Because Technology Matters:
Theorizing Interdependencies in Computational
Communication Science With Actor–Network Theory

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Technology heavily drives communication research in the computational turn, yet our research programs seldom reflect this heightened relevance of technology in both everyday life and our own scientific work. In this article, we revisit actor–network theory (ANT) as a helpful conceptual framework for theorizing and inspiring future computational communication scholars' research agendas. Based on a narrative literature review, we identify three key contributions of the ANT perspective in computational communication science: First, ANT enables us to address the role of technology in communication and the relationships between nonhumans and humans in more detail. Second, we may reflect more explicitly on the epistemological status of computational methods. Third, we can question the normative and ethical assumptions guiding our research. We close by discussing blind spots, limitations, and challenges of ANT, and we point out future perspectives of ANT-informed computational communication science.

Keywords: actor–network theory, computational methods, technology, communication theory, agency, nonhumans

Technology heavily drives communication research in the computational turn. Scholars work with massive data sets generated by technical infrastructures of online platforms and use powerful algorithms for their analyses; however, our research programs seldom reflect this heightened relevance of technology in both everyday life and (public) communication and our own scientific work. This coincides with a general lack of theoretical reflections in such a fast-moving field (Mahrt & Scharkow, 2013; Dijck, 2014).

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We contribute to the emerging field of computational communication science (CCS) with a conceptual intervention. The more we turn toward computational and often highly automatic research processes, the more rigorously we need to scrutinize the entanglement of technologies, social phenomena, and ourselves as researchers. How do technologies and data represent the social processes that we aim to study? How do the specifics of our research instruments, such as single computational procedures, shape our research questions and results? How are we as researchers positioned in relation to our objects of study? We suggest that actor–network theory (ANT; Callon, 1991; Latour, 1992) is instructive for addressing these interdependencies in CCS research, providing a conceptual framework for theorizing and inspiring CCS scholars' research agendas.

To unfold this contribution, we first briefly introduce the theoretical perspective. We then explicate our findings from a narrative literature review showing that ANT has already been used to study a variety of questions in media and communication research. Guided by this review, we identify three key contributions to current challenges in CCS informed by an ANT perspective. First, we may open our discipline to new questions and perspectives of communication research by focusing on the role of technology in communication and the relationships between nonhumans and humans. Second, from a metaperspective, we can reflect on the emergence, development, and inscriptions of computational methods in our discipline, as they are not only shaped by technological and scientific innovations, but they also influence how we do science now and in the future. Third, this metaperspective motivates an even further step of self-reflection, pushing researchers to deliberate about their roles in the research process as well as the normative and ethical assumptions guiding them. For each of these points, we explicate why and how an ANT perspective is useful and how it might be integrated into media and communication research in the computational turn. Finally, by discussing the blind spots, limitations, and challenges of ANT as a theoretical and methodological research frame, we highlight needs and opportunities to expand the ANT framework and to fruitfully combine it with other approaches.

Understanding the Social With ANT

Developed by Michel Callon and Bruno Latour in the 1980s in the context of the sociology of science, technology, and innovation, ANT has since become an often-applied theoretical perspective in the social sciences and beyond. Its major claim is that technology and society are inherently intertwined, coconstructing and stabilizing each other. Going beyond social constructivist perspectives, ANT holds that not only science and technology are socially constructed; technology also constructs the social (Primo & Zago, 2015, p. 42). Scholars from this perspective understand the social as networks of connections between human social actors and nonhuman technical actors as fundamentally symmetric in their contribution to society and social change (Callon, 1991, p. 140). This is also reflected in specific terms and definitions that are agnostic about the kinds of entities (human or nonhuman) or networks under study, being quite abstract as a consequence.

Actors and networks are considered reversible categories: A *network* is defined by its actors and associations, and an actor is fully defined by its network (Latour, 2011). The term *network* here focuses on the redistribution of action and agency (Latour, 2011, p. 797); thus, it is different from the common usage of the term in social network analysis and network science. In this perspective, the social is nothing but

actors and networks within networks, which in the end can be reduced to actors and their relations—in other words, "nothing but differently scaled individual singularities" (DeLanda, 2006, p. 28). Consequently, this *flat ontology* implies that hierarchical distinctions between micro and macro levels of analysis or between structure and actor are not possible within the scope of the framework (Latour, 2005, pp. 165–172).

