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Algorithms, Automation, and News

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Abstract

This special issue examines the growing importance of algorithms and automation in the gathering, composition, and distribution of news. It connects a long line of research on journalism and computation with scholarly and professional terrain yet to be explored. Taken as a whole, these articles share some of the noble ambitions of the pioneering publications on 'reporting algorithms', such as a desire to see computing help journalists in their watchdog role by holding power to account. However, they also go further, firstly by addressing the fuller range of technologies that computational journalism now consists of: from chatbots and recommender systems, to artificial intelligence and atomised journalism. Secondly, they advance the literature by demonstrating the increased variety of uses for these technologies, including engaging underserved audiences, selling subscriptions, and recombining and re-using content. Thirdly, they problematize computational journalism by, for example, pointing out some of the challenges inherent in applying AI to investigative journalism and in trying to preserve public service values. Fourthly, they offer suggestions for future research and practice, including by presenting a framework for developing democratic news recommenders and another that may help us think about computational journalism in a more integrated, structured manner.

Keywords: algorithms, atomised journalism, automated journalism, chatbots, computational journalism, news personalization, recommender systems, structured journalism

In recent times, algorithms and automation have become pervasive if not always fully understood facets of contemporary life. What we read and watch, how we meet people and develop relationships, and how decisions are made about jobs, loans, and insurance—these and many other features of the everyday are increasingly influenced by mathematical models and the data-driven systems behind them, each with varying degrees of opacity regarding how they operate, in whose interests, and with what implications. Algorithms and associated forms of computational automation can be defined technically or socially (Zamith 2019). Technical definitions, common in computer and information sciences, affirm that an algorithm follows a series of pre-designed steps or rules toward solving a problem (Latzer et al. 2016); social definitions, more common in communication and media studies, emphasize the human–machine dynamics, institutional arrangements, and environmental conditions (among other things) that give shape to algorithms as social, cultural, and material artefacts (e.g., Gillespie 2016; Napoli 2014). Despite their long history, algorithms and automation have never been so front-and-centre as shaping forces in public life (as described well in accounts such as Bucher 2018 and Diakopoulos 2019). Most strikingly, and perhaps controversially across many domains, the ubiquity of computing capabilities and automated

technologies has resulted in human decision-making being augmented, and even partially replaced, by software (Broussard 2018). Such augmentation and substitution is already common, and even predominates in some industries, including through forms of "communicative AI," or artificial intelligence applied to contexts of human communication (Guzman and Lewis 2019). This trend is likewise rapidly accelerating in news media, leading one observer to conclude, "Algorithms today influence, to some extent, nearly every aspect of journalism, from the initial stages of news production to the latter stages of news consumption" (Zamith 2019: 1).

What exactly does such influence look like, and how are scholars and practitioners to make sense of it? That question animates this special issue of *Digital Journalism*. We began working on this project more than two years ago under the premise that, although the journalism studies literature had made great strides in assessing the digitization of news in the 2000s and the emergence, in the 2010s, of data, code, and software as key organizing components of contemporary journalism (see, e.g., Anderson, 2013; Ausserhofer et al 2017; Lewis and Westlund 2015a; Usher 2016; Weber and Kosterich 2018), there was yet an opportunity to more fully capture and conceptualize the particular influence of algorithms and automation in newswork. By the mid-2010s, it had become clear that fully automated and semi-automated forms of gathering, filtering, composing, and sharing news had assumed a greater place in a growing number of newsrooms (Diakopoulos 2019; Dörr 2016), opening the possibility that there were places where shifts in the norms, patterns, and routines of news production were happening and even that, at a more fundamental level, taken-for-granted ideas about who (or what) does journalism were being challenged (Lewis, Guzman, and Schmidt 2019; Primo and Zago 2015). Some algorithms, for example, were being used to filter enormous quantities of content published on social media platforms, picking out what was potentially newsworthy and alerting journalists to its existence (Thurman et al 2016; Fletcher et al 2017). Other algorithms, meanwhile, were being used to produce automated journalism—thousands of stories at scale—by transforming structured data on sports results and financial earnings reports into narrative news texts with little or no human intervention (Carlson 2015). Moreover, by that point, automated processes were being used to test new forms of packaging and distributing news content, enabling consumers to request more of what they like and less of what they don't and also making decisions on consumers' behalf based on their behavioural traits, social networks, and personal characteristics (e.g., Thurman, Moeller, Helberger, and Trilling 2019). And, in a larger sense, it was becoming apparent that algorithms, as part of a decades-long "quantitative turn" in journalism (Coddington 2015), needed to be understood as assemblages of human and machine—as configurations of social actors and technological actants (Lewis and Westlund 2015b) that require a more thoroughgoing investigation around issues such as algorithmic accountability (Diakopoulos 2015), the ethics of algorithms (Ananny 2016; Dörr and Hollnbuchner 2017), algorithmically organized information enclaves (Bruns 2019; Haim et al 2018), and the symbolic value of machine-oriented journalistic work (Lewis and Zamith 2017; see also Bucher 2017).

