Algorithms and Routine Dynamics

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ALGORITHMS AND ROUTINE DYNAMICS

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ABSTRACT

Organizations increasingly rely upon algorithms to change their routines—with positive, negative, or messy outcomes. In this chapter, we argue that conceptualizing algorithms as an integral part of an assemblage provides scholars with the ability to generate novel theories about how algorithms influence routine dynamics. First, we review existing research that shows how algorithms operate as an actant making decisions; encode the intentions of designers; are entangled in broader assemblages of theories, artifacts, actors, and practices; and generate performative effects. Second, we elucidate five analytical approaches that can help management scholars to identify new connections between routine assemblages, their elements, and organizational outcomes. Finally, we outline directions for future research to explore how studying algorithms can advance our understanding of routine dynamics and how a routine dynamics perspective can contribute to the understanding of algorithms in strategy and organizational theory more broadly.

INTRODUCTION

Increasingly, algorithms—"abstract, formalized description[s] of computational procedure[s]" (Dourish, 2016: 3)—are becoming core components of organizational routines. For example, law enforcement agencies deploy algorithms within patrolling routines to predict the locations of future crimes (Brayne, 2017) and efficiently allocate security resources (Glaser, 2017); financial institutions use algorithms to calculate credit scores for individuals, which are used to determine credit amounts and terms of access to capital (Pasquale, 2015; see also Fourcade & Healy, 2017); internet companies use algorithms to classify text based on automated content analysis (MacCormick, 2012; Rieder, 2017); journalists use algorithmic metrics to shape their editorial and publishing activities (Christin, 2020); and academic organizations use algorithms to routinize the detection of plagiarism (Introna, 2007). Broadly speaking, many management scholars have suggested that using algorithms to handle "traditional business processes operated by workers, managers, process engineers, supervisors, or customer service representatives" (Iansiti & Lakhani, 2020: 60) creates opportunities for organizations to develop new capabilities and generate value (e.g., Davenport, 2018; Mayer-Schonberger & Cukier, 2013; Schildt, 2020).

Recently, however, scholars have begun to explore the dark side of algorithms by suggesting that incorporating algorithms into organizational routines influences professional power dynamics (e.g., Curchod, Patriotta, Cohen, & Neysen, 2019; Kellogg, Valentine, & Christin, 2019) and favors rational decision-making processes over more value-oriented decision-making processes (e.g., Lindebaum, Vesa, & den Hond, 2019), which may in turn produce negative or unintended societal outcomes. With continued use, the power dynamics undergirding the use of algorithms may fade into the organizational background (D'Adderio,

2008) as concerns regarding the "disempowered user" are superseded by the complexity of algorithmic systems (Burke, 2019: 12). Put simply, it is extremely difficult to effectively build accountability into algorithms (Buhmann, Paßmann, & Fieseler, 2019; Martin, 2019). Although algorithms are becoming an increasingly important component of modern organizational life, routine dynamics scholars have only just begun to explore algorithms as a topic in its own right.

In this chapter, our objective is to review existing literature in routine dynamics that contributes to our understanding of algorithmic phenomena, and to stimulate routines-oriented research about algorithms. We start by defining what an algorithm is, highlighting that routines theory about the role of artifacts (D'Adderio, 2008) can be applied to explain the relationship between algorithms and routine dynamics. We then observe how routines scholars have studied algorithms in prior work, showing : i) how algorithms can function as an actant that can make specific decisions in a routine or program a sequence of actions; ii) that algorithms encode designer intent; iii) that algorithms are entangled in broader assemblages of theories, artifacts, actors, and practices; and iv) the performativity of algorithms. We subsequently provide further methodological guidance by articulating five different analytical approaches that scholars can use in studying algorithms and routine dynamics. We close our chapter by suggesting potential avenues for future research on algorithms, highlighting specific opportunities for routine dynamics scholars to explore not only how understanding algorithms can advance our comprehension of routine dynamics, but also how routine dynamics can help advance our broader understanding of algorithms in management research.

WHAT IS AN ALGORITHM?