In the sense and wording of ANT, an *actor* is "any thing that does modify a state of affairs by making a difference" (Latour, 2005, p. 71). Actors do not have to be social but "can literally be anything provided it is granted to be the source of an action" (Latour, 1996, p. 373). *Agency* in terms of ANT does not imply intentionality, autonomy, or responsibility (Sayes, 2014, p. 139). Things "act" by having an impact on others: "Things might authorize, allow, afford, encourage, permit, suggest, influence, block, render possible, forbid, and so on" (Latour, 2005, p. 72). This minimalistic definition leaves room for nonhuman actors, which is why ANT scholars prefer the abstract term *actant* to denote any acting entity, particularly in its prefigurative stage (i.e., before becoming an *actor–network*; Latour, 2005, p. 71; Plesner, 2009, pp. 612–613). Technical entities are seen as particularly essential for the patterning of the social, stabilizing human collectives, objectifying moral and political norms, and gathering actors from other times and spaces in one locus (Sayes, 2014). However, this does not mean that ANT adheres to a new kind of technological determinism: Eschewing any notion of linear and one-sided effects, ANT highlights dynamic, circular, and reciprocal processes of coevolution between the social and the technical.

The process of establishing connections among entities in networks is called *translation* (Callon, 1991, p. 143). Translations lead to reciprocal adjustments of actions in the network. Enduring translations result in *inscriptions* that shape actors' actions in the long term while generating expectations and preconditions for the actions of others (Schulz-Schaeffer, 2000, p. 192). To the extent that the inscriptions of diverse actors are *convergent* (i.e., they match with each other) and *irreversible* (i.e., they are stable and resistant regarding further translations), a network becomes *black-boxed*, meaning that its actions are known and predictable disregarding its specific context (Callon, 1991, pp. 144–152).

In sum, ANT offers a holistic, comprehensive perspective of the social. It emphasizes the need to turn away from exclusively analyzing humans by integrating nonhuman actors into our understanding of social order. This mandate might have been quite radical in the 1980s, but it has gained strong relevance in our contemporary mediatized, datafied, and algorithmitized societies.

ANT Contributions to Communication Research in the Computational Turn

Researchers have already mobilized ANT in different fields of media and communication studies. Lately, we have witnessed an increasing yet still dispersed salience of this perspective in articles and conference presentations within the discipline. This is not surprising: One of the field's main challenges is conceptually addressing the increasing role of technology in interpersonal and mediated communication and the deeply intertwined nature of human–technical relationships (e.g., Luppicini, 2014). There is a paucity of adequate theoretical frameworks for analyzing communication in this regard; thus, we argue that ANT offers genuine contributions.

Intending to provide a holistic overview of the status quo of applying ANT to CCS, we conducted a narrative literature review (Grant & Booth, 2009; Paré, Trudel, Jaana, & Kitsiou, 2015) based on a systematic search and inspection of peer-reviewed journal articles that make use of ANT in media and communication research. On September 2, 2018, we queried the scientific EBSCO database *Communication and Mass Media Complete* for the search term *actor network theory* in article titles, abstracts, and author-supplied keywords from 1995 to 2018. This article collection yielded 142 articles in total. Two of us then jointly inspected these articles more closely, carefully reading, qualitatively examining, and aggregating the core strands of ANT adoption over the past 25 years guided by a number of predefined categories: the identification of research areas in which ANT has been applied, analytical as well as methodological potentials of ANT the authors explicitly addressed, the transfer and/or operationalization of ANT into empirical research, the use of computational methods in the respective study, and the authors' critical reflections on ANT.

This literature review shows that ANT has been applied in a variety of research fields in communication studies. Most studies belong to the fields of journalism (e.g., Anderson, 2013; Domingo, 2015; Hammond, 2017; Spyridou, Matsiola, Veglis, Kalliris, & Dimoulas, 2013), technology diffusion and adoption studies (e.g., Best, 2009; Dávila, 2017; Petersen, 2007), and marketing studies (e.g., Alexander & Nicholls, 2006; Hagberg, 2016; Shim & Shin, 2016), followed by research in the field of science and risk communication (e.g., Besel, 2011; De la Harpe & Roode, 2004) and media and television studies (e.g., Behdad, 2017; Hondros, 2016). Further areas of ANT research include learning through digital media (e.g., Martín-Bylund, 2017; Stenliden, Nissen, & Bodén, 2017), political participation and protest communication (e.g., Jørgensen, 2017; Poell, de Kloet, & Zeng, 2014; Teles & Joia, 2011), and rhetoric and language studies (e.g., Kelly & Maddalena, 2016).

