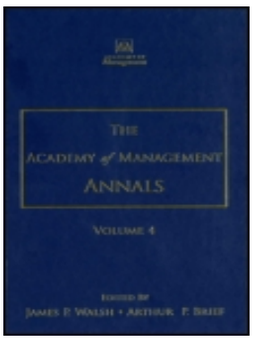

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10 Sociomateriality: Challenging the Separation of Technology, Work and Organization

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10
Sociomateriality:
Challenging the Separation of Technology, Work and Organization

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Abstract

We begin by juxtaposing the pervasive presence of technology in organizational work with its absence from the organization studies literature. Our analysis of four leading journals in the field confirms that over 95% of the articles published in top management research outlets do not take into account the role of technology in organizational life. We then examine the research that has been done on technology, and categorize this literature into two research streams according to their view of technology: *discrete entities* or *mutually dependent ensembles*. For each stream, we discuss three existing reviews spanning the last three decades of scholarship to highlight that while there have been many studies and approaches to studying organizational interactions and implications of technology, empirical research has produced mixed and often-conflicting

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results. Going forward, we suggest that further work is needed to theorize the fusion of technology and work in organizations, and that additional perspectives are needed to add to the palette of concepts in use. To this end, we identify a promising emerging genre of research that we refer to under the umbrella term: *sociomateriality*. Research framed according to the tenets of a sociomaterial approach challenges the deeply taken-for-granted assumption that technology, work, and organizations should be conceptualized separately, and advances the view that there is an inherent inseparability between the technical and the social. We discuss the intellectual motivation for proposing a sociomaterial research approach and point to some common themes evident in recent studies. We conclude by suggesting that a reconsideration of conventional views of technology may help us more effectively study and understand the multiple, emergent, and dynamic sociomaterial configurations that constitute contemporary organizational practices.

Introduction

We begin with what we believe is a telling observation about the management literature on technology in organizations. And that observation is that, for the most part, technology is missing in action. Consider that from the point of view of organizational phenomena, technology seems to be everywhere in the world of practice. Technology is a principal mediator of work on the production floor, in retail interactions, in front and back offices, on the road, at client sites, and in the global market place (Mansell, Avgerou, Quah & Silverstone, 2007). Annual corporate budgets for technology range in the billions of dollars for large firms, and spending on technology is for many firms their largest investment (Dewett & Jones, 2001). Technology has arguably become an integral aspect of most business operations—whether the small Internet start-up, mid-sized law firm, or large automobile manufacturer—and it is hard to think of any contemporary organization that does not, at some level, depend on some kind of technologies.

Yet a quick perusal of the academic management literature would suggest that from the point of view of organizational research, technology is largely absent from the world of organizing. We inspected the leading journals in the field of management to assess whether and how published scholarship addressed the role and influence of technology in organizations. We selected four journals—*The Academy of Management Journal* (AMJ), *The Academy of Management Review* (AMR), *Administrative Science Quarterly* (ASQ), and *Organization Science* (OS)—and examined every research article published in these journals for the past decade (from January 1997 to December 2006). For each article, we scrutinized title, keywords, abstract, and body to identify those research studies that dealt (in some way or another, and at various levels of analysis) with the issue or implications of technology. Based on the 2027 articles we analyzed, we found that 100 (4.9%) directly addressed the role and influence

Table 10.1 Publication of Technology Articles in Management Journals (1997–2006)

	Academy of Management Journal	*Academy of Management Review*	*Administrative Science Quarterly*	*Organization Science*	**Total Across Journals**
Number of published research articles	668	670	206	483	2027
Number of articles addressing technology	27	11	10	52	100
Percentage of articles addressing technology	4%	1.6%	4.9%	10.8%	4.9%

of technology in organizations. Table 10.1 provides the detailed breakdown by journal.

Thus, over the past decade of management research, over 95% of the articles published in leading management journals do not consider or take into account the role and influence of technology in organizational life.[1] This is a surprising and paradoxical finding, particularly given the following: (i) the pervasive empirical presence of technology in mediating organizational activities within and across firms, industries, and economies (Zammuto, Griffith, Majchrzack, Dougherty & Faraj, 2007); (ii) that much early organizational research recognized the important role of technology in organizational affairs (e.g., Aldrich, 1972; Blau et al., 1976; Blauner, 1964; Hage & Aiken, 1969; Harvey, 1968; Hickson, Pugh, & Pheysey, 1969; Leavitt & Whistler, 1958; Perrow, 1967; Thompson & Bates, 1958; Trist & Bamforth, 1951; Woodward, 1958); (iii) that the two divisions most focused on technological phenomena in the Academy of Management (AoM)—Technology & Innovation Management (TIM) and Organizational Communication & Information Systems (OCIS)—together account for some 19.2% of Academy members (2375 TIM members and 970 OCIS members out of a total AoM membership of 17,377)[2]; and (iv) the various calls over the years to redress the lack of attention paid to technology in organizational studies (e.g., Gagliardi, 1990; Goodman, Sproull & Associates, 1990; Huber, 1990; Dewett & Jones 2001; Rafaeli & Pratt 2006; Rousseau, 1979; Weick, 1990; Zammuto et al., 2007).

While it is not exactly clear what accounts for the paradox, a number of reasons may be identified. One reason involves the growing complexity and specialization of organizational life that requires detailed investigation of multiple issues—economic, political, strategic, psychological, and sociological—not

just technological ones. Attending to all these elements within a single study or even a single program of study is particularly challenging, perhaps even infeasible. So choices have to be made, and as a result, technology may be consistently passed over. Another explanation for the paradox may point to the apparent lack of interest in technological topics on the part of many organizational scholars, schooled as most are to attend to human, cultural, and economic elements of institutions, not material ones. A third reason for the paradox may be attributed to the general belief that technology is simply part of the institutional infrastructure, akin to the "utilities" of electricity, telephony or public transportation. As a result, it is not seen to require particular attention by organizational scholars and consequently it fades into the background and remains largely taken for granted. Zammuto et al. (2007, p. 751) characterize this as an "automated plumbing" view of technology. A fourth explanation for the paradox may reflect the growing scale, complexity, speciality, and rapid change in technological systems, particularly since the 1990s (Zammuto et al., 2007), which make it challenging for management scholars—especially those not trained in or conversant with technological matters—to track and analyze in detail.

Whatever the reasons, we are left with the apparent contradiction that while technology is everywhere to be found in organizational practice, it is largely absent from the recent research discourse within the management literature. We believe such an oversight is problematic. Not only are technologies critical in contemporary organizing, but they will arguably continue to be so, as firms attempt to grow globally, as they move onto the Web, as they deploy enterprise-wide infrastructure systems, and as they invest in new communication media to allow their members to work from multiple global locations. Such technological entailments are far from simple, straightforward, certain, or predictable, and they are associated with a range of organizational outcomes, many of which are emergent and unanticipated. What do such technological entailments imply for organizations, their norms and forms of structuring, their capabilities to act and interact, their performance of current and future strategies, and their possibilities for innovation and learning? Who decides what technologies get deployed in organizations, how are these designed, who gets to use and change them, and with what consequences? Given increasing reliance on technologies to get work done within and across organizations, these questions are highly salient and their answers profoundly affect the kinds of organizational realities that are produced.

