Communication Research*, *32*(3), 399–405.

Latzer, M., & Festic, N. (2019). **A guideline for understanding and measuring algorithmic governance in everyday life**. *Internet Policy Review*, *8*(2), 1–19.

Latzer, M., Hollnbuchner, K., Just, N., & Saurwein, F. (2016). **The economics of algorithmic selection on the Internet**. In J. Bauer & M. Latzer (Eds.), *Handbook on the economics of the Internet* (pp. 395–425). Cheltenham: Elgar.

Latzer, M., Just, N., & Saurwein, F. (2013). Self- and co-regulation: Evidence, legitimacy and governance choice. In M. E. Price, S. Verhulst, & L. Morgan (Eds.), *Handbook of media law and policy: A socio-legal approach* (pp. 373–397). London: Routledge.

Latzer, M., Just, N., Saurwein, F., & Slominski, P. (2003). Regulation remixed: Institutional change through self and co-regulation in the mediamatics sector. *Communications & Strategies*, *50*(2), 127–157.

Latzer, M., Saurwein, F., & Just, N. (2019). Assessing policy II: Governance-choice method. In H. Van den Bulck, M. Puppis, K. Donders, & L. Van Audenhove (Eds.), *The Palgrave handbook of methods for media policy research*. London: Palgrave Macmillan.

Lazer, D. M. J., Baum, M. A., Benkler, Y., Berinsky, A. J., Greenhill, K. M., Menczer, F., . . . Zittrain, J. L. (2018). **The science of fake news**. *Science*, *359*(6380), 1094–1096.

Lepri, B., Oliver, N., Letouzé, E., Pentland, A., & Vinck, P. (2018). **Fair, transparent, and accountable algorithmic decision-making processes: The premise, the proposed solutions, and the open challenges**. *Philosophy & Technology*, *31*(4), 611–627.

Lewis, S. C., & Westlund, O. (2015). **Big data and journalism: Epistemology, expertise, economics, and ethics**. *Digital Journalism*, *3*(3), 447–466.

Li, S. S., & Karahanna, E. (2015). **Online recommendation systems in a B2C e-commerce context: A review and future directions**. *Journal of the Association for Information Systems*, *16*(2), 72–107.

Luhmann, N. (1996). *Die Realität der Massenmedien* (2nd ed.). Opladen: VS Verlag für Sozialwissenschaften.

Lupton, D. (2016). *The quantified self: A sociology of self-tracking*. Cambridge, UK: Polity Press.

McBride, K., & Rosenstiel, T. (Eds.). (2013). *The new ethics of journalism: Principles for the 21st century*. London: CQ Press, Sage.

McDonald, A., & Cranor, L. F. (2010). ***Beliefs and behaviors: Internet users' understanding of behavioral advertising***. SSRN Scholarly Paper No. ID 1989092.

McGregor, L., Murray, D., & Ng, V. (2019). **International human rights law as a framework for algorithmic accountability**. *International and Comparative Law Quarterly*, *68*(2), 309–343.

Mager, A. (2012). **Algorithmic ideology**. *Information, Communication & Society*, *15*(5), 769–787.

Mager, A. (2018). **Internet governance as joint effort: (Re)ordering search engines at the intersection of global and local cultures**. *New Media & Society*, *20*(10), 3657–3677.

Martin, K. (2018). **Ethical implications and accountability of algorithms**. *Journal of Business Ethics*.

Mittelstadt, B. D., Allo, P., Taddeo, M., Wachter, S., & Floridi, L. (2016). **The ethics of algorithms: Mapping the debate**. *Big Data & Society*, *3*(2), 2053951716679679.

Möller, J., Trilling, D., Helberger, N., & Es, B. van. (2018). **Do not blame it on the algorithm: An empirical assessment of multiple recommender systems and their impact on content diversity**. *Information, Communication & Society*, *21*(7), 959–977.

Munson, S. A., Lee, S. Y., & Resnick, P. (2013). ***Encouraging reading of diverse political viewpoints with a browser widget***.

Napoli, P. M. (2014). **Automated media: An institutional theory perspective on algorithmic media production and consumption**. *Communication Theory*, *24*(3), 340–360.

Newman, N., Fletcher, R., Kalogeropoulos, A., Levy, D. A. L., & Nielsen, R. K. (2018). *Digital News Report 2018*. Oxford: Reuters Institute for the Study of Journalism, & Oxford University.

Nguyen, T. T., Hui, P.-M., Harper, F. M., Terveen, L., & Konstan, J. A. (2014). **Exploring the filter bubble: The effect of using recommender systems on content diversity**. In *Proceedings of the 23rd International Conference on World Wide Web—WWW '14* (pp. 677–686). Seoul, Korea: Association for Computing Machinery, Inc.

Nowak, R. (2016). **The multiplicity of iPod cultures in everyday life: Uncovering the performative hybridity of the iconic object**. *Journal for Cultural Research*, *20*(2), 189–203.

OECD. (2010). ***Risk and regulatory policy: Improving the governance of risk***.

O'Leary, D. E. (2016). **Ethics for big data and analytics**. *IEEE Intelligent Systems*, *31*(4), 81–84.

O'Neil, C. (2016). *Weapons of math destruction: How big data increases inequality and threatens democracy* (1st ed.). New York: Crown.

OSTP. (2016). ***Preparing for the future of artificial intelligence (agency report)***.

Pariser, E. (2012). *The filter bubble: What the Internet is hiding from you*. London: Penguin.

Pasquale, F. (2015). *The black box society*. Cambridge, MA: Harvard University Press.