Several areas were rarely studied, including health communication (e.g., Lassen, 2012; Mager, 2009), deviant behavior (such as cybercrime; e.g., Luppicini, 2014), social inequality (e.g., Halford & Savage, 2010), game studies (e.g., Farnsworth & Austrin, 2010), feminist and gender studies (e.g., Hallenbeck, 2012), and organizational communication (e.g., Cooren, Brummans, & Charrieras, 2008; Verhoeven, 2008). Despite the specifics and differences of these subfields and of the individual articles, we identify key themes in these ANT contributions that we present in the following according to their analytical potential, their methodological contributions, and the normative and ethical considerations they highlight.

Analytical Potentials of ANT

Looking at the analytical potential the ANT-informed studies in our literature review foreground, the overarching recurrent theme is the challenge of the "black box" (i.e., uncovering the processes, values, and interests at work inside digitized and deeply mediatized communication processes). By retracing the inscription of values and interest in detailed case studies, often focusing on conflicts and controversies, ANT has proven fruitful in uncovering the hidden social order within actor–networks, examining structures of power and hierarchy, and addressing questions about competing values and meaning-making among network actors. It is also useful in identifying and analytically separating human and technical actors to understand the complexity of agency within digital and technical networks.

For example, Poell et al. (2014) trace how particular technological features of a Chinese website, user cultures, and emerging user practices as well as the platform's systematic self-censorship become entangled and constitute each other. Another typical example is Ramati and Pinchevski's (2018) study of automated language translation procedures from post-World War II rule-based methods to contemporary algorithmic statistical methods. By retracing in detail how values and assumptions are inscribed into the technology, in turn shaping social practices, the authors illuminate the underlying power structure of algorithmic and human collaboration that becomes hidden once a technology is in place—thus, black-boxed.

That ANT and similar perspectives have recently experienced a renewed interest (Couldry & Hepp, 2016; Gillespie, 2014; Katzenbach, 2017) sits comfortably with an increased attention toward the role of technology in structuring mediated and digitized communication in general, triggered by the ascending role of automation, the pervasive processes of datafication, and the "mediation of everything" (Livingstone, 2009). It thus seems obvious that key questions of media and communication studies cannot be answered without turning to the very fabric of technologies: How is content selected, displayed, and shared? How is relevance determined? Do the technical mechanisms of online platforms fuel hate speech and political misinformation through fake news? Approaches that emphasize the ordering effect of technology (once it is in place) complement the long-standing dominance of social constructivism.

Social studies of technology have long held the idea that technology is never neutral regarding politics or values. Accordingly, an increasing number of researchers have been taking nonhumans seriously—for instance, in their analyses of algorithmic culture (e.g., Cheney-Lippold, 2011; Crawford, 2016; Gillespie, 2014; Karppi & Crawford, 2016), the politics and ethics of social media platforms (e.g., Gillespie, 2010; Light & McGrath, 2010), and interventions by social bots (e.g., Guilbeault, 2016; Klinger, & Svensson, 2018; Maréchal, 2016). Yet, guided by the theoretical perspective of ANT, researchers have sharpened their focus on the shaping role of technology as a proper actor in the digital communication spheres they study (e.g., Hammond, 2017; Weiss & Domingo, 2010) and have started theorizing nonhuman agency to gain a better understanding of human capacities and human/nonhuman dependencies. For example, analyzing interactions between human and nonhuman actors using the example of Microsoft's chatbot Tay powered by machine learning, Neff and Nagy (2018) show how different qualities of agency, different expectations for technologies, and different capacities for affordance—triggered by imagined affordances of emerging technology—shape the communication between users and the bot. Here, the users ascribed agency to the technological actor, affecting their behavior.

Although these analytical contributions certainly cannot be uniquely attributed to ANT, they have developed within the broader field of science and technology studies that constantly engage with classic and more recent ANT contributions and provocations (cf. Gillespie, Boczkowsi, & Foot, 2014, for a well-balanced collection of approaches). This global picture holds true for our review as well: Although the studies in our review seldom follow ANT literally, and some even fundamentally criticize assumptions such as flat ontology (Couldry & Hepp, 2016, p. 62), engaging with ANT does inform fruitful approaches to analyze how social norms and expectations are translated into technical artifacts, structuring social behavior, and eventually, social change. This perspective is highly instructive when studying how search algorithms and newsfeeds are developed and, once in place, how they structure basic social behaviors such as searching and selecting information.