Altogether, these developments have raised important questions about where algorithms and automation figure in relation to the social roles of journalism as a longstanding facilitator of

public knowledge. In that spirit, this special issue represents a selection of papers that were originally presented at the 2018 Algorithms, Automation, and News Conference.[1] The articles in this special issue represent about a third of that conference programme and are introduced in more detail below. We have grouped the articles into four themes: 'Publics and public service', 'Personalization and politics', 'Professionals and practices', and 'Promise and possibilities'.

Publics and public service

Although chatbots, a form of conversational user-interface (CUI), are familiar in other contexts, such as customer service, their use as a news distribution medium has been less common. However, this is starting to change, and the development and deployment of chatbots by two public-service news organizations, the BBC and the Australian Broadcasting Corporation (ABC), is the subject of two articles in this special issue. The adoption of chatbots has, in part, been driven by changes in the use of social media platforms, as people have moved away from more public channels, such as Facebook's News Feed, to more private environments, such as WhatsApp and Facebook Messenger. Public service media (PSM), such as the BBC and ABC, often feel obligated to make their content, including news, available on the diverse media platforms that their audiences choose to use. Heather Ford and Jonathon Hutchinson's (2019) special issue article is a case study of the ABC's "newsbot," and uses ethnographically inspired methods to examine how this chatbot mediates the relationships between the ABC and its audience. They find that some of the public who use the chatbot are broadly positive about it and appreciate the informal, colloquial mode of address and the control the bot gives them about what information they receive, where, and when. Some of the journalists behind the bot are also broadly positive, seeing it as a way to reach underserved audiences. Despite these positive outcomes, Ford and Hutchinson also address the implications and possible consequences that flow from the ABC chatbot's reliance on the private infrastructure of Facebook and Chatfuel, including questions around who gets to own and use the public's data.

Bronwyn and Rhianne Jones' (2019a) special issue article is also a qualitative study of newsbots at a PSM organization, the BBC. As the authors show, the BBC has launched nearly a dozen newsbots across a mixture of third-party platforms—Twitter, Facebook, and Telegram—as well as on their own website, with some being conversational in nature. The article shows how, as with the ABC, the BBC's experiments with bots have been in part prompted by a desire to reach and engage with underserved audiences, particularly the young. Jones and Jones make the important point that robust empirical evidence about the success of such strategies is still very limited. These two articles will, we hope, both inform and inspire further research in this area. The issues raised by the involvement of third parties in the

[1] The conference took place on 22–23 May 2018 at the Center for Advanced Studies at Ludwig-Maximilians-Universität München, with support from The Volkswagen Foundation as well as additional support from the Shirley Papé Chair in Emerging Media and the School of Journalism and Communication at the University of Oregon. The meeting featured 29 papers from an international ensemble of speakers, presented across eight sessions, with a keynote address from Professor Philip Napoli of Duke University.

development and hosting of PSM newsbots, as discussed by Ford and Hutchinson, were also apparent at the BBC, which has begun to develop strategies to ensure public service values are preserved.

Personalization and politics

As both Ford and Hutchinson's and Jones and Jones' articles make clear, chatbots can make news appear more personal, both in its tone and content. The personalization of news content has a history stretching back decades (Thurman 2019a). It is, however, an ever-evolving phenomenon necessitating ongoing oversight from the research community. The special issue article by Balázs Bodó (2019) does just this through a qualitative study of algorithmic news personalization at twelve European "quality" news outlets. Automated news content personalization is often discussed in negative terms because of its supposed promotion of so-called filter bubbles and echo chambers (see Bruns 2019; Nechushtai and Lewis 2019), and is often treated as if it were a single, homogeneous phenomenon. Bodó's article challenges this idea, making a crucial distinction between the personalization done by platforms and that done by publishers. For platforms such as Facebook, Bodó argues, personalization is driven by huge quantities of user data and content and enacted to maximize users' engagement so that their attention can be sold to advertisers, all without much, if any, editorial oversight of the content recommendations made. He argues that, in contrast, the news publishers that are the focus of his study personalize content in a very different way, with different outcomes in mind. They are more hands-on, driven by a desire to sell subscriptions or demonstrate the benefits of public subsidies, which often means using personalization to try to cultivate interest in quality information, including hard news, and to promote journalistic authority and reliability.