In current social discourse, the "algorithm" concept is used in a variety of ways, ranging from a simple "recipe composed in programmable steps" (Gillespie, 2016: 19) to mystical "boxes" that evoke "feelings of a technological sublime" (Ames, 2018: 2). Cultural perspectives on algorithms emphasize the opacity of algorithms in practice, and highlight the importance of recognizing that algorithms are embedded in broader systems of activities (Seaver, 2017: 418–419). For the purposes of studying the role of algorithms in routines, we focus on the more tangible, practical definition of an algorithm as an "abstract, formalized description of a computational procedure" (Dourish, 2016: 3). Algorithms are often depicted as mathematical models (Fei, Li, & Sun, 2017) that represent a problem in numerical or categorical terms that can be analyzed to optimize a response to that problem. For instance, in an optimization algorithm, the algorithm designer optimizes performance with respect to a goal by choosing from among a "set of given alternatives of action" that can be selected within an environment that is itself represented by "a set of parameters, which may be known with certainty or only in terms of a probability distribution" (Simon, 1996: 115).

Although algorithms are computational procedures, they are often embedded in software as functions that operate based on data structures and produce outputs that can influence organizational activities (Dourish, 2016). This decision-making role of algorithmic artifacts was described in detail in a recent article in *Harvard Business Review*:

> At the core of the new firm is a decision factory—what we call the "AI factory." Its software runs the millions of daily ad auctions at Google and Baidu. Its algorithms decide which cars offer rides on Didi, Grab, Lyft, and Uber. It sets the prices of headphones and polo shirts on Amazon and runs the robots that clean floors in some Walmart locations. It enables customer service bots at Fidelity and interprets X-rays at Zebra Medical. In each case the AI factory treats decision-making as a science. Analytics systematically convert internal and external data into predictions, insights, and choices, which in turn guide and automate operational workflows. (Iansiti & Lakhani, 2020: 61)

Thus, algorithms can be thought of as computational procedures embedded in broader networks of activities.

In research on algorithms in organizations, and in social science research more broadly, algorithms tend to be viewed from "a narrow technical perspective" that conceptualizes them as artifacts that are "self-standing, autonomous, and black-boxed entities" (Glaser, Pollock, & D'Adderio, 2020: 4). For instance, Kellogg et al. (2019: 50) conceptualized algorithmic systems in organizational settings as entities that offer affordances that recommend or restrict human action—that is, an algorithm is an entity that organizational leaders use to control less powerful actors. Similarly, Curchod et al. (2019: 5) suggested that algorithms are "instruments for the regulation of social relationships." In general, management scholars conceptualize algorithms as tools that can be used by humans to exercise agency and dominion over a set of tasks conceptualized by a designer, such as by assisting, augmenting, arresting, or automating organizational activity (e.g., Murray, Rhymer, & Sirmon, forthcoming). However, other research in management has built out a more nuanced approach for conceptualizing algorithms in organizational life. For instance, Glaser et al.'s (2020) introduction of a performative, sociomaterial perspective on algorithms—which accounts for the relational, temporal, and spatial dynamics that have been overlooked in these previous organizational studies—relies on two principles: algorithmic assemblages and biographical moments. In this chapter, we argue that this latter conceptualization of algorithms represents a more promising path for routine dynamics studies.

ARTIFACTS, ALGORITHMS, AND ROUTINE DYNAMICS

While much of what has been discussed in management research regards algorithms as simple tools, as discussed above, we contend that algorithms are embedded in the fabric of organizations as ongoing social performances and therefore should not be framed as hermetically sealed objects with fixed characteristics. Given that routines research relies on a performative understanding of artifacts that resists conceptualizing artifacts as independent black-boxed entities (D'Adderio, 2008), this holds promise for the potential of a focused research programme in routine dynamics considering how algorithms are analyzed in the context of their relational connections with other artifacts, actors, practices, and theories (D'Adderio, 2011). In reviewing work in routines research on algorithms, we demonstrate the coherence of this emerging perspective.

Existing routines research has yielded several insights that provide us with a basic understanding of algorithms and their relationship to routine dynamics. First, algorithms are artifacts that function as actants to make specific decisions or to program sequences of actions (e.g., Callon 1980, 1986, 2017; Latour, 1986, 1996, 2005; Latour & Woolgar, 1979; Sele & Grand, 2016; see also D'Adderio, this volume and Sele, this volume). Second, designers create algorithms to realize intended goals. Third, these algorithms are embedded in broader assemblages of actors, artifacts, theories, and practices. Finally, algorithms influence routines through performative dynamics associated with algorithmic assemblages. It is important to recognize that an algorithm is a type of artifact, and that generalized routine theory about artifacts applies to algorithms (D'Adderio, 2008).