Methodological Advances and Critical Methodological Reflections

The observation that our social lives are fundamentally changed by the increasing agency of technology also challenges communication and media research from a methodological and data-analytical perspective. Some scholars have thus also used perspectives derived from ANT as a starting point for further methodological advances and critical reflections on methodology. For example, building on the observation that digital devices and data are becoming ever more part of academic practices, Ruppert, Law, and Savage (2013) outline how they are shaped by social worlds but can in turn become agents that simultaneously shape those worlds, "reworking, mediating, mobilizing, materializing and intensifying social and other relations" (p. 24). Whereas Latour, Jensen, Venturini, Grauwin, and Boullier (2012) argue that computational methods might finally put an end to the distinction between the individual and the aggregate level, the studies in our sample make methodologically more elaborated statements that complicate, in the best sense, the relation between the data that are collected and analyzed on the one hand and the object under study on the other hand.

An increasing group of researchers is progressively aware of actions produced by nonhuman actors incorporated in large-scale Web research (e.g., Keyling & Jünger, 2016, p. 194; Ruths & Pfeffer, 2014, p. 1064). When scholars study digital traces originally generated with social media, these data are primarily created to stimulate user behavior serving underlying business models. As a consequence, the "surface" of digital communication under study—be it the analysis of social media interactions on platforms such as Facebook (e.g., Turcotte, York, Irving, Scholl, & Pingree, 2015) or Reddit (e.g., Kilgo et al., 2016), the selective exposure to media (e.g., Winter, Metzger, & Flanagin, 2016), of reading and sharing metrics provided by online news sites (e.g., Zamith, 2016), of search engines such as Google (e.g., Pan et al., 2007), or of intimate landscapes of data prediction (e.g., Hong, 2012)—may not necessarily mirror a digital social reality in any genuine sense. Instead, it may merely display the product of underlying continuous and largely automated acting technology, serving the interests of the private or governmental institutions using the data (Couldry & Hepp, 2016, p. 124).

The problem that resulting analyses may "misrepresent the real world" (Ruths & Pfeffer, 2014, p. 1063) is even more startling when spammers and bots masquerading as authentic social humans covertly make their way into these analytics. Studying digitized social settings, scholars must reflect on the difference between behavioral data and messages that are "actually traceable to human activity" and output "being the result of spam bots, click farms, fake accounts and other automated mechanisms" (Keyling & Jünger, 2016, p. 194). Although such an analytical reflection on how digital data are automatically generated and processed before the researcher comes into play has become tremendously important (Mahrt & Scharkow, 2013), scholars have placed little focus on the methodological consequences of using digital data for research purposes. An ANT perspective can raise our awareness of components, principles, and mechanisms that researchers should address both theoretically and methodologically when working with digital data and innovative computational methods.

Against this background, it is even more surprising that researchers have not yet fully elaborated the close connection between ANT and computational methods. Numerous scholars, informed by ANT perspectives, have examined the integration of computational applications in communication and media and

its consequences, for example, problematizing instances of acting technology and tracing the resulting networks of humans and nonhumans in information visualization (Dávila, 2017), machine translation (Littau, 2016), and digital technologies in the newsroom (Spyridou et al., 2013). Nevertheless, in our sample, we found only a handful of studies in which researchers put the combination of ANT and computational methods of data collection and/or data analysis into practice. Not surprisingly, most of them integrate an ANT approach with computational network analyses. Mager (2009) uses hyperlink crawling and network analysis together with search engine results and qualitative text analysis and interviews to study actor–networks in online health. Likewise, Marres (2012) shows how hyperlink network analysis in combination with textual analysis (such as tag clouds) can help us visualize how technologies are publicly problematized. Also, inspired by ANT, Contractor, Monge, and Leonardi (2011) conceptually develop an approach to integrate human and nonhuman actors into multimodal and multidimensional network analysis. Finally, Potts (2009) gives an early example of a study scraping and analyzing data from the Flickr application programming interface to trace the movements of users and their interactions with Web tools after the London bombings in 2005.