Our aim in this paper is two-fold: to provide a broad overview of the organizational research that has been done on technology, and to offer a proposal for future research that may offer some new directions and opportunities. In our review of the literature, we identify and discuss two streams of research on studying technology, and for each, we consider their key characteristics, contributions and challenges. Space constraints preclude an exhaustive review

of all published articles on technology in organizations, so we focus our attention on key articles and reviews that have been particularly influential in the field. In our proposal for future research, we consider a third research stream on technology, which we refer to under the umbrella term of *sociomateriality*. While this stream of research is not much evident in the management literature, we identify an emerging corpus of scholarship developing around closely related themes. We believe that some of the premises, concepts, and approaches in this stream may be especially useful in current and future research on technology, work, and organization. We conclude by arguing that developing additional conceptual lenses and alternative research approaches is particularly important given the dynamic, distributed, and interdependent nature of technologies in use today, and the multiple and unprecedented ways in which they are shaping and will continue to shape organizational realities.

Before proceeding, however, we need to address the thorny issue of definitions. As we will see in the course of this chapter, technology has been defined and theorized in many different ways in the management literature (Barley, 1988; Goodman et al., 1990; Kipnis, 1991; Orlikowski & Iacono, 2001). A multiplicity of meanings is also evident in the many other disciplines that have in one way or another addressed technology, for example, history, philosophy, psychology, sociology, anthropology, design, engineering, archeology, and economics. The English-language Wikipedia includes the following description in its entry on *technology*:

> Technology is a broad concept that deals with a species' usage and knowledge of tools and crafts, and how it affects a species' ability to control and adapt to its environment. […] However, a strict definition is elusive; "technology" can refer to material objects of use to humanity, such as machines, hardware or utensils, but can also encompass broader themes, including systems, methods of organization, and techniques. […] The term is mostly used in three different contexts: when referring to a tool (or machine); a technique; the cultural force; or a combination of the three. (http://en.wikipedia.org/wiki/technology [accessed 26 December 2007]

Similarly, reflecting the elusive sense of technology, Weick (1990) suggests that technologies be understood in terms of an equivoque: "An equivoque is something that admits of several possible or plausible interpretations and therefore can be esoteric, subject to misunderstandings, uncertain, complex, and recondite" (p. 1). Developing a singular or definitive definition of technology is thus inherently problematic, and it may be more useful to understand this term as theoretically and historically contingent. As a result, we will not attempt a specific definition here, but will draw attention to (some of) the different definitions that are evident in the extant literature. In our discussion of future research, we will discuss recent intellectual developments

which challenge the notion of a singular view or definition of technology, and which advance instead a conception of materiality as integral to human activities and relations, and thus as better understood in terms of sociomateriality.

The Literature on Technology in Organizations

Assumptions are central to all research. As Ackoff (1979) reminds us, they make the complex phenomena tackled by social science researchable. These assumptions shape what researchers do, why they focus on which aspects of the phenomena, what they see as more or less salient, how they design their study, and what they find (Morgan, 1983). This is no more evident than in the studies of technology in organizations where, over the years, researchers have adopted and implemented a number of diverse approaches, reflecting quite different assumptions about the nature of technology and its role in organizations, the logical structure of theoretical accounts, the key empirical mechanisms at work, and the preferred methodological orientation. To understand this diverse literature, it is helpful to have a sense of the various approaches and the implications of their different choices.

The existing literature on technology in organizations can be characterized in multiple ways depending on purpose and point of view. We focused on the different ways in which scholars conceptualize and analyze technology,[3] and identified two dominant research streams that are distinguished by their theoretical stance towards technology, leading to differences in research results, contributions made to knowledge, and recommendations proposed for future research. The primary characteristics of these two research streams

Table 10.2 Two Streams of Research on Technology and Organizations

	Research Stream I	Research Stream II
Ontological Priority	Discrete Entities	Mutually Dependent Ensembles
Primary Mechanisms	Impact; Moderation	Interaction; Affordance
Logical Structure	Variance	Process
Key Concepts	Technological Imperative Contingency	Social Constructivism Structuration
View of Social and Technical Worlds	Humans/organizations and technology are assumed to be discrete, independent entities with inherent characteristics	Humans/organizations and technology are assumed to be interdependent systems that shape each other through ongoing interaction
Examples	Blau et al. (1976) Huber (1990) Aiman-Smith & Green (2002)	Barley (1986) Prasad (1993) Boudreau & Robey (2005)

are depicted in Table 10.2. Broadly speaking, the first research stream reflects an ontological commitment to a world of discrete entities that have some inherent and relatively stable characteristics. This is a focus on individual actors and things that are seen to be largely independent, but linked through uni-directional causal relationships, and having largely determinate effects on each other. The second research stream is characterized by its general commitment to an ensemble or web ontology (Kling, 1991), where actors and things are seen to be related through a reciprocal and emergent process of interaction, leading over time to co-evolved or interdependent systems. We consider each of these two research streams in turn.

Research Stream I: *Discrete Entities*

In this stream of work, technology is treated as a specific and relatively distinct entity that interacts with various aspects of the organization, becoming particularly salient during moments of technology design, diffusion, implementation, deployment, adoption, adaptation, use, or breakdown. Many of the studies in this stream posit technology as an independent variable (operationalized variously as number, type, or cost of machinery, devices, techniques, etc.) having a range of effects—at different levels of analysis (individual, group, enterprise, and inter-organizational)—on multiple organizational outcomes (the dependent variables). Other studies in this stream depart from treating technology as an independent variable, viewing technology instead as a moderating variable that variously influences the relationship between organizational variables (e.g., structure, culture, inter-organizational relations) and certain outcomes (e.g., efficiency, innovation, learning). Whether considering technology as an independent or moderating variable, studies in this stream tend to adopt a variance approach in their research designs (Mohr, 1982).

Examples of this stream of work include the following: research into the meanings or attitudes towards computing at the individual level (e.g., Davis, 1989; Griffith, 1999; Rafaeli, 1986; Rice & Aydin, 1991); studies of changes in communication and decision-making at individual or group levels related to technology use (e.g., Huber, 1990; Hinds & Kiesler, 1995; Trevino, Webster, & Stein, 2000); investigations of productivity improvements at both individual and enterprise levels linked to the adoption or investment in new technologies (e.g., Aral & Weill, 2007; Brynjolfsson & Hitt, 1996; Kraut et al., 1989); research into shifts in firm structure associated with technology (e.g., Blau et al., 1976; Burkhardt & Brass, 1990; Fry, 1982; Pfeffer & Leblebici, 1977); and examinations of transformations in market or industry conditions attributed to the widespread diffusion of new technological capacities (e.g., Malone, Yates, & Benjamin, 1987; Tushman & Anderson, 1986).

Given the broad scope of this literature, across multiple levels of analysis and multiple topics (from individual attitudes to market structures), it is not possible to do a comprehensive review of this work here. We decided instead

to discuss three influential reviews of this literature, selecting these reviews to represent three different decades of management research (Attewell & Rule, 1984; Huber, 1990; Dewett & Jones, 2001). Focusing on these reviews of literature allows us to highlight the key rationales, problematics, views, logics, and recommendations of the discrete entities stream of research. Table 10.3 provides a summary of the three reviews.

Rationale for Studying Technology in Organizational Research

All three of the reviews motivate the need to study technology in organization studies by appealing to the rapid and widespread deployment of technology (especially, information technology) throughout organizations and society. Attewell and Rule (1984) argue that the rapid diffusion of technology raises critical concerns about its social impacts on skills and quality of work, shifts in balance of power among workers and managers, and changes in employment levels. Huber (1990) in turn, contends that organizations are increasingly adopting technologies that are substantially more varied and more sophisticated than earlier technologies, and that these can be expected to have profound effects on organizational design, intelligence, and decision-making. Dewett and Jones (2001) pick up on Huber's argument and extend it by pointing to the ubiquity and range of contemporary information technology that mediates organizational affairs at multiple levels (from individual aids to inter-organizational linkages).