Algorithms as Artifacts

Routines scholars have shown that algorithms function as artifacts that automate decisions traditionally made by humans. For instance, Glaser (2017) described how a law enforcement agency used a game-theoretic algorithm to automatically generate randomized patrol schedules. Law enforcement agencies seek to deploy police officers to specific locations at specific times to best reduce or interdict crime. Traditionally, human schedulers have made these decisions. However, Glaser showed how game theoretic algorithms helped a law enforcement agency automate these decisions, thereby reducing human effort and increasing the randomness of patrol assignments to better achieve the goal of reducing crime. In another example, D'Adderio (2001) showed how organizational actors use algorithms to translate tacit knowledge automatically. Specifically, she studied the routines by which organizational actors created a digital model or virtual prototype. To convert the digital to the physical, and the physical to the digital, organizational actors used a series of algorithms to translate the tacit knowledge of designers into numeric parameters and algorithmic calculations. D'Adderio's (2001) study thus shows how organizations use algorithms to convert tacit knowledge into materialized decisions.

Studies in the routines literature also show that algorithms can automate sequences of actions. For example, D'Adderio and Pollock (2014: 1825) showed how an organization used a process called "Autoswap:" "every time a faulty board was returned for a vendor to repair, this would immediately issue a new board and ship it to the integrator." This algorithmic approach to addressing board failures resulted in the development of a recurring sequence of actions as the organization chose to handle defects by using the algorithmic autoswap process as opposed to repairing faulty boards. Algorithms have also been shown to direct patterns of routine activity in agriculture (Labatut, Aggeri, & Girard, 2012) and the credit industry (Kiviat, 2019; Pasquale, 2015). In the technology industry, algorithms automate not only human-operated routines, but also patterns of action that did not exist previously, such as search engine indexing, page ranking, or cryptography (MacCormick, 2012), indicating that algorithms also have the potential to autonomously create new routines.

Work has also shown how algorithms can be used to control the relationships between routines in organizations. One thread in this research stream has shown that programmed interfaces determine where one routine stops and another begins in routine clusters (Kremser & Schreyögg, 2016). For instance, Berente, Lyytinen, Yoo, and King (2016) studied a software implementation project at NASA and found that algorithms can be used to control the interfaces between routines. Additionally, as another empirical example, financial institutions use fraud detection algorithms to initiate routines whereby humans verify the legitimacy of financial transactions. In summary, routines research has shown that algorithms are artifacts that can be used to replace individual decisions that are central to routines, to establish sequences of actions within routines or new routines, or to program interfaces between different routines.

Algorithm Design

Another important insight from routines research shows how an algorithm is an artifact that encodes the intent of a designer (Pentland & Hærem, 2015). Put simply, an algorithm's computational procedure must be specified a priori by a designer (Simon, 1970; see also, Wegener & Glaser, this volume) who must construct a rational sequence of actions whereby a decision is contextualized, quantified, and calculated (Cabantous, Gond, & Johnson-Cramer, 2010). Algorithms therefore function as material artifacts or tools that carry this rationality (Cabantous & Gond, 2011). The process of creating and/or contextualizing an algorithm for a particular routine carries some important implications.

First, creating an algorithm requires organizational actors to project a future state of affairs (Wenzel, Krämer, Koch, & Reckwitz, 2020). Simon (1970) observed that creating an artifact such as an algorithm requires a designer to construct a view of how things should be, as opposed to merely describing how things are. A designed artifact has a goal and is structured to take actions that enable it to adapt to a changing environment. Designers must model the environment based on a set of parameters, establish the set of actions available to the artifact, and define a goal that will be used to evaluate the different potential courses of action (Simon, 1970: 115). Glaser (2014) showed how this unfolds by describing how organizational actors who design algorithms model organizational problems by establishing numerical parameters, selecting computational models, and constructing evaluative measures for selecting a particular course of action.