In sum, researchers have shown that ANT is a valuable approach in empirically researching digital communication and consequences of digitalization in the broadest sense, be it in combination with qualitative (e.g., Hondros, 2016; Weiss & Domingo, 2010), quantitative (Sørensen, 2013; Spyridou et al., 2013), or qualitative–quantitative approaches (Eardley-Weaver, 2013; Light, Bagnall, Crawford, & Gosling, 2018; Read & Swarts, 2015; Shin & Lee, 2011; Zhang, 2010).

Normative and Ethical Assumptions of Computational Research

ANT triggers researchers to reflect on their own roles in the research process and their (often hidden) normative and ethical assumptions guiding it. Following Domingo (2015), ANT invites us to be "self-reflexive, not only to avoid imposing our analytical categories in the analysis but also to accept and make explicit our engagement as researchers with improving the society we serve" (p. 70). Latour (2005, p. 258) explicitly argues that whenever a scholar writes an account, he or she is already part of the reality that he or she is researching. This particularly holds true when applying computational methods to study social communication in mediatized and digitalized environments. Here, ANT acknowledges the agency and normative implications of research tools and eventually black-boxed technologies such as bots and data crawlers collecting information based on computational algorithms. In emphasizing the interactions between technology and humans, ANT is also a good precaution against technological determinism in the ontological principles that guide our research designs.

Although it goes without saying, this is even more important considering that humans design applied software and computational tools. Programmers inscribe their own values and definitions in these tools that, once put in research practice, "may exert power over its adopters with the implacability of materiality" (Domingo, 2015, p. 72). This also complicates the ethical evaluation of research designs and processes. Who is accountable? In using computational tools, researchers are delegating subtasks to nonhuman actors that can act in unintentional and unexpected ways. These twists hold the potential "to harm before we know what has happened and can intervene" (Light, 2016, p. 15).

Following Light (2016), researchers need not only think about what might happen with the applied tools and methods, data, and research in the future, but they must also consider how, if, and when adjustments are to be made when harm is caused. In that sense, we strongly argue for reconsidering the researcher's accountability and responsibility in computational research procedures and the application of instruments. In line with Ruppert et al. (2013), we highlight that we "need to attend to how . . . qualities of digital devices demand rethinking the theoretical assumptions of our social science methods and making those assumptions explicit" (p. 24).

At the same time, and without weakening the prior position, we concordantly see one major contribution of ANT in its attribution of accountability and even morality to nonhuman actors. Even if studies address the role of technology in shaping social spaces, they have predominantly discussed technological functions and features as "man-made" properties that human developers designed (e.g., Klinger & Svensson, 2018). In this line of argumentation, the focus is often put on human agency, and technology is downplayed or even ignored (Light & McGrath, 2010). Yet, considering nonhumans as actors that have agency and that can transform situations, in view of ANT, we can also partially ascribe authority, accountability, and morality to these actors (Latour, 1992, 2005). This perspective opens new angles when studying, for example, tweets from hacked press accounts affecting financial markets (Karppi & Crawford, 2016), Facebook's moral values (Light & McGrath, 2010), or Amazon's homophobic scope (Striphas, 2015). We further discuss the theoretical implications and limitations of such a perspective in contrast to other social theories in the next section.

While encouraging self-reflection and the need to unpack the mutual interdependencies between technologies/methodologies and developers/researchers, we stress that ANT by itself is not a normative or critical theory. Rather, its flat ontology and its focus on description instead of explanation (Latour, 2005, p. 136) limit its normative and critical potential (Whittle & Spicer, 2008), for example, by neglecting long-term power structures and institutions (Couldry, 2008; cf. below).

Future Perspectives and Challenges of Doing CCS Research Informed by ANT

After having outlined the key contributions of ANT for CCS, this section now discusses future perspectives of ANT-informed CCS research. Specifically, we address blind spots as well as theoretical and methodological challenges and limitations of the ANT framework and discuss how to account for these in future work.

Blind Spots of Current Studies Applying ANT and Future Research Fields

As our systematically conducted narrative literature review reveals, researchers already apply ANT in many subfields of the discipline. Health communication, deviant behavior, social inequality, and organizational communication, however, are rarely confronted with ANT. It is particularly these fields that exert technological developments that make the use of ANT highly suitable.