Problems with Existing Literature

Interestingly, the three reviews—spanning three decades of scholarship—identify similar difficulties with the existing management literature in making their case for increased attention to technology in organization studies. All three point to the disparate, fragmentary, and apparently conflicting results reported by empirical research on the effects of technology. Attewell and Rule (1984) criticize what they see as a widespread perception that much is known about the consequences of computing and that these effects are "foregone conclusions" (p. 1184). They argue that such *a priori* assessments are inappropriate given the mixed empirical record, and the range and variety of variables that are relevant. Huber (1990) also points to the mixed empirical results to argue that existing organization theory cannot account for these findings because it was developed in an earlier time when technologies were simpler and much less varied. Dewett and Jones (2001) likewise suggest that new organization theories are needed to explain more fully the implications of information technology (IT) for organizations. They write "We believe that the pace of IT change that has swept through the economy has left the academic community behind and that the definition, meaning, and current significance of many of the basic building blocks and theories of organizational studies need to be reexamined" (p. 335). They call for the development

Table 10.3 Reviews of the Literature on Technology and Organizations—*Research Stream I*

	Attewell & Rule (1984)	Huber (1990)	Dewett & Jones (2001)
Rationale for Studying Technology	Widespread use of information technology (IT) in society raises critical issues about their social consequences. Need to understand both socio-economic impacts (e.g., employment, efficiency, decision making) and social experiences (e.g., how fulfilling is computer-mediated work?).	Organizations are increasingly adopting "advanced information technology (IT)", whose effects are more sophisticated and more varied than those of earlier technologies. We need to investigate the impacts of such new technologies on the nature of organizational design, intelligence, and decision-making.	Information technology (IT) is ubiquitous and multiple (ranging from enterprise-wide systems and global databases, to personal digital assistants and fax machines). Spending on technology amounts to the largest investment made by firms (in billions of dollars) and this is growing. Need to understand the impacts these technologies have on "strategic outcomes".
Problems with Existing Literature	Need to challenge the widespread view that IT impacts are "foregone conclusions" (e.g., deskilling or upgrading). Need to develop theories that account for the fragmentary, disparate, and seemingly conflicting results associated with IT.	The use of "advanced IT" in organizations is associated with multiple empirical findings that cannot be explained by existing organization theory that was developed in an earlier time, when technological capabilities were simpler and constant. Need a theory of the effects of IT on organizations, which synthesizes, integrates, and explicates the multiple empirical results.	The implications of IT for organizational outcomes are significant and evolving, and many of the basic building blocks of organization studies will need to be reexamined and rewritten. Need to enhance Huber's (1990) model to develop an updated and "theoretically plausible" account of IT's role in strategic organizational outcomes.

Table 10.3 Reviews of the Literature on Technology and Organizations—*Research Stream I* (Continued)

	Attewell & Rule (1984)	Huber (1990)	Dewett & Jones (2001)
Definition of Technology	Technology is not defined. Focus is on IT, seen broadly as "computing technologies".	Technology is seen here as "advanced IT", and defined as rationality-enhancing devices that (i) transmit, manipulate, analyze, or exploit information; (ii) in which a digital computer processes information integral to the user's communication or decision task; and (iii) that have made their appearance since 1970.	Technology is seen here as IT, and defined as having certain "useful properties": (i) *information efficiencies* (i.e., cost and time savings that result when IT increases task performance and expansion of roles); and (ii) *information synergies* (i.e., performance gains that result when IT enables individuals or units to pool resources and collaborate across boundaries).
Logic of Argument	View IT as an independent variable affecting: (i) number and quality of jobs (i.e., job satisfaction, changes in skills over time, alienation, unemployment, worker productivity); (ii) management decision-making (i.e., extent of centralization of information and power); and (iii) organizational interactions with their environments (i.e., how technology mediates dealings with the public, clients, and customers).	Develop propositions that posit the use of computer-assisted communication and the use of computer-assisted decision-aiding technologies as independent variables, and posit the following as dependent variables: (i) characteristics of organization intelligence and decision-making (e.g., more rapid and accurate identification of problems and opportunities); and (ii) aspects of organization design (e.g., size and heterogeneity of decision units, number of levels).	Build on Huber's (1990) account of IT as an independent variable that enhances organization intelligence, decision-making, and performance, but propose IT as a moderating variable that links employees, codifies knowledge bases, improves information processing, increases boundary spanning, and enhances coordination. IT thus moderates the relationship between organization characteristics (e.g., size, structure, inter-organizational relations) and strategic outcomes (i.e., efficiency and innovation).

Research Agenda	No simple set of theoretical relationships can account for all the data revealed through empirical inquiry. While the social impacts of computing are infinitely variable, the sources of these variations are accessible to study. Thus need large samples and extensive replication so as to characterize the effects of computing in their full variety at multiple levels of analysis: skills, jobs, workers, organizations, unemployment, etc. Recommend a two-pronged focus for future research: (i) determine what particular cause–effect relations prevail in specific contexts; and (ii) locate such cases within the larger ranges of cases in which similar cause–effect relations can be expected to prevail.	Organization theory has always been concerned with processes of communication, coordination, and control, and the nature and effectiveness of these processes are changing with advanced IT. Organization scholars should thus accept that IT fits within the domain of organization theory, and that it will have a significant effect on organization design, intelligence, and decision-making. Recommend researchers study advanced IT as: (i) an intervention or jolt in the life of an organization that may have unanticipated consequences; (ii) a variable that enhances the quality and timeliness of organizational intelligence and decision-making; and (iii) a variable that enables organizations to be designed differently than was possible before.	The full implications of IT for organizational characteristics are still evolving and will continue to do so. Need to recognize that there are feedback loops as people learn how to "optimally apply" the IT to its context over time. Recommend researchers focus on several issues going forward: (i) how does IT moderate the way strategy affects performance and how does IT facilitate competitive advantage; (ii) what is the relationship between IT and firm performance (may need to develop a contingency framework to sort out the mixed and ambiguous results); (iii) what is the role of time in applying IT (how to deal with learning and change over time); and (iv) what are the different types of IT employed at different levels of the organization, and what different roles does IT fulfill at different levels.

of a more "theoretically plausible" account of IT and its role in a wide array of strategic organizational issues (p. 315).

Definition of Technology

The views of technology adopted by the three reviews are related in that they all assume technology is a distinct entity, but they also differ somewhat, reflecting perhaps the changing contours of and knowledge about technological artifacts over the years. In 1984, Attewell and Rule concentrated their attention on what they generically refer to as "computing", without indicating the particular features, dimensions, or properties designated by their term. Six years on, Huber (1990) focus on "advanced information technology", which he defined as devices having both "basic characteristics" (e.g., data storage capacity, transmission capacity, and processing capacity), and "advanced properties" (e.g., features that facilitate easier, less expensive, more precise, and more controlled communication and information access and retrieval). He argues that these latter properties are particularly typical of devices that entail the following features: (i) they transmit, manipulate, analyze or exploit information; (ii) they include a digital computer which processes information integral to users' communication and decision-making tasks; and (iii) they were developed after 1970.

Eleven years later, Dewett and Jones (2001) concentrate on what they refer to as "information systems and information technologies" (and label as "IT"). With this term they encompass a wide variety of software and hardware platforms, from enterprise-wide accounting applications and inter-organizational distribution systems to communication media such as intranets, voice mail, fax, email, and videoconferencing, as well as personal digital assistants and mobile phones. They follow Huber in claiming that these technologies have some important properties that are particularly useful in organizational affairs. They single out two such properties: (i) information efficiencies, which represent the cost and time savings that result when IT facilitates task performance and allows role expansion; and (ii) information synergies, which represent the gains in performance that follow from the pooling of resources and collaboration across roles or boundaries enabled by IT.