Second, different actors attempt to embed different points of view into algorithms during the design process. For instance, Cacciatori (2012) observed that some artifacts instantiate formal representations of specific occupational knowledge. Occupational members inscribe their interests into algorithms during the design process (D'Adderio, 2008, 2011, 2014) by influencing how data are selected and constructed, and/or how algorithmic outputs are produced and interpreted. In summary, algorithms are artifacts that are designed and inscribed with particular points of view.

The Algorithmic Assemblage

Routines scholars have highlighted that artifacts such as algorithms are best understood and studied as being entangled within broader assemblages of theories, artifacts, actors, and practices (D'Adderio, Glaser, & Pollock, 2019; D'Adderio & Pollock, 2020). As a computational procedure, an algorithm is an artifact in and of itself, but can only be understood relative to the theories, actors, other artifacts, and practices involved in a routine's enactment.

Algorithms typically rely on a theory—a causal understanding that relates concepts (e.g., Marti & Gond, 2018)—to generate a computational procedure. For example, Glaser (2017) showed how algorithms used to generate law enforcement patrolling schedules relied on insights from game theory, specifically Bayesian Stackleberg games. Similarly, D'Adderio and Pollock (2014) showed how modularity theory informed the design of a swapping algorithm used in a routine to deal with circuit board failures. Theories are particularly important in the study of algorithms and routines, because they provide a conceptual infrastructure for generating the abstractions necessary to represent the environment parametrically (Cabantous & Gond, 2011).

Algorithms are also embedded in systems of artifacts that interact with each other (Cacciatori, 2012). For instance, Glaser (2017) described how a game theoretic algorithm uses a computational formula to generate patrolling recommendations; however, this formula requires data inputs which also generate visualized outputs in the form of Excel spreadsheets. Typically, algorithms are embedded in systems of other artifacts, such as software systems that capture different types of digital data, and visualization devices that help actors interpret and deploy outputs in routines.

The Performativity of Algorithms

Routines researchers have also developed theories about how artifacts such as algorithms influence routine dynamics by describing how they interact with the performative and ostensive aspects of routines (D'Adderio, 2011). Specifically, artifacts play a "framing" role by providing organizational actors with important inputs and parameters that can shape routine performance (D'Adderio, 2008). To illustrate, during the enactment of a particular routine, situational factors may require actors to deviate from the standard operating procedure (e.g., a customer might begin to say something that was not envisioned in the artifact). When the specific performance of a routine is not accounted for by an artifact such as a standard operating procedure, the framing is not complete and an "overflow" occurs. Under these circumstances, actors must integrate or account for these overflows in order to perform the routine. Consequently, the artifact frames the action by providing the actors who perform a routine with a resource that they may or may not use (Hales & Tidd, 2009); such overflows influence future routine performances if they change the artifacts or if actors respond by adjusting their understandings of ostensive aspects of the routine.

It is important to note that an algorithm can be seen as a particular type of artifact that differs significantly from other types of artifacts such as physically written standard operating procedures in terms of the flexibility of the algorithmic assemblage. Whereas artifacts such as standard operating procedures often function as guidelines (e.g., hiring instructions outlined in the manual of the human resources department of a private company) that actors can readily ignore, algorithms can compute decisions by following rules designed prior to the routine's performance that are materially embedded in the algorithmic assemblage (e.g., operational procedures encoded in an enterprise resource planning softwaresuch as SAP or Oracle). In other words, once rules and procedures are algorithmically embedded in a software, they become "locked doors in that they truly constrain action" (Pentland & Feldman, 2008: 242)—even though actors that are part of the assemblage might always decide to look for alternative, unlocked doors elsewhere (e.g., D'Adderio, 2008).

This is crucial insight, because deploying algorithmic artifacts in a routine involves several prerequisites. First, algorithm designers must generate a representation of the environment (Simon, 1970). Although this abstraction does not completely represent the environment, it ultimately frames actions in a particular way. For example, an optimization algorithm might analyze a variable called "customer importance." Such a variable might be modeled categorically (e.g., "high," "medium," and "low" levels of importance, or a 1–5 scale) and be used by the algorithm to calculate decisions. These inputs are embedded in software and thus less malleable and more "durable" than the loose guidelines set up in a standard operating procedure (D'Adderio, 2008: 773). Put another way, "artifacts are front-loaded with the habits, intentions, and rationales held by the agencies by which they have been created, adopted, and adapted" (D'Adderio, 2011: 207). Algorithms may be more deeply embedded in the material infrastructure of a routine than other types of artifacts because in most organizational settings, the assumptions and calculations of an algorithm might not be easily modified after deployment.