For example, studying the rising demand of human activity recognition using so-called wearables (e.g., Kumari, Mathew, & Syal, 2017) from an ANT perspective could bring up interesting questions for

health communication scholars: What are the patterns and scripts inscribed into such wearables? What does this tell us about the human agency implemented here? How do humans interact with wearables as technical actors? How are their patterns and scripts then adopted, and how do they possibly change these actions?

Likewise, tools such as chatbots, text-mining, and data-driven targeting are not only promising for marketing purposes, but also for other fields of organizational communication. Given the current massive interest in smart systems, deep learning, and artificial intelligence, it is surprising that these topics are (still) widely lacking in our sample, although they appear to be a perfect fit for ANT perspectives. In light of recent developments from Siri to AlphaGo, we can already see that artificial intelligence and deep learning are developing rapidly because of improvements in processing capacity, the accumulation of big data, and the range of complex tasks they successfully perform (e.g., Engemann & Sudmann, 2018; LeCun, Bengio, & Hinton, 2015), particularly in specific intellectual areas such as image recognition, speech recognition, and dialogue response. Considering ANT's basic assumptions, we believe that the more these technical actors evolve as self-learning, self-developing systems, the more it becomes crucial to conceptually differentiate between the agency of nonhuman and human actors while comprehensively analyzing their interactions and dependencies.

Here, we slightly disagree with Klinger and Svensson's (2018) account of agency: "While algorithms account for some projectivity, they cannot move beyond themselves and are not able to change their relationship to their design; they cannot replace the human and institutional actors at the input stage" (p. 8). As they argue, it might be wise to worry less about the machines than about the humans behind them; however, ANT reminds us that focusing only on human agency almost always gives an incomplete picture. For example, although it is true that we should examine the conditions and structures informing and influencing the people behind social media bots, from an ANT perspective, it is equally important to ask to which degree behavioral patterns and normative standards may be inscribed and already black-boxed into the whole technical infrastructure that enables the phenomenon of bots. Given the developments in machine learning, particularly deep learning, it is very likely that an understanding of agency that merely focuses on human actors and their inscription in artifacts without addressing the artifacts' further evolution will soon be outdated.

Next to the need for more elaborate reflection on the research process, science as a whole societal subsystem is also challenged by the current developments: Science itself changes and is changed by digitalization, mediatization, datafication, algorithmization and computational methods. Taking these changes seriously must ultimately result in a self-reflexive process of how science is changed by, throughout, and alongside technology, and how it, on the contrary, influences technological change as well. ANT-informed perspectives are well positioned to bring forward critical analyses of interrelated changes of action by humans and nonhumans inside our scientific realm. The very origins of ANT in the laboratory studies of the 1970s made exactly this point very clear: Scientific knowledge is heavily dependent on or, to put it more forcefully, constructed by the specific technological apparatus that researchers mobilize in their studies (Bloor, 1976; Latour & Woolgar, 1979). Building on this, researchers in CCS need to reflect: How do online platform architectures and the tools they offer (or do not offer) shape our research questions and definitions of concepts? Shall we operationalize concepts such as *issue* and *opinion* in the context of CCS research as hashtags, keywords, sentiments, or likes? How does an increasing automatization of research processes

change methodological and ethical standards in our discipline? ANT allows us to reflect on the ongoing computational turn in communication science as an innovation process that does not simply inspire and stimulate research activities, but that also affects how communication research is conducted, as it is socially and technically coconstructed.

Theoretical Challenges

The specific value, but also important limitations of ANT in particular, become apparent when juxtaposing ANT with other neighboring or opposing theoretical concepts. In the following, we discuss how conceptual debates around mediatization, agency and social structure, and social networks challenge ANT and how ANT challenges them. We try to make productive use of these tensions and identify possible theoretical advancements.

ANT and Mediatization

ANT provides a valuable perspective to the study of digital media environments and communication, and *mediatization theory* has also profoundly addressed the idea that technological changes are interrelated "with long-term and culture-crossing changes . . . which influence the social and cultural development of humankind in the long run" (Krotz, 2007, p. 27). Mediatization theory suggests that processes of *deep mediatization*—in which "the very elements and building-blocks" that construct social reality "become themselves based in technologically based processes of mediation" (Couldry & Hepp, 2016, p. 7)—affect and change the nature of the social world. Following these ideas, the mediatization of inner media structures, increasingly incorporating algorithmized data processing (operating behind the scenes of mediated everyday interaction) may also produce self-referential and self-implicating media structures, content, and interactions.