Logic of Argument

All three of the reviews privilege a variance approach in their characterization of the relationship between technology and organizations. Where they differ is in whether they posit technology as an independent or moderating variable. Thus, Attewell and Rule (1984) assume IT is an independent variable, which affects a number of outcomes at multiple levels of analysis, for example, the quality of work (assessed through studying changes in job satisfaction, alienation, and skills), the level of unemployment (measured as declines in jobs available across sectors, worker productivity), management decision-making

(as observed in the extent of centralization/decentralization of information and power), and organizational interactions with their environments (examined in terms of how technology affects an organization's dealings with its publics and customers). Huber (1990) similarly posits IT as an independent variable that enhances organization intelligence and decision-making, thus firm performance. Distinguishing between the use of "computer-assisted communication technologies" and "computer-assisted decision-aiding technologies", he develops 14 propositions concerning these independent variables and a range of dependent variables related to the following: (i) characteristics of organization intelligence and decision-making (e.g., the speed and accuracy of problem identification, the quality of decisions made), and (ii) aspects of organization design (e.g., the size and heterogeneity of decision units, the number of organizational levels, the extent of centralization/decentralization, etc.).

While building on Huber's (1990) model, Dewett and Jones (2001) depart from it by positing IT as a moderating variable. In particular, they contend that IT offers five important benefits—linking and enabling employees, codifying the knowledge base, increasing boundary spanning, improving information processing, and enhancing collaboration and coordination—which moderate the relationship between organization characteristics (specifically, structure, size, culture, learning, and inter-organizational relations) and the strategic organizational outcomes of efficiency and innovation.

Research Agenda

In making recommendations for future research, each of the three reviews offers specific suggestions concerning what should be studied and how. Attewell and Rule (1984) note that while the social impacts of computing are infinitely variable, the sources of these variations are accessible to study. They thus advise the use of large samples and extensive replication so as to characterize the effects of computing in their full variety at multiple levels of analysis (i.e., skills, jobs, workers, organizations, and employment levels). They recommend that future research should proceed along two tracks, the first to determine what particular cause–effect relations prevail in specific contexts, and the second to locate such specific findings within the larger array of cases in which similar cause–effect relations might be expected. Huber's (1990) recommendations are aimed at the management literature more generally, urging organization scholars to pay more attention to IT. He argues that organization theory has always been concerned with processes of communication, coordination, and control, and that these are changing dramatically with the advent of advanced IT. He urges organization scholars to incorporate IT more centrally within the domain of organization theory as it is having, and will continue to have, significant effects on organization design, intelligence, and decision-making. He recommends researchers study advanced IT as: (i) an intervention or jolt in the life of an organization that may have unanticipated

consequences; (ii) a variable that enhances the quality and timeliness of organizational intelligence and decision-making; and (iii) a variable that enables organizations to be designed differently than was possible before the advent of advanced IT.

Dewett and Jones (2001) note that the full implications of IT for organizations are still evolving and will continue to do so. Researchers need to keep this in mind, while also recognizing the feedback loops that arise as people learn how to "optimally apply" the IT to its context over time. For future research, they recommend that researchers focus on the following sets of issues: (i) how does IT moderate the way strategy affects performance and how does IT facilitate competitive advantage (e.g., through reducing transaction costs, increasing quality or innovation, differentiation, leveraging knowledge, etc.)? (ii) what is the relationship between IT and organizational performance (for which they suggest that more fine-grained analyses and a contingency framework may be needed to sort out the range of mixed and ambiguous results)? (iii) what is the role of time in applying IT in organizations (as this will help address how to deal with learning and change over time)? and (iv) what are the different types of IT employed at different levels of the organization, how do these effects play out, and what different roles does IT fulfill at these different levels?

Research Stream II: ***Mutually Dependent Ensembles***

In the second stream of literature, technology is understood as part of the complex process through which organizing is accomplished. In a departure from the ontology of discrete entities dominating the first research stream, the focus here is on the dynamic interactions between people (or organizations) and technology over time. These interconnections are understood to be embedded and emergent, and thus not fully determinate (Ciborra & Associates, 2001). Studies in this stream of work posit neither independent nor dependent variables, but rather adopt a processual logic where interactions and outcomes are seen to be mutually dependent, integrative, and co-evolving over time.

The issues studied in this stream include research regarding the interplay between aspects of technology and various elements of organizational life, such as what meanings emerge to make sense of a new information system (e.g., Prasad, 1993), how do technological implementations entail the mutual adaptation of technology and organization (Leonard-Barton, 1988), how does the use of electronic media get shaped by existing cultural norms and practices (e.g., Markus, 1994; Yates, Orlikowski, & Okamura, 1999), how do technologies serve as boundary objects to afford knowledge sharing across disparate communities (e.g., Bechky, 2003; Carlile, 2002), how does the design and use of technology shift the nature of work (e.g., Boudreau & Robey, 2005; Orlikowski, 2000; Zuboff, 1988), how does electronic surveillance affect team dynamics (Sewell, 1998), how do lead users shape the nature and capabilities

of new technologies (von Hippel, 1994), how does the use of technology restructure organizational relations (e.g., Barley, 1986, 1990; DeSanctis & Poole, 1994; Walsham, 1993), how do power positions shape the design of technologies over time (e.g., Thomas, 1994), when and how does the design, implementation, and adoption of a new industry-wide information system shift relations among multiple players in a financial market (e.g., Barrett & Walsham, 1999).

More recent work in this stream has drawn on institutional theory to argue that on the one hand technology can become inscribed with institutional forces that set the rules of rationality (Powell & DiMaggio, 1991), while on the other it is one of the carriers within the environment that contributes to the structuring of organizations (Scott, 1995). For example, Silva and Backhouse's (1997) case study of the London Ambulance Service considers how technology comes to be institutionalized (or not) by rendering new rules and meanings embedded during systems design with those already circulating in the organization. In another example, Avgerou's (2002) analysis of innovation and economic reform in developing countries treats technology as "institutionally constituted", acquiring a momentum of its own that is noticeably separate from plans to align it with business objectives.

As with the first research stream, the wide range of issues and phenomena covered by this stream precludes an exhaustive review. We thus discuss three literature reviews, selected as before to represent three different decades of management research (Barley, 1988; Roberts & Grabowski, 1996; Zammuto et al., 2007). Focusing on these reviews of literature allows us to highlight the key rationales, problematics, views, logics, and recommendations of the ensemble stream of research. Table 10.4 provides a summary of the three reviews.

Rationale for Studying Technology in Organizational Research

The rationale for why organizational scholars should study technology echoes many of the issues raised by the first research stream: an articulation of the widespread advance and use of complex technologies is following by a discussion of the lack of solid organizational knowledge to explain the empirical patterns. Barley (1988) suggests that given the many advances in technology (e.g., robotics, microelectronics, artificial intelligence, and genetic engineering), Western society is on the verge of a transformation on a similar scale to the industrial revolution. However, there is little or no consensus on the character and direction of these transformations. More focused research in organizational studies is needed if scholars are to tackle this important phenomenon. Roberts and Grabowski (1996) similarly point to the rapid advances of technology in organizations, and the inability of management research to keep pace. They highlight a number of problems associated with existing views of technology in organizations, particularly with measurement and assessment, and argue for rethinking the utility of the technology

Table 10.4 Reviews of the Literature on Technology and Organizations—*Research Stream II*