METHODOLOGICAL PRECEPTS FOR STUDYING ALGORITHMS AND ROUTINES

Studying algorithms can be challenging due to how they are embedded in complex systems (e.g., Gillespie, 2014; Seaver, 2017) and are often opaque and difficult to observe (Dourish, 2016; Pasquale, 2015)—necessitating careful methodological consideration by scholars interested in understanding the relationship between algorithms and routine dynamics. Put simply, Seaver (2017) observes these unique characteristics of algorithms require the modification and customization of traditional ethnographic techniques (see Dittrich, this volume). Routines scholars who adopt a practice perspective (Feldman & Orlikowski, 2011) recognize that the elements of an assemblage (i.e., actors, artifacts, theories, and practices) are mutually constituted. This means that the differentiation between such elements is analytical rather than ontological, and that researchers are advised to study them not in terms of dualistic distinctions (such as the classic agency-structure dichotomy), but to acknowledge their entangled nature at the outset (see Glaser et al., 2020). There has been "ongoing, shifting, and open-ended work to delimit and define the social and the material and the relationship between them" (Mazmanian, Cohn, & Dourish, 2014: 832); the methodology deployed to study algorithms and routines must capture these dynamic relationships that constitute and reconfigure sociomaterial assemblages on an ongoing basis.

To capture such dynamism, the methodological perspective advanced here follows existing routines research in advocating for a highly action-focused approach (Feldman, 2016;

Feldman & Orlikowski, 2011), but differentiates from studies that have considered algorithms as entities in and of themselves (e.g., Kellogg et al., 2019). In a nutshell, the perspective we advocate here is that algorithms should be studied as embedded in action, and more specifically, that researchers should follow the actions associated with algorithms. Although practical challenges may arise when deploying this approach because some algorithmic actions might be hidden and embedded in software (D'Adderio, 2008), recent work has unveiled promising avenues for ethnographic studies of algorithmic systems. For example, building on the concept of polymorphous engagement whereby the researcher interacts personally and virtually with informants across dispersed sites to collect eclectic data from unorthodox sources (Gusterson, 1997), Seaver (2017) advanced "scavenging" tactics to study computational codes as heterogeneous and diffuse sociotechnical systems, proposing that algorithms manifest across sites in different ways. We suggest that the sociomaterial assemblage perspective (Glaser et al., 2020) articulated here can inform a set of analytical approaches that can be used to investigate algorithms from a routine dynamics perspective.

First, because algorithms are artifacts, researchers who study them must pay close attention to their materiality (see D'Adderio, this volume, and Sele, this volume). It is important to understand the computational procedures involved in the algorithm (Dourish, 2016). Key questions concern the decision and how it is computed. For example, the computation can be based on different types of evaluation criteria (i.e., optimization or satisficing). What are the steps involved in the computation? Second, it is important to understand how data are used within the computation. For example, which parameters are used in the computation, and how are they updated when the environment changes? Finally, it is important to understand how the algorithm is embedded in a broader software package. Paying attention to the material composition of the algorithm is particularly important when studying its relationship with routine dynamics (D'Adderio, 2008, 2011).

Second, to understand the relationship between algorithms and routine dynamics, we suggest it is important to analyze both the design and use of algorithms (see Wegener & Glaser, this volume). One theme in practice-based research is to challenge the degree of control exercised by the designers of artifacts (e.g., algorithms) over the situated actions taken by actors who use them to perform routines (e.g., Pentland & Feldman, 2008; Suchman, 2007). Although research along these lines has demonstrated that intentional changes implemented by strategic leaders often lead to unintended outcomes due to actors' decisions during routine performances (Rerup & Feldman, 2011), we suggest that understanding routine dynamics requires particular care be paid to understanding how emergent intentions influence action (Dittrich & Seidl, 2018). Specifically, although plans and intentions may not control future actions, the specific actions involved in artifact design can substantively influence routine dynamics (Glaser, 2017). This is likely to be of particular importance for artifacts such as algorithms that function as actants in a routine.