From mediatization theory as well as from an ANT perspective, it becomes mandatory to critically reflect on the phenomenon of deep mediatization not only from an empirical but also from a methodological perspective. Yet, whereas mediatization theory strongly focuses on technology as a power tool shaping social behavior by application, ANT eventually goes beyond this claim by assuming that technology has a life of its own. From an ANT perspective, technology is conceptualized as a sovereign actor that, once established, literally takes action in social interactions, playing an equal and symmetric role in it. This perspective is instructive, such as when dealing with the increasing relevance of nonhumans in large-scale Web research (e.g., Keyling & Jünger, 2016, p. 194; Ruths & Pfeffer, 2014, p. 1064). Instead of just regarding these as spam or fake, an ANT perspective indicates that we study technical actors as actors in their own right who participate in and bring change to social interactions.

ANT and Social Structures

In addition to the status of nonhuman actors, the assumption of a flat ontology is probably what holds ANT apart from other social theories. As introduced above, ANT posits that there is nothing but actors and networks within networks, which in turn can be reduced to actors and their relations. Although this sits comfortably with recent developments in praxis theory that reduces social structures to practices (Pentzold,

2016; Schatzki, 1995), this flat ontology opposes classic social theories, and as Couldry and Hepp (2016, p. 62) rightfully highlight, it runs the risk of downplaying resources, sense-making processes, and other structural features. We will not reproduce the ontological debate here, but for research designs, it might indeed make sense to complement ANT perspectives with approaches highlighting the interdependency between agency and structure, such as structuration theory and institutional theories.

Giddens' (1984) structuration theory describes agents and structures as mutually constitutive entities with equal ontological status. Depending on the research question, it may be useful to not always unpack each and every (human or nonhuman) actor in minute detail, as ANT would suggest. For example, looking at patterns of technology adoption, Mead and Neves (2018) bring ANT and structuration theory together to account for both recurring social patterns as well as for artifacts' agency. Looking at Internet governance, Epstein (2015) mobilizes structuration theory to account for the duality of both technology and policy, thus integrating individual agency and microbehaviors of individuals on the Web and the systemic and structural properties of the environments where information technologies are being created, regulated, and used.

Institutional theories in sociology use a different option to mitigate the risk of ANT becoming lost in the endless tracing of associations. Sociological theories of institutions are plenty, and some might overemphasize structural features over practices, technology, and individual agency. Yet, following Scott (2007), these perspectives can help categorize different forms and modes of structuration and institutionalization. Both Pentzold (2016) and Katzenbach (2017) suggest differentiating regulative, normative, cognitive–discursive, and material forms of patterning the social. This helps to analytically and empirically anchor investigations while tracing networks and associations in detail.

ANT and Social Networks

Another neighboring approach is social network analysis. Here, ANT scholars distance themselves from the common usage of the term *network* (Mützel, 2009; Philipp, 2017). Probably the most important difference to social network analysis is that ANT includes not only human individual actors as nodes in the networks, but also nonhuman, nonindividual entities (Latour, 1996, p. 369). Latour (1996) points out that in contrast to social network analysis and theory, ANT does not consider network associations as yet another explanatory variable for explaining the social, but instead it asks how actor–networks emerge and considers networks as the essential frame for understanding all social phenomena: "It does not wish to add social networks to social theory, but to rebuild social theory out of networks" (Latour, 1996, p. 369).

However, we do not consider these incompatible differences but rather opportunities for advancements of network theory and analysis. For example, in a study applying both ANT and social network analysis, Read and Swarts (2015) show that both approaches are complementary in that they each highlight different aspects and thus are valuable for triangulating empirical research. Another option is to consider nonhumans as endogenous parts of bi- or multimodal networks, as Contractor et al. (2011) propose. In a case study, they show that this move yields much richer insights than unimodal network analyses, in which technology is merely regarded as an exogenous variable. In such multidimensional networks, different types of nodes (e.g., humans and technologies) are held together by different types of relations (e.g., friendships

and information retrieval). For media and communication scholars, this approach is highly instructive, as it allows researchers to make important theoretical and practical distinctions. For example, regarding the question of whether bots should be granted freedom of speech (Maréchal, 2016), it might be important to distinguish bot agency from human agency without disregarding bots as actors altogether.