The different ways in which news content personalization can be enacted are at the heart of Natali Helberger's (2019) special issue article, "On the Democratic Role of News Recommenders." In it she contributes to ongoing debates about the perils and promise of personalization by developing a conceptual framework based on what she sees as the three main democratic theories used in academic work on the media. Firstly, the *liberal* tradition, in which individuals' autonomy and rights to free expression and privacy are emphasized along with the decentralization of power. Secondly, the *participatory* model, which emphasizes a shared civic culture through the active participation of citizens. Thirdly, the *deliberativ*e theory of democracy, which shares much with the participatory model but has a greater focus on deliberation, with the media playing an important role as a sphere—open to all—in which many ideas are presented and debated.

Helberger then uses this democratic framework to examine the various roles that news recommenders have played, and may play, within society. She argues that the first wave of recommenders, including those on social media platforms, are broadly liberal in the priority they give to users' interests, although rather illiberal in their market concentration and lack of transparency, and in how they collect and share users' data. News recommenders that promote participatory democracy would, she suggests, put less priority on serving individual

users' tastes and more on providing information that reflects the interests of society more broadly and on seeking to encourage citizens' involvement. Deliberative news recommenders are yet another step removed from liberal recommenders, placing the greatest level of importance on exposing users to a diversity of views and information and promoting discourse. With her article, Helberger casts fresh light on debates about news personalization, showing how judgements about its effects are very much dependent on one's democratic values and how, like most technologies, recommender systems are neither inherently good nor bad. Their outcomes for democracy are very much dependent on the values with which they are imbued.

Jonathan Stray's (2019) article for this special issue also has the democratic role of the media at its heart but takes us to the other end of the news cycle, focusing on investigative news gathering rather than news distribution. He is interested in journalism's watchdog role—how it can reveal wrongdoing and discourage corruption—and the part that technology, and AI in particular, might play in that. While Helberger's article took political theory as its starting point, Stray's is grounded in his understanding of how AI works, his reflections on the nature of the data to which journalists have access, and the legal and commercial context in which news is published. Stray shows how, despite hopes that computational journalism would enhance journalism's watchdog role, the uses of AI in investigative journalism have, thus far, been modest. He suggests the reasons for this include the difficulties involved in acquiring data, the journalistic requirement for accuracy, the costs involved, the limitations of current technology, and the challenges involved in trying to codify news values. His article is a salutary lesson in how hopes that computation could be transformative for the way in which journalism is practiced have bumped up against the messy reality of the world as we find it. Nevertheless, Stray does see some near-term opportunities for AI in investigative journalism, particularly in the extraction of data from document caches and in how databases can be fused to reveal relationships that might otherwise remain hidden—for example, between offshore companies and their beneficial owners.

Professionals and practices

An emphasis on news professionals and their practices has long been a central element of journalism studies in general and *digital* journalism studies in particular (e.g., see Eldridge, Hess, Tandoc, and Westlund 2019; Robinson, Lewis, and Carlson 2019). This special issue is no exception. Following this tradition, Marko Milosavljević and Igor Vobič (2019) offer a comparative study of editors in the United Kingdom and Germany, seeking to understand how the core ideals of professional journalism are being rearticulated (or not) in relation to the "automation novelties" that increasingly are being deployed in legacy news institutions. They examine how automation—which ostensibly threatens to leave humans "out of the loop" as production techniques are progressively automated—is situated in tension with some longstanding ideals of journalism (such as public service, autonomy, and objectivity) while also potentially complementing others (such as timeliness). The editors they interviewed find journalism's professional ideology to be in a state of flux, with attitudes about automation that are neither euphoric nor dystopian, and which appear to tread something of a fine line

between the civic-oriented normative aims of the newsroom and the profit-oriented financial aims of a business side that seeks to minimize costly human labour. Indeed, the central contribution of their study is to illustrate the extent to which humans remain "in the loop" in the strategic roll-out of newsroom automation, suggesting that "human journalists are still regarded as the dominant agents in news production and its continuous reinvention." This leads them to argue that the longer-term incorporation of automation hints at "a realistic promise of a 'hybrid state' in which both machine and human fingerprints will appear all over what is now understood as professional journalism—defining both its production and ideologisation."