Third, in examining the role of algorithms in routine dynamics, it is particularly important to consider the underlying theories that inform computational decisions (D'Adderio et al., 2019; see also Pollock & Williams, 2016). An algorithm inherently reflects a model based on a theoretical understanding of the world that connects inputs with outputs in a particular way. Although algorithms can be conceptually unreflexive, they often rely on complex academic theories that function as instantiations of professional knowledge. More abstract, theoretical knowledge often generates political power (Zbaracki & Bergen, 2010); therefore, understanding how different communities of practice embed theoretical knowledge into artifacts such as algorithms is an important way to connect algorithms to routine dynamics (Cacciatori, 2012; D'Adderio, 2014; see also D'Adderio & Pollock, 2014) and may connect to our understanding of the political aspects of routine dynamics (see D'Adderio & Safavi, this volume).

Fourth, it is also important to understand how an algorithm fits within the actions of both the routine itself and the broader cluster of routines (Kremser & Schreyögg, 2016). Because an algorithm typically makes one particular decision, the researcher must understand how the algorithm fits into the broader actions associated with the routine. How is the algorithm actually applied in a routine's enactment? The (in)flexibility of the artifact's algorithm can be differentially designed and used (D'Adderio, 2008), and is an important characteristic to analyze. Algorithms might also be used to stimulate new routines in contexts such as police work (Brayne, 2017).

Finally, researchers should pay attention to the temporal issues associated with algorithmic assemblages (D'Adderio et al., 2019; Garud & Gehman, 2019). Drawing on biographical approaches to software (Hyysalo, Pollock, & Williams, 2019; Pollock & Williams, 2009), Glaser, Pollock, and D'Adderio (2020) noted the importance of recognizing that algorithmic assemblages differ at different moments in time. Specifically, they highlighted that in addition to the normal enactment of an algorithmic routine, there are other biographical moments in the life of an algorithm such as the inscribing and layering of programs of action, performative struggles between different algorithmic assemblages, and translating an algorithm from one context to another (Glaser et al., 2020).

To sum up, understanding how algorithms relate to routine dynamics requires paying careful attention to the methods involved in the design and use of algorithms. Routines research involves following actions (Feldman, 2016), and studying algorithms requires the researcher to take a somewhat broader perspective on those actions. We suggest that dynamic and thoughtful consideration of algorithmic assemblages will help researchers develop appropriate practice-theoretic perspectives on this topic.

FUTURE RESEARCH DIRECTIONS

Adopting a routine dynamics perspective that leverages the assemblage concept reveals several directions for future research that could provide opportunities to develop novel and important theory about algorithms and about routine dynamics. With that, in this section we explore three specific avenues in which a cross-fertilization between routine dynamics and algorithmic perspectives and conceptualizations seems particularly promising.

Algorithms, Routine Dynamics, and Replication

First, algorithms are likely to play an important role in our understanding of a central topic in routines and strategy research: routine replication. Management scholars have long acknowledged that transferring or replicating successful routines is critical for organizations that want to scale up, and that there is a tension between copying the template of a routine, and innovating by modifying it (Winter & Szulanski, 2001); this tension is called the "replication dilemma." In practical terms, the digital character of algorithms enables both their exact replication and transposition with minimal effort, which introduces complexities that deserve further attention. For example, an organization might implement the exact copy of a hiring algorithm that had been successfully deployed as part of the hiring routine of another organization. However, due to dynamics associated with other elements of the assemblage, such as theories, artifacts, actors, and practices, efforts at replicating an algorithm exactly are likely to result in unexpected outcomes. Despite the relevance of the theme, to date, research examining routine replication has been limited in at least two significant dimensions. First, many researchers have focused on organizations with reduced dynamism when it comes to incentives to innovate (e.g., food franchise chains; see Winter et al., 2011). Second, when studying more complex settings, researchers have tended to focus on artifacts that articulate the pattern of a routine (e.g., standard operating procedures, models, rules) (see D'Adderio, 2014; D'Adderio & Pollock, forthcoming). Studying the effects of algorithmic artifacts in routine transfer processes constitutes a promising path to address both limitations.