Methodological Challenges

ANT is regarded not only as an ontology and theoretical framework to describe the social, but also as a "mode of inquiry" (Latour, 1996) to which certain methodological premises are tied. With its flat ontology, ANT does not accept explanations outside the network, nor does it distinguish between cause and effect or between the micro and macro level (Latour, 2011). With these premises, ANT scholars reject classic approaches and distinctions of sociological theory and quantitative research (Philipp, 2017, p. 138). On the contrary, explanation—in their view—must be achieved by detailed, process-oriented descriptions of the actors and the emerging translations in the network without any a priori assumptions (Schulz-Schaeffer, 2000, pp. 198–199). In doing so, ANT researchers prefer highly explorative, descriptive, nonreductionist, and mainly qualitative methods.

We argue against these self-imposed limitations in terms of methodology as they likely hinder social scientific progress. Particularly, eschewing all kinds of preassumptions is overly restrictive and ignores fruitful empirical insights by previous research. The real strengths of ANT become obvious when combined with other more quantitative methodological approaches. Particularly, recent developments in computational methods and the availability of big digital trace data facilitate the integration of quantitative and qualitative approaches (Latour et al., 2012) and to push inductive and data-driven approaches to a quantitative scale (Waldherr, Heyer, Jähnichen, Niekler, & Wiedemann, 2016, p. 213). Thus, a major opportunity of future ANT-inspired CCS consists in further integrating qualitative and quantitative research approaches.

In sum, without subscribing to all of the radical premises and complicated vocabulary of ANT, media and communication scholars can be inspired and productively irritated by ideas and methodological emphases of ANT. As Couldry (2008) points out, ANT can be inspiring, even if we push its insights "in other directions and over different territory from that which it originally set for itself" (p. 107). In this sense, researchers might include technical actors into explanations, place more emphasis on dynamic network evolution and processes, connect micro and macro explanations more closely in their work, and reflect inscriptions of actions into enduring technical objects and artifacts. As we outlined, the latter is also highly relevant with respect to the agency of our own research instruments. These impulses will eventually lead to a more self-reflective, critical, and theory-driven CCS.

Conclusion

Media and communication scholars are being confronted with massively changing objects of study and are at the same time bringing forward a remarkable change in instruments of study. They increasingly deploy computational methods for analyzing massive data sets, routinely using several orders of magnitude more data points than the classic four-digital quantitative study. This computational turn has been

increasingly criticized for being primarily data-driven and lacking theoretical orientations, for both understanding the social phenomena under study and reflecting the proper research process.

In this context, we have suggested considering ANT as an instructive source for conceptual progress in the emerging field of CCS. Our literature review on existing adoptions of ANT in the general field of media and communication studies over the last 25 years has yielded three main contributions of ANT interventions: ANT has repeatedly pushed our discipline toward new questions and perspectives by triggering us to focus more on the role of technology in communication; it has also triggered methodological questions and critique by addressing the proper role of technology in the very research process; finally, it has provoked ethical reflections of researchers' relations to and impact on the objects they study.

All of these considerations and contributions are, as we have shown, becoming more and more relevant for media and communication studies in its current computational turn. The more we turn toward computational and often highly automatic research processes, the more rigorously we need to scrutinize the entanglement of technologies, social phenomena, and ourselves as researchers. However, as we have argued, ANT is not the single answer to all of these challenges, and it has theoretical and methodological limitations. Thus, to identify future avenues of research, we have brought the approach into conversation with other neighboring and opposing theoretical concepts.

In sum, notwithstanding its partly inaccessible vocabulary, ANT is a framework that speaks directly to current concerns of CCS research. With this article, we invite media and communication scholars to allow ANT to irritate and inspire them in their work. Thus, we do not advise a dogmatic following, but we rather suggest combining it with concepts and perspectives such as mediatization theory, institutional perspectives, and network theories. ANT sensitizes researchers to the agency of technology, allowing them to zoom in and out, unpack and repackage social phenomena, and reflect on their own positions. It does not help us to finally answer the question, "Are we researching society or technology?" (Marres, 2017, p. 116); instead, it helps us to ask better questions and complicate the picture in the best sense.

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Articles marked with * are selected references from the literature review, which we considered representative for the respective strands of research. The full reference list is available at https://osf.io/xm8bq/?view_only=a63daeadbc844cf2801c7f5fa54b5295

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