Focusing particularly on the professional ideal of objectivity, Matt Carlson (2019) in this special issue offers a creative exploration of "mechanical objectivity," or the belief that machine systems are capable of offering representations and outputs "that overcome the limits of human subjectivity." Carlson does this by comparing the history of photography and then photojournalism with the present introduction of news algorithms. In his conceptual essay, he shows how a historically grounded study of objectivity—particularly perceptions about what it constitutes, how it might be attained, and why human judgement matters (or not) in rendering an "objective" picture of reality—can open up a range of interesting questions about what technologies and associated techniques mean for news as a form of knowledge. Carlson adapts the idea of mechanical objectivity from Daston and Galison's (2007) study of photography's emerging role in scientific observation and recording in the nineteenth century—a period when scientists were initially fascinated by the potential of the "automatism of the photographic process," which appeared to promise "images free of human interpretation" (130–131). He then outlines the allure that photojournalism had as a means of mirroring the world through faithful reproduction at a time—the early twentieth century—when objectivity in journalism was coming to the fore, and relates that to the promise of algorithmic objectivity that has been a central claim (and point of contention) in our era. "What mechanical objectivity provides to journalism studies," he argues, "is a perspective for examining how algorithms are made to work as an epistemic actor within news"—one that raises essential questions about biases, judgements, representations, and the role of technologies in these issues.

Promise and possibilities

The potential that is tantalizingly offered by mechanical forms of objectivity is indicative of a fourth and final dimension of these special issue articles: a hopeful vision of how journalism may develop when the full possibilities associated with algorithms and automation in news are understood. Nicely illustrating this is David Caswell's (2019) piece, "Structured Journalism and the Semantic Units of News," which makes the case that computational journalism is a largely unfinished project. "Computational approaches to news have largely developed *ad hoc,* as opportunistic adoption of technical innovations originating in other fields," he writes, "and the academic study of computational journalism has similarly developed *ad hoc*, often as case-by-case responses to specific technologies applied to journalism" (cf. Thurman 2019b). The result, he suggests, is a space of practice and inquiry

that is populated by intriguing tools, applications, and case studies, but one without "an integrated framework for understanding computational journalism," leaving the field "ill-equipped to proactively influence the adaption of journalism to a technologically mediated future." Caswell thus offers an analytical framework for organizing the many varieties of computational journalism. He illustrates how journalistic knowledge can be understood as "semantic units" that are smaller than the news article, and which can be expressed partially or in full as structured data. The representation of journalism as structured data—or "structured journalism"—is, he argues, more than a speculative conception and offers a compelling, semantic-unit paradigm for illustrating not merely a strand of computational journalism but indeed *all* of its forms. Such an approach, he suggests, points to a research agenda for computational journalism: e.g., for capturing (and structuring) repeating patterns in news events and storylines; for cataloguing "editorial micro-structures" in news articles; and for understanding the "semantic boundaries of computation" in journalism.

In a related vein, Rhianne Jones and Bronwyn Jones (2019b)—in their second contribution to this special issue—analyse two of the BBC's recent initiatives in "atomising" the news. Atomization, in this case, refers to a news story being broken into "atoms" (or objects, units, or components) of discrete information, which algorithms and automation can then recombine into adaptable and scalable news products. "The atoms," they write, "live on within, and can continually build, databases of organised and structured information." Drawing on their own experience at the BBC, in combination with interviews and document analysis, Jones and Jones (2019b) illustrate how the BBC framed experimentation with news atomization (as seeking efficiency and personalization). They also identify three key characteristics of atomized approaches—recording, recombining, and re-use—that have implications for the way journalists produce news with machines and structure in mind. Importantly, they find "journalists are 'writing for machines' by converting unstructured information into structured data to enable automated recombination and future re-use of content." Beyond the technical shifts involved, these developments, Jones and Jones argue, call up the need for further research that accounts for, among other things, the "politics of structured or atomised journalism." This is particularly true, we would add, as algorithms, automation, and related dynamics come to play an ever-larger role in questions of power within journalism (cf. Robinson et al. 2019): Who has control, on what terms, in whose interests? There remains much for us to learn about what automatization means for journalism's roles and routines, norms and values, and authority and expertise, as these discursive debates and material struggles are negotiated in the coming years at the intersection of human and machine.

Looking backward and forward: Extending research on computational journalism

In total, this special issue represents a significant step forward in digital journalism studies and in the field's approach to algorithms and automation and their implications for news. The issue and its contributions also represent a crucial bridging point, linking a long line of research on journalism and computation with scholarly terrain yet to be explored. This is particularly so as artificial intelligence—and the human–machine communication that it

facilitates—becomes a more salient factor in the way people make sense of the world and create meaning, both with each other and in relation to machines (Guzman and Lewis 2019; Lewis et al 2019).

The application of computing to news is not new. For at least half a century, investigative journalists have made use of computers in data analysis (Anderson and Caswell 2019). Harnessing software to select stories for, and present them to, individual audience members also has a decades-long history, with news publishers deploying recommender systems to personalize news since the 1980s, if not before (Thurman 2019a). After information is analyzed, but before the stories it informs can be distributed, those stories must, of course, be composed. Some of the pioneering publications on "reporting algorithms" (e.g., Hamilton and Turner 2009) underestimated the impact that automation would have on news composition. However, automated journalism—as it has become known—has now been adopted by a range of news organizations (Dörr 2016). So too has the use of computing in large-scale news gathering, with the high volumes of digital data, particularly on social networks, fueling this development (Thurman 2018).