Examining how an electronics organization dealt with competing pressures to replicate and innovate during routine transfer processes, D'Adderio (2014) found that representational artifacts could be harnessed to support both stability and change. Two artifactual mechanisms were highlighted as being associated with a routine's deviation from a template. The first mechanism, inscription (Latour, 1992), is the process whereby designers delegate knowledge and goals to artifacts. The second mechanism, affordances, corresponds to perceptual and negotiated possibilities of use that artifacts enable (Gibson, 1979; Hutchby, 2001; Leonardi, Bailey, & Pierce, 2019). Building on these findings, we suggest that scholars should specifically investigate the interplay between inscription and affordances of algorithmic artifacts at the core of routine transfer processes. Often, as underlined here, designers of algorithms are not directly engaged in the routines they are attempting to address, and little is known about the micro-processes through which the inscription of such algorithmic artifacts might affect routine transfer. Additionally, and in the same vein, although representational artifacts might enable a wide range of affordances via relational negotiations among users, considerably more studies are necessary to understand how algorithmic inscriptions of artifacts might affect their range of affordances, which ultimately would affect the variance observed in routine transfer processes.

Algorithms, Routine Dynamics, and Power

Second, there is an opportunity for routines scholars to study the political and power dynamics associated with algorithms. In the past decade, discussions have proliferated about how powerful actors like Google are using algorithmic routines to exploit people (Zuboff, 2019). However, there are also means of resistance, as actors also can deploy algorithms to fight back (Kiviat, 2019). Routines scholars can provide a nuanced view by examining how different occupational groups exert authority through algorithms (e.g., Curchod et al., 2019; Kellogg et al., 2019) or by exploring how algorithms affect the dynamic imbalance of routines as organizational truces (see D'Adderio & Safavi, this volume). Moreover, they can cast more light on the specific mechanisms through which the actors who use algorithms resist, such as the ways that police officers resist their controllers (Brayne, 2017), the ways that journalists respond to algorithmic measurements (Christin, 2020), or drivers respond to algorithms that seek to control their job performance (Cameron, 2020).

Routines research provides a fairly straightforward account of the relationship between routines and power. Specifically, Nelson and Winter (1982) highlighted that routines play three fundamental coordinating roles in organizational life by providing: i) a cognitive means to coordinate actors by functioning as a type of organizational memory, ii) a motivational means of ensuring that people work together to achieve organizational goals, and iii) targets for routine performance. They suggested that routine performance becomes a way for organizational actors to deal with conflict in a manner that minimizes its potential to create organizational dysfunction. Thus, by limiting conflict to "largely predictable paths," routines can help build a "comprehensive truce in organizational conflict" (Nelson & Winter, 1982). For instance, Zbaracki and Bergen (2010) showed how sales and marketing departments enacted conflict over a price adjustment routine. Their empirical account shows how performative aspects of the routine were able to deal with smaller breakdowns, but that ostensive aspects of the routine ended up dominating the actions associated with resolving a major breakdown in the routine truce. Routines are thus an important mechanism through which organizations stabilize inherent conflict between competing internal interests.

We suggest that studying algorithms can help scholars more effectively unpack power dynamics in routines. For example, reasearchers have shown that algorithms can be used by powerful actors to impose their will on organizations (Curchod et al., 2019; Kellogg et al., 2019). By adopting the methodological perspective we discussed earlier, scholars can theorize these dynamics more effectively. For example, examining the “theory” component of the algorithmic assemblage can help explain how powerful actors envision a future organization. Similarly, understanding the materiality of the algorithm can help explain the amount of latitude held by those who perform the routine to either deviate or conform to the underlying vision. Moreover, understanding the design performances of a routine (Glaser, 2017) can help scholars understand how the powerful actually go about imposing their will on the less powerful (Clegg, 1989).

The methods outlined in this chapter also can be applied to understand how less powerful actors can resist more powerful actors (e.g., Brayne, 2017; Cameron, 2020). The algorithmic assemblage reveals how the material nature of the algorithm leads to cycles of framing and overflowing. Observing how actors who perform routines resist the visions cast by organizational leaders could help scholars expand theory that explains how visions of leadership can be subverted by trial and error (e.g., Rerup & Feldman, 2011) by revealing more active mechanisms of subversion.