	Barley (1988)	Roberts & Grabowski (1996)	Zammuto et al. (2007)
Rationale for Studying Technology	Given advances in technology (robotics, microelectronics, genetic engineering), Western society is on the verge of a transformation akin to the industrial revolution. But there is no consensus in the direction of these changes. Need an alternative approach to studying changes in this area.	Technology advances rapidly, yet there are multiple problems with existing views of technology in organizations, particularly with its measurement and assessment in a changing world. Need to rethink the utility of the technology construct in organization research, and develop frameworks that afford considering technology as both a process and a product.	Technology has been a central variable in organizational theory since the fifties, but there has been a significant decline in interest in technology since then. This is problematic, particularly given the pervasive presence of technology in contemporary organizations, and the potential for such technologies to enable important shifts in organizational form and function.
Problems with Existing Literature	Scholars have been misled by the dual status of technology as both physical and social object. A focus on the former leads to *technological determinism,* while a focus on the latter results in *social determinism*. A desire to explain all events with a single logic discounts social complexity, distorting the nature of technology, and leading to inappropriate claims that technology's effects are foregone conclusions.	Organizations and technology are undergoing profound changes, resulting in a growing inadequacy of existing views of technology. The literature includes two separate conceptions: (i) *descriptive* (focus on definitions and roles of technology); and (ii) *relational* (focus on relations between technology and structure). These two views need to be integrated to account for what technology is, how it develops, and how its relations with organizations are changing.	The problem with the existing organization literature is the lack of attention afforded to the changing relationship between technology and organizations. While this may reflect the earlier role of technology in merely "automating" existing operations or speeding up information flow, contemporary technology is replacing the central role of hierarchy in controlling and coordinating organizational activities.

Definition of Technology	Technology is here defined as objects and actions that "admit the possibility of ostensive definition".	Technology is here defined as comprising mechanical (i.e., hardware), human (i.e., skills and human energy), and knowledge (i.e., meanings and concepts) systems.	Technology is not specifically defined, but the focus is primarily on IT, and in particular, its material features, which may create new affordances for organizing.
Logic of Argument	Technology has a dual nature—as a physical and social object. Propose an *interpretive materialism* that views technology as a social object. This perspective recognizes that technologies are construed and reconstrued as they are designed, built, sold, and used, but also acknowledges that this process of social construction is limited by technology's physical properties and by the larger socio-economic context.	Technology has a dual nature—as a product and a process. Propose adoption of both positional and relational views of technology drawing on structuration theory. A *positional* view, focusing on technological and structural constructs (e.g., complexity, task definition, workflow integration, etc.), should be followed by a *relational* view that examines the relations between technology and structure in organizations (understood to be continuous, changing, and interactive).	Technology may be usefully understood through the lens of affordances, which allows examination of how the materiality of an object both invites and inhibits a set of specific uses. Propose the term *affordances for organizing* as a way to conceptualize the dynamic process by which IT and organizations intersect and evolve together over time.
Research Agenda	Unidirectional patterns of change are inappropriate when one examines a technology's ramifications across a range of occupations or organizations (e.g.,	Uniform or generalized descriptions of technology and organizational adaptability or utility are no longer appropriate. Instead, need a contingency framework, and more	Need to open up the black box of technology and organizations by examining their dynamic interplay.

Table 10.4 Reviews of the Literature on Technology and Organizations—*Research Stream II* (Continued)

	Barley (1988)	Roberts & Grabowski (1996)	Zammuto et al. (2007)
	the same technology's capacity can occasion contrasting social orders in different contexts). Need to entertain complex and equivocal trends in the relations between technology and organizations. To understand how technology restructures work, researchers need to focus on actions and interpretations, as well as relevant technical attributes, characteristics of occupations and organizations, and parameters of the larger socio-economic environment.	refined typologies of technology. Also need more studies of decision settings that are characterized by increasing knowledge, complexity and turbulence. Need temporal and longitudinal studies of organizations and technology, in particular to account for the dual nature of technology as process and product, and the changing relations between technology and organizations in a fluid and changing world.	Propose five *affordances* that characterize the IT-organization relationship, and which can create the potential for new forms of organizing to emerge: (i) visualizing entire work processes; (ii) real-time/flexible product and service innovation; (iii) virtual collaboration; (iv) mass collaboration; and (v) simulation/synthetic reality.

construct within organization research. Zammuto et al. (2007) observe that while technology has been a central variable in organizational theory since the 1950s, the past couple of decades have seen a noticeable and significant decline in interest and attention among organizational scholars. They argue that this is problematic given the pervasive presence of technology in contemporary organizations, and the potential for such technologies to enable important shifts in organizational form and function. They suggest that organization scholars need to rediscover the central principle of the sociotechnical systems perspective (Trist, 1981), that is of viewing "the social and technological systems in organizations in concert" (Zammuto et al., 2007, p. 752).

Problems with Existing Literature

The three reviews highlight somewhat different concerns with the literature, concerns they suggest lead to the literature's difficulties in explaining existing technological phenomena. Barley (1988) for example, argues that scholars have been misled by assuming that technology is either a physical object or a social product. He observes that a focus on the physical aspects of technology has led researchers into an inappropriate materialism that often results in *technological determinism*—the view that technology's effects on social life are determining and inevitable. In turn, a focus on technology as a social production has led to an overreliance on culture as a primary driver, potentially leading to a form of *social determinism.* Barley further criticizes the existing literature for seeking "to subsume all events under a single ethos", which has led to "visions that shortchange social complexity, distort the nature of technology, and lead ultimately to a claim that a technology's effects are foregone conclusions" (1988, p. 34). He contends that, as a result, current theories of technology and work are either too brutish or too brittle to capture the multiple and subtle ramifications of technical change.

Writing almost 10 years later, Roberts and Grabowski (1996) suggest that the organization literature offers two distinct perspectives on technology: (i) a *descriptive* view (which focuses on types and roles of technology within organizations), and (ii) a *relational* view (which focuses on the relations between technology and structure). They argue that these two views, on their own, are incomplete, and thus need to be integrated so as to account for the nature and development of technology, and for its relations with organizations, particularly as these evolve over time with the changes brought on by the post-industrial age. Focusing less on how the literature has treated technology, Zammuto et al. (2007) note that since the central focus on technology in early contingency research, considerations of technology have been displaced over time as institutional, population ecology, and resource dependence theories have gained prominence in organization science. They argue that the problem with the existing management literature is its lack of attention to the changing relationship between technology and organization, and

specifically, how "IT is supplanting hierarchy's role in coordinating and controlling activities" (p. 750).

Definition of Technology

Definitions of technology and what is most salient differ somewhat across the three reviews. Barley (1988, p. 46) for example, draws on Winner (1977) to note three different uses of the term "technology" in social science: technology as machines and devices, technology as technique (stylized behaviors and cognitions), and technology as organization (specific arrangement of tools, people, and tasks). He argues that equating technology with social elements is conceptually confusing: "When technology and organization are allowed to share the same semantic domain, it often becomes difficult to decide where technology stops and organization begins" (Barley, 1988, p. 46). He thus advocates restricting the term "technology" to objects and actions that "admit the possibility of ostensive definition", proposing the notion of technology as a "social object".

Roberts and Grabowski (1996) discuss seven different definitions of technology that are evident in the literature, noting interesting and conflicting differences. They conclude by drawing on Collins, Hage and Hull's (1986) proposal that posits technology as including three aspects: mechanical systems (i.e., hardware); human systems (i.e., skills and human energy); and knowledge systems (i.e., abstract meanings and concepts). Zammuto et al. (2007, p. 751) do not offer an explicit definition of technology, grounding their view instead in specific features of contemporary information technology: "increasing capacity in terms of computing power, communication, and integration capabilities", as well as the development of enterprise-wide information systems that have "created opportunities to organize around processes, not only separate steps or functions".