Although some of these practices have been apparent for decades, it was not until 2006 that a term—'computational journalism'—was coined that encompassed them all and started to become widely adopted (Georgia Tech 2013).[2] The early computational journalism literature focused on how computing could help journalists act as watchdogs, monitoring the powerful and holding them to account (see, e.g., Hamilton and Turner 2009; Cohen et al. 2011) by facilitating better exploration and interpretation of data. Over time, the computational journalism literature has started to reflect the full range of uses that journalism is making of computation and has also started to problematize (see, e.g., Anderson 2011) the claims made on its behalf—for example, that it would increase "the public's ability to monitor power" (Cohen et al 2011). Stray's (2019) article in this special issue is exemplary in this respect, sharing the noble ambitions of some of the early authors in the computational journalism field, but acutely aware of the challenges of applying AI to investigative journalism. Following Stray's lead, future research could better compare the hope and hype that develop around particular technologies with the stark realities that often emerge when such things initially prove underwhelming. Beyond merely critiquing such states of affairs, however, researchers can also take a cue from Stray by actually offering interventions and solutions.

While continuing to focus on news gathering, those researching computational journalism have begun to cast their gaze more widely, including toward the use of automation and algorithms to compose news texts (see, e.g., Graefe et al. 2016; Montal and Reich 2017; Thurman et al. 2017). Initially, the automation of traditional, static news texts was the primary object of study. However, as news chatbots have been developed and deployed, these novel, interactive interfaces have also come under academic scrutiny. Jones and Jones' (2019a) and Ford and Hutchinson's (2019) articles in this special issue are two ground-breaking examples of such work. Additionally, they set the stage for future research on

[2] A search for "computational journalism" on Google Scholar on 24 September 2019 resulted in 1,360 results.

human–machine communication in journalism studies (cf. Lewis et al 2019), setting up a series of questions that deserve to be explored, such as: To what extent does the use of socialbots and other chat technologies alter the conditions for meaning-making around news, for journalists and audiences alike? What does it mean—socially, culturally, normatively, institutionally, and so forth—to organize news and information to suit automated forms of technology that are intended to mimic human communication and behaviour? And, to the degree that chatbots for news are perceived to have "failed" recently (Benton 2019), what might that suggest about audience interest in and engagement with automated forms of journalism—and with what broader meaning for human–machine forms of communication?

Meanwhile, news personalization goes back further than the automated composition of news texts, as do related discussions within and without the academy—back as far, one could argue, as 1889, when Jules Verne, and his son Michel, published their predictions for a personalized news service, with subscribers able to "give attention to one editor and refuse it to another" (Verne and Verne 1889). The Vernes' fantasy was set in the year 2889. In actual fact, forms of personalized news appeared considerably sooner, as early as 1989 (PR Newswire 1989). Their appearance has provoked a range of responses, often negative in tone. Cass Sunstein (2001, 2007) suggested that cultural fragmentation and extremism could result from citizens being isolated in informational echo chambers, whether by their own choices or those of others. Eli Pariser's (2011) *The Filter Bubble* also predicted dire consequences should pervasive information filtering centralize control over who sees what, thereby limiting the diversity of users' information diet. Recent analyses suggest that such fears are largely overblown (Bruns 2019), though the issue of how diverse the information environments created by algorithms and automation should be—of what sort of gatekeepers people would like machines to be (Nechushtai and Lewis 2019)—remains hotly debated. Helberger's (2019) and Bodo's (2019) articles in this special issue join what is now a considerable body of work on the personalization of news, but theirs are important and distinctive in reminding us that technology's effects are inexorably dependent on how publishers, platforms, and society at large decide to organize and implement such tools.

This recognition of the importance of the political and economic contexts in which computational journalism operates was not always apparent in the field's pioneering publications, which, some authors (see, e.g., Diakopoulos 2017) claim, concentrated on the applications that were being built, and failed to examine journalism's "larger … currents" (Anderson 2013: 1008). Anderson (2013) suggested adopting Schudson's (2005) political, economic, organizational, and cultural approaches to the sociology of news as a remedy. In many respects, scholarship on computational and algorithmic journalism has yet to realize that kind of multi-faceted sociological inquiry, though there have been some efforts to apply a Bourdieuan field perspective that Anderson also prescribed (see, e.g., Wu, Tandoc, and Salmon 2019). There has, it seems, been more of an emphasis on charting the latest trends and technologies at the intersection of computing and journalism than on interrogating the taken-for-granted assumptions underlying the news media industry's ceaseless chasing of "bright, shiny things" (Posetti 2018). However, Milosavljević and Vobič (2019) article in this special issue does help to address this imbalance, paying close attention to how journalists'

and editors' attitudes to automation are influenced by the cultural and economic conditions that prevail in UK and German newsrooms.