Research on algorithms and routine dynamics also can address several questions that are relevant to organizational studies: How do powerful actors in organizations attempt to use materiality to increase their control over the less powerful? How do powerful actors use theories to increase their control over organizations? How do theories interact with the materiality of algorithms in this process? Although we have learned how actors involved in the performance of a routine resist the will of the powerful through actions, can they resist through other means such as materiality, or by developing alternative theories? In conclusion, we suggest that viewing algorithms as assemblages can help routines scholars better understand how power might influence routine dynamics, thereby enabling them to contribute to broader organizational discussions about power and politics (Clegg, Courpasson, & Phillips, 2006).

Algorithms, Routine Dynamics, and Innovation

Third, routines scholars should explore how algorithms and routines are used creatively to foster innovation (e.g., Cohendet & Simon, 2016; Sele & Grand, 2016; Sonenshein, 2016). Creativity entails having organizational actors coming up with ideas for modifying products, services, and processes, as a manner to better achieve organizational objectives (Amabile, Barsade, Mueller, & Staw, 2005). As discussed by Deken and Sele (this volume), many organizations strive to channel creativity in an attempt to routinize organizational innovation (see Hargadon, 2005). For example, Cohendet and Simon (2016: 615) highlighted that when organizations face a "creativity crisis" (i.e., inability to obtain novelty as the expected outcome of routines for doing innovation), changes to routines may be necessary that "entail breaking existing rules and roles" and "reshuffling and reconfiguring" the organizational structure. At the same time, Sonenshein (2016) revealed a different dimension in the relationship between routines and innovation by showing how organizational actors use the familiar artifacts of a routine to stimulate additional creativity. Sele and Grand (2016) argued that innovation is facilitated by routines that are more generative when actors or artifacts function as mediators who modify connections, rather than as intermediaries who maintain connections. These studies suggest that interactions among artifacts, actors, and practices play an important role in explaining innovation.

We suggest that understanding the mediating role of algorithms in the creative process is becoming increasingly important to understand innovation, as actors begin to use algorithms and big data in creative processes, even in areas such as art and literature (e.g., Elgammal, 2018). Much of the existing work on algorithms highlights how they can be used to automate decision-making processes and deskill workers (Kellogg et al., 2019), or to remove bias from decision-making (Mayer-Schonberger & Cukier, 2013). In future work, researchers could also examine the links between algorithms and their manifestations, such as visualizations, which are central artifacts used by organizational actors to induce novel insights from data.

Finally, there is an opportunity in the area of machine learning[1] and artificial intelligence. As mentioned herein, the intersection between algorithms and routine dynamics is an area that remains underexplored. Although we have conceptualized algorithms as artifacts intertwined with other elements such as actors, practices, and theories in dynamic sociomaterial assemblages that can have substantial effects on organizational routines, machine learning introduces another layer of complexity. Scholars from science and technology studies (Grint & Woolgar, 1997; Hutchby, 2001; Kling, 1991, 1992) have long debated about how technological artifacts enable different affordances (i.e., possibilities of use). Put simply, machine learning engenders

[1] Despite divergent uses among practitioners, in computing science, the term machine learning refers specifically to a branch of artificial intelligence that enables computers to learn from data without human assistance—or with minimum human intervention—to power ubiquitous applications such as spam filters for e-mail (Géron, 2017).

affordances which entails algorithms creating subsequent algorithms through a process that often challenges the comprehension of more traditional designers (e.g., programmers, data analysts) and users. Consequently, we believe that a routine dynamics perspective can help scholars and practitioners better explain dynamics associated with artificial intelligence and machine learning. Such elements are at the core of what professional data scientists do. In this sense, investigating how the range of affordances of machine learning algorithms affect organizational routines constitutes an open and promising avenue for future research.

CONCLUSION

In this chapter, we have reviewed prior work on routines and algorithms and suggested that studying algorithms offers a fruitful opportunity for routines scholars to develop new theory about routine dynamics. Additionally, we believe that scholars can use the theoretical and methodological infrastructure provided by a routines lens to develop theory to move beyond management research that conceptualizes algorithms in an entiative manner (e.g., Curchod et al., 2020; Kellogg et al., 2020), and that this research has the potential to contribute unique insights to the broader social conversation around big data, predictive analytics, machine learning, and artificial intelligence. By viewing algorithms as an integral part of the assemblage of a routine, scholars can see new connections that can help us better understand the relationships among algorithms, routines, and important organizational outcomes such as rourtine replication, organizational power, and innovation.

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