Logic of Argument

All three of the reviews highlight a process approach to studying technology, and incorporate such an approach in their proposals. Arguing for what he calls an *interpretive materialism,* Barley (1988) proposes that scholars investigate how a technology is construed and reconstrued as it is designed, built, sold, and used, while also examining how these processes of social construction are constrained by a technology's physical properties as well as by the larger socio-economic contexts in which the technology is situated. Roberts and Grabowski (1996) draw on structuration theory (Giddens, 1984) to propose an integration of technology's status as both a product and a process. They suggest that scholars first adopt a *positional* lens that focuses on technological and structural constructs such as complexity, task definition, and workflow integration, and then follow this with a *relational* lens that examines the fluid and interactive relations between technology and structure in organizations.

Zammuto et al. (2007, p. 752) draw on ecological psychology (Gibson, 1979) to advocate the analytic lens of "affordances" (Gibson, 1977; Hutchby, 2001) in studying technology and organizations: "An affordance perspective recognizes how the materiality of an object favors, shapes, or invites, and at the same time constrains, a set of specific uses". They introduce the term *affordances for organizing* as a way to conceptualize the process by which IT and organizations are "woven together", arguing that "although IT and organization features may exist independently of each other, their value for explaining organizational form and function comes from how they are enacted together" (Zummato et al., 2007, p. 753).

Research Agenda

In making recommendations for future organization research, each of the three reviews makes a number of specific suggestions. Barley (1988) cautions scholars to avoid unidirectional models of technical change, arguing that any examination of a technology's ramifications across a range of occupations or organizations will reveal that single or invariant relationships do not apply. He recommends attending to how a technology interacts with specific meanings, actions, cultures, structures, and institutional environments, examining how the same technical capacity may be used in multiple contexts to occasion quite different social structures. He encourages researchers to engage with (rather than reduce) the complexity and equivocality that they observe empirically in relations between technology and organizations.

Echoing Barley (1988), Roberts and Grabowski (1996) similarly caution that uniform or generalized descriptions of technology and organizational utility are no longer appropriate. Instead, they argue for a contingency framework, augmented with more refined typologies of technology. They further recommend additional investigations of decision settings that are characterized by increasing knowledge, complexity, and turbulence. Reflecting their process orientation, they urge more temporal and longitudinal studies of organizations and technology, arguing that these are needed to account for the dual nature of technology as process and product, and to accommodate the necessarily changing relations that exist between technology and organizations in a fluid and dynamic world.

Zammuto et al. (2007), in turn, advocate using the notion of affordances to examine the dynamic and often unpredictable interplay of IT and organizations. They articulate five possible affordances (not an exhaustive list) jointly created by technical and organizational features that appear to be particularly salient in contemporary workplaces: visualizing entire work processes, real-time/flexible product and service innovation, virtual collaboration, mass collaboration, and simulation/synthetic reality. They urge organizational scholars to address seriously the influence of IT in organizing: "[I]t does not make sense to study the dynamics of human behavior within

organizations without taking into account how information technologies might affect it" (p. 760).

Moving Forward: Beyond Separation and Towards Fusion

Whether emphasizing individual, stable entities or ongoing, interactive processes, the two research streams have generated valuable insights into specific aspects of the relationships between technology and organizations. As with all perspectives, however, they also entail conceptual commitments that generate some distinctive blindspots in dealing with technology in organizational life. After discussing two of these difficulties, we will propose that a possible way forward is to challenge the deeply taken-for-granted assumption that technology, work, and organizations should be conceptualized separately, and to theorize their fusion. To this end, we discuss a promising emerging stream of research that we refer to under the umbrella term *sociomateriality*, which posits the inherent inseparability between the technical and the social.

Research Streams I and II: *Some Difficulties*

The first difficulty evident in both Research Stream I and II concerns the focus on technology as causing or occasioning some organizational effect or change (e.g., development, diffusion, adoption, adaptation, improvement, etc.). This suggests that technology is relevant to organizational theorizing only as specific technological events or processes occur. As such, technology is seen to be of particular interest at certain times, in explicit places, and during special organizational circumstances.

While we learn much by considering technology as a specific organizational event or process, such a view also obscures ways of seeing how all organizational practices and relations *always* entail some sort of technological (or material) mediation. As we discuss below, to the extent that technology is treated as an occasional or separate organizational phenomenon, we lose the possibility of seeing how it is an integral part of all organizing at all times, places, and circumstances.

The second difficulty is associated with positing the technology–human (or organizational) relationship as involving distinct entities or processes that interrelate in some way. What becomes relevant to study in this logic is the nature of the relationship entailed, whether this is understood as a unidirectional causal influence (e.g., in the technological imperative or strategic design perspectives or Research Stream I) or as a mutual interaction (as in the process perspective of Research Stream II) (Markus & Robey, 1988).

By studying how technology and humans (or organizations) influence each other, the studies constituting Research Streams I and II have shed important light on the impacts, interactions, and unanticipated consequences of technology design and use in organizations. But what remains unquestioned in this

logic is the assumption that technology and humans (or organizations) are separate in the first place. As we discuss below, research conducted in what may be seen as an emerging third research stream has begun to challenge this ontological separation, arguing in contrast for a relational ontology that dissolves analytical boundaries between technologies and humans (Knorr-Cetina, 1997; Latour, 2005; Pickering, 1995).

Research Stream III: *Sociomaterial Assemblages*

This promising stream of research, which we organize under the banner of "sociomateriality", makes a distinctive move away from seeing actors and objects as primarily self-contained entities that influence each other (Slife, 2005), either through impacts (Research Stream I) or interactions (Research Stream II). Instead, the focus is on agencies that have so thoroughly saturated each other that previously taken-for-granted boundaries are dissolved. Our analytical gaze is drawn away from discrete entities of people and technology, or ensembles "of equipment, techniques, applications, and people" (Orlikowski & Iacono, 2001) to composite and shifting assemblages. Another way to put this is that this is a move away from focusing on how technologies influence humans, to examining how materiality is intrinsic to everyday activities and relations. As a thought experiment, consider doing anything in the world (whether at home, on the road, or in organizations) that does not in some way or another entail material means (e.g., bodies, clothes, food, spectacles, buildings, classrooms, devices, water pipes, paper, telephones, email, etc.). Furthermore, these material means are not so much tools to be used to accomplish some tasks, but they are constitutive of both activities and identities. Latour's (2004, p. 227) provocative quote makes this point particularly well:

> To distinguish a piori "material" and "social" ties before linking them together again makes about as much sense as to account for the dynamic of a battle by imagining, first, a group of soldiers and officers stark naked; second, a heap of paraphernalia—tanks, paperwork, uniforms—and then claim that "of course there exists some (dialectical) relation between the two". No! one should retort, there exists no relation whatsoever between the material and the social world, because it is the division that is first of all a complete artefact. To abandon the division is not to "relate" the heap of naked soldiers with the heap of material stuff, it is to rethink the whole assemblage from top to bottom and from beginning to end.

From this perspective, people and things only exist in relation to each other, and as Slife (2005, p. 159) puts it: "They start out and forever remain in relationship". In other words, entities (whether humans or technologies) have no inherent properties, but acquire form, attributes, and capabilities through their

interpenetration. This is a relational ontology that presumes the social and the material are inherently inseparable. As Barad (2003. p. 816) argues, this is a constitutive entanglement that does not presume independent or even interdependent entities with distinct and inherent characteristics.[4] The portmanteau "sociomaterial" (no hyphen) attempts to signal this ontological fusion. Any distinction of humans and technologies is analytical only, and done with the recognition that these entities necessarily entail each other in practice.