That Anderson (2013) has placed importance on the study of the sociology of computational journalism has not prevented him from also inviting a closer evaluation of the "actual role played by materiality and technology in the processes of journalism" (p. 1016), a suggestion echoed by Primo and Zago (2015) and also by Lewis and Westlund (2015b), the latter of whom have written about the "distinct role of technology" and the "opportunity for developing a sociotechnical emphasis in journalism studies" (p. 21). The special issue articles by Caswell (2019) and Jones and Jones (2019a)—on 'structured' or 'atomised' journalism—can be seen as part of such a development. Their contributions offer a promising way forward for future research. They illustrate how to bring forward the material features, potentialities, and consequences of such technologies, and how to do so from both a conceptual (Caswell) and an empirical (Jones and Jones) point of view. Moreover, they point to a vast and largely unexplored domain of journalism studies: an entire rethinking of news that shifts away from "the news story" as the fundamental unit toward a more database-driven conception of news according to its semantic units, down to the smallest editorial micro-structures of events, actor names, dates, and so forth—all of it discrete pieces of information that, when captured and classified as structured data, can be reconstituted in a variety of forms and functions.

In conclusion, the study of the *computational* in journalism has matured over several decades, in connection with the digitalization of media and society and the concurrent rise of digital journalism (studies). This special issue both builds upon this research and extends it by examining a particularly prominent development in journalism today—the growing visibility and importance of algorithms and associated forms of automation in how news is organized, produced, and distributed. The articles in this issue offer an essential starting point for future research that will continue to evaluate the automatization of news and what it means for a range of concerns central to the field—from politics and personalization, to professional norms and practices, to the possibilities and pitfalls of remaking news in a way that prioritizes the logic of machines.

References

Anderson, Christopher W. 2011. Notes Towards an Analysis of Computational Journalism. *HIIG Discussion Paper Series No. 2012–1*. doi:10.2139/ssrn.2009292.

Anderson, C. W. (2013). Towards a sociology of computational and algorithmic journalism. *New Media & Society*, *15*(7), 1005–1021.

Anderson, C. W., & Caswell, D. (2019). Computational journalism. In T. Vos & F. Hanusch (Eds.), *The international encyclopedia of journalism studies*. Hoboken, NJ: John Wiley & Sons.

Ananny, Mike. 2016. "Toward an Ethics of Algorithms: Convening, Observation, Probability, and Timeliness." *Science, Technology & Human Values* 41 (1): 93–117.

Ausserhofer, Julian, Robert Gutounig, Michael Oppermann, Sarah Matiasek, and Eva Goldgruber (2017) "The Datafication of Data Journalism Scholarship: Focal Points, Methods, and Research Propositions for the Investigation of Data-Intensive Newswork." *Journalism*, DOI: 10.1177/1464884917700667

Benton, J. (2019, June 24). R.I.P. Quartz Brief, the innovative mobile news app. Maybe "chatting with the news" isn't something most people really want to do? *NiemanLab*. https://www.niemanlab.org/2019/06/r-i-p-quartz-brief-the-innovative-mobile-news-app-maybe-chatting-with-the-news-isnt-something-most-people-really-want-to-do/

Bodó, Balázs (2019) Selling News to Audiences – A Qualitative Inquiry into the Emerging Logics of Algorithmic News Personalization in European Quality News Media, *Digital Journalism*, 7(8): 1054–1075.

Broussard, Meredith (2018) *Artificial Unintelligence: How Computers Misunderstand the World*. Cambridge, MA: MIT Press.

Bruns, Axel (2019) *Are Filter Bubbles Real?* Cambridge, UK: Polity.

Bucher, Taina (2017) "'Machines don't have instincts': Articulating the computational in journalism." *New Media & Society*, *19*(6), 918–933.

Bucher, Taina (2018) *If... Then: Algorithmic Power and Politics*. Oxford, UK: Oxford University Press.

Carlson, Matt (2015) "The Robotic Reporter: Automated Journalism and the Redefinition of Labor, Compositional Forms, and Journalistic Authority." *Digital Journalism* 3 (3): 416–431.

Carlson, Matt (2019) "News Algorithms, Photojournalism and the Assumption of Mechanical Objectivity in Journalism." *Digital Journalism,* 7(8): 1117–1133.

Caswell, David. 2019. "Structured Journalism and the Semantic Units of News." *Digital Journalism*, 7(8): 1134–1156.