Pasquale, F. (2016). **Platform neutrality: Enhancing freedom of expression in spheres of private power**. *Theoretical Inquiries in Law*, *17*(2), 487–513.

Patterson, M. R. (2013). **Google and search engine market power**. *Harvard Journal of Law & Technology Online Paper Series*, *26*(2).

Rader, E. (2017). **Examining user surprise as a symptom of algorithmic filtering**. *International Journal of Human–Computer Studies*, *98*, 72–88.

Rader, E., & Gray, R. (2015). **Understanding user beliefs about algorithmic curation in the Facebook news feed**. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems* (pp. 173–182). Seoul, Korea: ACM.

Rammert, W. (2008). **Where the action is: Distributed agency between humans, machines, and programs**. In U. Seifert, J. H. Kim, & A. Moore (Eds.), *Paradoxes of interactivity* (pp. 62–91). Bielefeld: transcript Verlag.

Rapp, A., & Cena, F. (2016). **Personal informatics for everyday life: How users without prior self-tracking experience engage with personal data**. *International Journal of Human–Computer Studies*, *94*, 1–17.

Raso, F., Hilligoss, H., Krishnamurthy, V., Bavitz, C., & Kim, L. Y. (2018). **Artificial intelligence & human rights: Opportunities & risks**. *The Berkman Klein Center for Internet & Society Research Publication Series*.

Richards, N. M., & King, J. H. (2014). Big data ethics. *Wake Forest Law Review*, *49*, 393–432.

Rieder, B., & Sire, G. (2014). **Conflicts of interest and incentives to bias: A microeconomic critique of Google's tangled position on the Web**. *New Media & Society*, *16*(2), 195–211.

Risse, M. (2019). **Human rights and artificial intelligence: An urgently needed agenda**. *Human Rights Quarterly*, *41*(1), 1–16.

Sandvig, C., Hamilton, K., Karahalios, K., & Langbort, C. (2014, May 22). Auditing algorithms: Research methods for detecting discrimination on Internet platforms. Paper presented to "*Data and Discrimination: Converting Critical Concerns into Productive*

Inquiry," a preconference at the 64th Annual Meeting of the International Communication Association. Seattle, WA, USA.

Saurwein, F., Just, N., & Latzer, M. (2015). **Governance of algorithms: Options and limitations**. *Info*, *17*(6), 35–49.

Shearer, E., & Matsa, K. E. (2018). **News use across social media platforms 2018**. Pew Research Center, September 10.

Smit, E. G., Noort, G. van, & Voorveld, H. A. M. (2014). **Understanding online behavioural advertising: User knowledge, privacy concerns and online coping behaviour in Europe**. *Computers in Human Behavior*, *32*, 15–22.

Striphas, T. (2015). **Algorithmic culture**. *European Journal of Cultural Studies*, *18*(4–5), 395–412.

Summers, C. A., Smith, R. W., & Reczek, R. W. (2016). **An audience of one: Behaviorally targeted ads as implied social labels**. *Journal of Consumer Research*, *43*(1), 156–178.

Sunstein, C. R. (2001). *Echo chambers: Bush v. Gore, impeachment, and beyond*. Princeton, NJ: Princeton University Press.

Tufekci, Z. (2015). Algorithmic harms beyond Facebook and Google: Emergent challenges of computational agency. *Colorado Technology Law Journal*, *13*, 203–218.

Ur, B., Leon, P. G., Cranor, L. F., Shay, R., & Wang, Y. (2012). **Smart, useful, scary, creepy: Perceptions of online behavioral advertising**. *Proceedings of the Eighth Symposium on Usable Privacy and Security*.

Ur Rehman, Z., Hussain, F. K., & Hussain, O. K. (2013). ***Frequency-based similarity measure for multimedia recommender systems***.

Vaughan, L., & Thelwall, M. (2004). **Search engine coverage bias: Evidence and possible causes**. *Information Processing & Management*, *40*(4), 693–707.

Vosoughi, S., Roy, D., & Aral, S. (2018). **The spread of true and false news online**. *Science*, *359*(6380), 1146–1151.

Williamson, B. (2015). **Algorithmic skin: Health-tracking technologies, personal analytics and the biopedagogies of digitized health and physical education**. *Sport, Education and Society*, *20*(1), 133–151.

Willson, M. (2017). **Algorithms (and the) everyday**. *Information, Communication & Society*, *20*(1), 137–150.

Zittrain, J., & Palfrey, J. (2008). Internet Filtering: The Politics and Mechanisms of Control. In R. Deibert, J. Palfrey, R. Rohozinski, & J. Zittrain (Eds.), *Access Denied: The Practice and Policy of Global Internet Filtering* (pp. 29–56). Cambridge, MA: MIT Press.

Zuiderveen Borgesius, F. J., Möller, J., Kruikemeier, S., Ó Fathaigh, R., Irion, K., Dobber, T., . . . De Vreese, C. (2018). **Online political microtargeting: Promises and threats for democracy**. *Utrecht Law Review*, *14*(1), 82–96.

Zuiderveen Borgesius, F. J., Trilling, D., Möller, J., Bodó, B., Vreese, C. H. de, & Helberger, N. (2016). **Should we worry about filter bubbles?***Internet Policy Review*, *5*(1), 1–16.

Zwitter, A. (2014). **Big data ethics**. *Big Data & Society*, *1*(2), 1–6.

Michael Latzer

Department of Communication and Media Research, University of Zurich

Natascha Just

Department of Communication and Media Research, University of Zurich