This third research stream is relatively new, as reflected in the breadth and fluidity of its intellectual ideas and substantive themes. While the key contours and core contents of a sociomaterial approach are still emerging, they point to a body of work that transcends both the focus on discrete entities of the first research stream and the focus on mutually dependent ensembles of the second. Table 10.5 depicts the primary characteristics of sociomaterial research (as currently evident) in relation to the other two research streams.

While this stream of research is still too unsettled to admit the sort of analysis we conducted for the other two streams, we can highlight a few emerging research themes, as well as outline a possible research agenda for scholarship going forward.

Research Themes

This emerging stream of work includes a number of interesting studies and generative concepts that appear to offer some promising directions for future work (see Table 10.6).

The most prominent body of literature that we are organizing under the umbrella term of sociomateriality belongs to Actor Network Theory (ANT), originally developed by sociologists Michel Callon (1986) and Bruno Latour (1987). In this view, as Law (2000, p. 1) explains: "an object is an effect of an array of relations", in which humans and technologies are not only reciprocally interdependent, but also symmetrically relevant. From an ANT perspective, there are no distinct and separate social or technological elements that interact with each other; rather, technological artifacts are considered as equivalent participants in a network of human and non-human agencies that (temporarily) align to achieve particular effects.

In ANT studies, relations are no longer seen as a concept with which to frame some aspect of the research, but instead become the theoretical foci and central explanatory vehicle of the research. The analytical goal in such studies is to present "society, organizations, agents, and machines [as] effects generated in patterned networks of diverse (not simply human) materials" (Law, 1992, p. 380). In one of the influential papers often cited in support of this approach, Callon (1986) famously blurs the human and material agencies at work on a beach: "Scallops make the fisherman do things just as nets placed in the ocean lure the scallops into attaching themselves to the nets and just as the data collectors bring together the fisherman and the scallops in oceanography".

Table 10.5 Three Streams of Research on Technology and Organizations

	Research Stream I	Research Stream II	Research Stream III
Ontological Priority	Discrete Entities	Mutually Dependent Ensembles	Sociomaterial Assemblages
Primary Mechanisms	Impact; Moderation	Interaction; Affordance	Entanglement; Performativity
Logical Structure	Variance	Process	Relationality
Key Concepts	Technological Imperative; Contingency	Social Constructivism; Structuration	Actor-Network; Mangle of Practice
View of Social and Technical Worlds	Humans/organizations and technology are assumed to be discrete, independent entities with inherent characteristics	Humans/organizations and technology are assumed to be interdependent systems that shape each other through ongoing interaction	Humans/organizations and technology are assumed to exist only through their temporally emergent constitutive entanglement
Examples	Blau et al. (1976) Huber (1990) Aiman-Smith & Green (2002)	Barley (1986) Prasad (1993) Boudreau & Robey (2005)	Callon (1986) Pickering (1995) Suchman (2007)

Table 10.6 Emerging Concepts within the Sociomateriality Research Stream

Sociomaterial Concepts	Definition	Researchers	Examples of research
Actor-Network	Organization constituted by relationships that form ties with both human and non-human agencies	Callon (1986) Latour (1992) Berg (1997)	Networks of scientific knowledge; travel infrastructure
Mangle of practice	Human and material agencies are temporally emergent in everyday practice	Pickering (1995) Jones (1998)	Invention of bubble chamber; introduction of manufacturing technology
Human-machine (re)configurations	The boundaries between persons and machines are discursively and materially performed	Suchman (2007)	Cyborg information services; engineering with computer-aided design technology
Digital formations	Sociodigitized structures that imbricate social and technical agencies with novel consequences	Latham & Sassen (2003)	Electronic markets; open source software development; activist networks in civil society
Technological information	A computational rendition of reality that reconstitutes organizations in various forms	Kallinikos (2006)	Information flows in financial services and media companies
Algorithmic configuration	The distributed calculative agencies of humans and technologies	Callon & Muniesa (2005) MacKenzie (2006)	Production of prices in financial markets

In the area of technology and organizations, the use of ANT has been used to shed light on technological relations in the workplace (Berg, 1997; Monteiro & Hanseth, 1996; Walsham & Sahay, 1999). For example, Scott and Wagner (2003) use ANT to discuss a case in which the ambitions of a university vice president to elevate his organization to the status of "gold standard" combined with the concerns of the financial controller regarding their top rated (AAA) audit compliance to drive the adoption of a particular technical accounting method during the implementation of an enterprise resource planning (ERP) package. This accounting method was written into the programming code during the customization of the ERP software and subsequently manifested in the graphical representation and calculative processes of reports that the university administrators were told they must use. In this way, the social life worlds of university rankings, claims regarding expert accounting knowledge, government regulations, and the practices of credit rating agencies were entangled with the technological agencies of the ERP package and routine conversations among administrators and academics about how much money they had left in their grants. These entanglements triggered intense controversies over values, identities, and community within the university.

Similarly drawing on a relational ontology, Latham and Sassen (2005) point to the emergence of whole new sociotechnical relations and domains—*digital formations*—which they argue need to be constructed as objects of study. These "sociodigitized" structures "exhibit dynamics of their own that derive from technological capacities that enable specific patterns of interaction (Latham & Sassen, 2005, pp. 3–5). In another example, Kallinikos (2006) explores the issue of information growth, challenging the assumption that there is a straightforward connection between an objectified domain of technology and a normative world of institutions. He rejects the standard maxim that data, information, and knowledge are separate organizational resources representing a hierarchy of phenomena that can be strategically leveraged through the application of technology. He argues instead that "technological information" is a pervasive element of institutional life (its habitat), and thus crucially involved in the reconstitution of organizational reality in various novel forms.

In work in the sociology of science, Pickering (1993, 1995) argues for the value of a relational ontology that is premised on the "insistence that material and human agencies are mutually and emergently productive of one another" (Pickering, 1993, p. 567). Based on his empirical studies of scientific practice, he develops the concept of a *mangle of practice* to highlight that human and material agencies are not pre-given but emerge temporally in practice through a dialectic process of resistance and accommodation. Jones (1998) subsequently extends Pickering's ideas to the case of information technology within organizations, arguing that the production and use of this technology entails a "double mangling" of human and material agencies:

> … as human agents seek to marshal material agency to direct the actions of other human agents. The outcome of technology development and use cannot be reliably predicted, as both the technical and social are mangled together in the process to produce specific, situated instantiations. Rather than seeing humans with clearly-defined goals applying technologies with clearly-defined properties to achieve clearly-defined organizational effects, therefore, we need to understand the process of information systems development and use as an ongoing double dance of agency. (Jones, 1998, p. 299)

In related phenomenologically-grounded research, Suchman (2007) argues for the sociomaterial dynamics of everyday practices, drawing on a number of cases including photocopiers, robots, and cyborg information systems. In one example, she describes an engineer working at a computer-aided design (CAD) workstation, where the technology, rather than being understood as representing the specific details of a site—features of the locale, roadways, environments, people, etc.—is seen to constitute and connect the engineering work to those objects:

> The engineer knows the project through a multiplicity of documents, discussions, extended excursions to the project site, embodied labors, and accountabilities: the textual, graphical, and symbolic inscriptions of the interface are read in relation to these heterogeneous forms of embodied knowing. Immersed in her work, the CAD interface becomes for the engineer a simulacrum of the site, not in the sense of a substitute for it but rather of a place in which to work, with its own specific materialities, constraints and possibilities. (Suchman, 2007, p. 279)

In this view, everyday practice is configured and reconfigured by the multiple meanings and materialities that are fused together in the engineer's work. This fusion is evident in Figure 10.1, which shows at a glance how office work is inextricably tied up with the sociomaterial. We see the physical hub of a person's work practices composed of an array of materiality imbued with multiple logics and capabilities (programs, reminders, sources, and connections) all poised to form part of the pattern of her work flow, ready to be actively configured into a situated work performance.