Coddington, Mark (2015) "Clarifying Journalism's Quantitative Turn: A Typology for Evaluating Data Journalism, Computational Journalism, and Computer-Assisted Reporting." *Digital Journalism* 3 (3): 331–348.

Cohen, S., Hamilton, J. T., & Turner, F. (2011). Computational journalism. Communications of the ACM, 54(10), 66–71.

Daston, Lorraine and Peter Galison (2007) *Objectivity*. New York: Zone Books.

Diakopoulos, Nicholas (2015) "Algorithmic Accountability: Journalistic Investigation of Computational Power Structures." *Digital Journalism* 3 (3): 398–415.

Diakopoulos, N. (2017). Computational journalism and the emergence of news platforms. In B. Franklin & S. Eldridge II (Eds.), *The Routledge companion to digital journalism studies* (pp. 176–184). Abingdon: Routledge.

Diakopoulos, Nicholas (2019) *Automating the News: How Algorithms Are Rewriting the Media*. Cambridge, MA: Harvard University Press.

Dörr, Konstantin N. (2016) "Mapping the Field of Algorithmic Journalism." *Digital Journalism* 4 (6): 700–722.

Dörr, Konstantin N., and Katharina Hollnbuchner (2017) "Ethical Challenges of Algorithmic Journalism." *Digital Journalism* 5 (4): 404–419.

Ford, Heather & Jonathon Hutchinson (2019) "Newsbots That Mediate Journalist and Audience Relationships." *Digital Journalism*, 7(8): 1013–1031.

Eldridge, Scott A., Kristy Hess, Edson C. Tandoc, and Oscar Westlund (2019) "Navigating the Scholarly Terrain: Introducing the Digital Journalism Studies Compass." *Digital Journalism* 7 (3): 386–403.

Fletcher, R., Schifferes, S., & Thurman, N. (2017) "Building the 'Truthmeter': Training Algorithms to Help Journalists Assess the Credibility of Social Media Sources." *Convergence: The International Journal of Research into New Media Technologies*. Advance online publication. DOI: 10.1177/1354856517714955

Georgia Tech (2013). GVU brown bag seminar: Computational journalism. Retrieved from http://www.gatech.edu/hg/item/182791

Gillespie, Tarleton (2016) "Algorithm." In B. Peters (Ed.), *Digital keywords: A vocabulary of information society and culture* (pp. 18–30). Princeton, NJ: Princeton University Press.

Graefe, A., Haim, M., Haarmann, B., & Brosius, H.-B. (2016). Readers' perception of computer-generated news: Credibility, expertise, and readability. *Journalism*. Advance online publication. doi:10.1177/1464884916641269

Guzman, Andrea L., and Seth C. Lewis (2019) "Artificial Intelligence and Communication: A Human–Machine Communication Research Agenda." *New Media & Society*, doi: 1461444819858691.

Haim, Mario, Andreas Graefe, and Hans-Bernd Brosius (2018) "Burst of the Filter Bubble? Effects of personalization on the diversity of Google News" *Digital Journalism* 6 (3): 330–343.

Hamilton, J. T., & Turner, F. (2009). Accountability through algorithm: Developing the field of computational journalism. Retrieved from http://web.stanford.edu/~fturner/Hamilton%20Turner%20Acc%20by%20Alg%20Final.pdf

Helberger, Natali (2019) "On the Democratic Role of News Recommenders." *Digital Journalism*, 7(8): 993–1012.

Jones, Bronwyn & Rhianne Jones (2019a) "Public Service Chatbots: Automating Conversation with BBC News." *Digital Journalism*, 7(8): 1032–1053.

Jones, Rhianne & Bronwyn Jones (2019b) "Atomising the News: The (In)Flexibility of Structured Journalism." *Digital Journalism*, 7(8): 1157–1179.

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

Lewis, Seth C., and Oscar Westlund (2015a) "Big Data and Journalism: Epistemology, expertise, economics, and ethics." *Digital Journalism*, *3*(3), 447–466.

Lewis, Seth C., and Oscar Westlund (2015b) "Actors, Actants, Audiences, and Activities in Cross-Media News Work: A Matrix and a Research Agenda." *Digital Journalism* 3 (1): 19–37.

Lewis, Seth C., and Rodrigo Zamith (2017) "On the Worlds of Journalism." In *Remaking the News: Essays on the Future of Journalism Scholarship in the Digital Age*, edited by Pablo J. Boczkowski and C. W. Anderson, 111–128. Cambridge, MA: MIT Press.

Lewis, Seth C., Andrea L. Guzman, and Thomas R. Schmidt (2019) "Automation, Journalism, and Human–Machine Communication: Rethinking Roles and Relationships of Humans and Machines in News." *Digital Journalism* 7 (4): 409–427.

Milosavljević, Marko, and Igor Vobič (2019) "Human Still in the Loop: Editors Reconsider the Ideals of Professional Journalism Through Automation" *Digital Journalism*, 7(8): 1098–1116.

Montal, T., & Reich, Z. (2017). I, robot. You, journalist. Who is the author? *Digital Journalism*, *5*(7), 829–849. doi:10.1080/21670811.2016.1209083

Napoli, Philip M. (2014) "Automated Media: An Institutional Theory Perspective on Algorithmic Media Production and Consumption." *Communication Theory* 24 (3): 340–360.

Nechushtai, Efrat, and Seth C. Lewis (2019) "What Kind of News Gatekeepers Do We Want Machines to Be? Filter Bubbles, Fragmentation, and the Normative Dimensions of Algorithmic Recommendations." *Computers in Human Behavior* 90 (January): 298–307.

Pariser, E. (2011). *The filter bubble*. London: Penguin Books.

Posetti, J. (2018). *Time to step away from the "bright, shiny things"? Towards a sustainable model of journalism innovation in an era of perpetual change*. Retrieved from Reuters Institute for the Study of Journalism, University of Oxford website: https://reutersinstitute.politics.ox.ac.uk/sites/default/files/2018-11/Posetti_Towards_a_Sustainable_model_of_Journalism_FINAL.pdf

Primo, Alex, and Gabriela Zago (2015) "Who and What Do Journalism? An actor-network perspective" *Digital Journalism* 3 (1): 38–52.

PR Newswire. (1989, 9 February). *USA Today* launches Sports Center information service. Retrieved from the Nexis database.

Robinson, Sue, Lewis, Seth C., and Matt Carlson (2019) "Locating the 'Digital' in Digital Journalism Studies: Transformations in Research." *Digital Journalism*, *7*(3), 368–377.

Schudson, M. (2005). Four approaches to the sociology of news. In J. Curran & M. Gurevitch (Eds.), *Mass Media and Society* (4th ed.) (pp. 172–197). London: Hodder Arnold.

Stray, Jonathan (2019) "Making Artificial Intelligence Work for Investigative Journalism." *Digital Journalism*, 7(8): 1076–1097.

Sunstein, C. R. (2001). *Republic.com*. Princeton, NJ: Princeton University Press.

Sunstein, C. R. (2007). *Republic.com 2.0*. Princeton, NJ: Princeton University Press.

Thurman, N., Dörr, K., & Kunert, J. (2017). When reporters get hands-on with robo-writing: Professionals consider automated journalism's capabilities and consequences. *Digital Journalism*, *5*(10), 1240–1259.

Thurman, Neil, Steve Schifferes, Richard Fletcher, Nic Newman, Stephen Hunt, and Aljosha Karim Schapals (2016) "Giving Computers a Nose for News: Exploring the limits of story detection and verification" *Digital Journalism* 4 (7): 838–848.

Thurman, N., Moeller, J., Helberger, N., & Trilling, D. (2019). My friends, editors, algorithms, and I: Examining audience attitudes to news selection. *Digital Journalism*, *7*(4), 447–469

Thurman, Neil. (2018). Social media, surveillance, and news work: On the apps promising journalists a "crystal ball". *Digital Journalism*, *6*(1), 76–97.

Thurman, Neil (2019a) "Personalization of News" in Tim Vos and Folker Hanusch (Eds.) *The International Encyclopedia of Journalism Studies*. Hoboken, NJ: John Wiley & Sons.

Thurman, Neil (2019b) "Computational Journalism" in Karin Wahl-Jorgensen and Thomas Hanitzsch (Eds.) *The Handbook of Journalism Studies*, Second Edition. New York: Routledge.

Usher, Nikki (2016) *Interactive Journalism: Hackers, Data, and Code*. Urbana-Champaign, IL: University of Illinois Press.

Verne, J., & Verne, M. (1889, February). In the year 2889. *The Forum*. Retrieved from http://www.gutenberg.org/files/19362/19362-h/19362-h.htm

Weber, Matthew S., and Allie Kosterich. 2018. "Coding the News: The role of computer code in filtering and distributing news" *Digital Journalism* 6 (3): 310–329.

Wu, S., Tandoc, E. C., & Salmon, C. T. (2019). A Field Analysis of Journalism in the Automation Age: Understanding Journalistic Transformations and Struggles Through Structure and Agency. *Digital Journalism*, *7*(4), 428–446.

Zamith, Rodrigo (2019) "Algorithms and journalism." In H. Örnebring, Y.Y. Chan, M. Carlson, S. Craft, M. Karlsson, H. Sjøvaag & H. Wasserman (Eds.), *Oxford Encyclopedia of Journalism Studies*. Oxford: Oxford University Press. https://doi.org/10.1093/acrefore/9780190228613.013.779