A central idea entailed in sociomateriality is the notion of *performativity* (Barad, 2003). While related to the notion of performance, performativity is not synonymous with it. Where "performance" refers to the doing of some activity (as when a physician "performs" a medical examination, or a musician "performs" in front of an audience), performativity refers to enactment. It has its roots in J.L. Austin's (1962) notion of "performative utterances" (i.e., language that executes action, as in uttering "I do" at a wedding, or "I name this ship …" at a launching ceremony). More generally, a discourse may be said to

Figure 10.1 Example of Sociomateriality in Office Work.

be performative if it contributes to the constitution of the reality that it describes (Callon, 1998).

The notion of performativity has been taken up by a number of social scientists. For example, Judith Butler (1990) has used the notion to study how gendered identities are not "naturally-given" but actively and materially constructed ("performed") through discourse. Other examples are evident in the sociology of technology and science, where scholars have used the notion of performativity to understand how financial models and economic theories produce the market conditions and effects that they attempt to represent and explain (Beunza & Stark, 2004; Callon, 1998; Callon & Muniesa, 2005; MacKenzie, 2006; MacKenzie & Millo, 2003). In this view, "economics creates the phenomenon it describes, rather than describing an already existing 'economy'" (MacKenzie, 2005, p. 64). In an example of this work, MacKenzie (2006) analyzes the Black-Scholes pricing model in options markets, showing how the Black-Scholes formula first described the world of options pricing, but how over time it came to enact that world through its inscriptions in computer algorithms, professional skills, and financial institutions. As MacKenzie and Millo (2003) note: "Option pricing theory … succeeded empirically not because it discovered preexisting price patterns but because markets changed in ways that made its assumptions more accurate and because the theory was used in arbitrage" (p. 107).

The performativity of models is a particularly relevant theme for scholars of technology, entailing what Callon and Muniesa (2005) refer to as "algorithmic configurations", forms of work and ordering that are produced by the distributed and mutually constituting calculative agencies of humans and technologies. For example, in their study of arbitrage trading, Beunza and Stark (2004, pp. 396–397) show how the technologies of quantitative finance "visualize, cut, probe, and dissect ephemeral properties in the project of interpreting markets", and how in so doing "the products of their interventions become a part of the phenomenon they are monitoring".

For scholars of sociomateriality, the notion of performativity draws attention to how relations and boundaries between humans and technologies are not pre-given or fixed, but enacted in practice. A practice lens is thus particularly helpful in grounding this notion of performativity. Practice studies—or more accurately what has been referred to as "the practice turn" (Schatzki, Knorr-Cetina, & Savigny, 2001)—has received growing attention in recent management and organization studies research (e.g., *Organization Studies* 2006, volume 17, number 5). The term "practice" in this context does not refer to rendering pragmatic insights from management research for a practitioner audience, nor is it meant to imply separation of academic theory from practice. Rather, it is the scholarly effort of understanding how boundaries and relations are enacted in recurrent activities. As Reckwitz (2002, p. 252) notes, the routinized way in which "bodies are shaped, objects are handled, subjects are treated, things are described, and the world is understood". In this view, an organization is held to be a recurrently enacted and patterned set of relations, reproduced over time and space. Attempts to identify an encompassing, systematic "practice theory" (Friedmann, 1987, p.186) have largely given way to the suggestion that the concept of practice is most effectively used as a way of framing and orienting research (Schatzki, 2001, p 4.).

The practice lens marks out a distinctive way of thinking about organizations and activities of organizing (Gherardi, 2006; Orlikowski, 2000; Whittington, 2006). Organization studies that have adopted this approach analyze the flow of situated action as expressed through, for example, organizational routines (Feldman & Pentland, 2003), global product development (Orlikowski, 2002), interactive strategizing (Jarzabkowski, 2005), and communities of practice (Wenger, 1998). Ironically, as Duguid (2005) notes: once the unit of analysis has been framed, the idea of practice is theoretically bracketed by many scholars. As he put it when critiquing community of practice studies: there is often more emphasis on the community than the *practice*. Our observation is that, since technology and contemporary work practices saturate each other, further efforts to theorize practice must encompass technology in organizations. We believe a way to achieve this is with the notion of sociomateriality, and turn next to some thoughts on a possible research agenda.

Research Agenda

Since any approach influences the way phenomena are framed from the outset of a study, it might help if we compare a sociomaterial framing to that of the previous research streams of work and technology discussed above. As we saw, both Research Streams I and II have tended (in different ways) to objectify the technical and to sequestrate the social, creating two distinct domains within the research. This presumption of separation is then inscribed in the priorities of the study and, most importantly, in its analytical gaze, producing strategies of data gathering and analysis that are necessarily split between two categories: the technologies (artifacts, techniques, systems, media) and the social (meaning, activities, contexts, outcomes). The language and assumptions of separation thus lead conceptually and methodologically to a realm of possible findings that are already configured. By design then, the frames, methods, and findings of Research Streams I and II entail accounts of impacts or interactions of the social and the technical. As a result, we lose the possibility of seeing the technical and social as inextricably fused. Part of the problem, as we have noted, is linguistic. Suchman (2007, p. 263) writes that "our language for talking about […] persons or artefacts presupposes a field of discrete, self-standing entities".

The notion of sociomateriality distinguishing Research Stream III attempts to move beyond the separation of the technical and the social. For researchers in this stream, practices are always sociomaterial, and this sociomateriality is integral, inherent, and constitutive, shaping the contours and possibilities of everyday organizing. As Barad (2003, p. 818) puts it, "Agencies are not attributes [of either humans or nonhumans] but ongoing reconfigurations of the world". Thus, an important challenge for research going forward is developing ways of thinking and talking about the social and material worlds as inseparable, as constitutively entangled.

Without wishing to prematurely preclude any approach to studying sociomateriality, we offer some thoughts about how such research might be framed in order to provide suggestions for those interested in pursuing this agenda further. We illustrate the research agenda discussed here with contemporary phenomena many of which are associated with computer-based information systems, because this reflects our belief that sociomateriality resonates particularly well with current organizational challenges. However, there is no reason, in principle, why this genre of scholarship would not be appropriate for historical manifestations of work and organizations, if they lend themselves to analysis from a sociomaterial perspective.

Whereas scholars in Research Stream II often center their analyses on events and processes, sociomateriality studies would seek to find ways to bring to the foreground patterns within the constitution of everyday work practices. For example, a sociomateriality lens may be particularly valuable in helping to

research the expansion of management knowledge (Sahlin-Andersson & Engwall, 2002) in everyday organizational life. The expansion of management knowledge in organizations marks the escalation of specific sociomaterial techniques into packages of ideas and management recipes that spread with all the dynamics of a fashion or fad until they attain the status of commonly espoused or "canonical" practices (Brown & Duguid, 2000, p. 99). Some of these techniques become known by acronyms such as ERP (Enterprise Resource Planning) or NPM (New Public Management), while others are more recognizable as programs of action that gain sufficient momentum to be assumed to be "best practice" (Wagner, Scott, & Galliers, 2006). Whether the banner is "globalization" (for example, the competitive shift to global electronic trading), or "modernization" (for example, the focus on transparency, accountability, and accessibility in the public domain), sociomateriality is inseparable from these formulations of management knowledge, their implementation, and their capacity to 'travel' as global ideas.

This points to the next theme in our research agenda, an analysis of the demands brought about by the need to accommodate sociomaterial reformulations. While previous studies have concentrated on processes of translation between global ideas and context, the analytical language is still one of separateness. What is needed is a recognition of these programs of action as sociomaterial enactments, and as requiring concepts capable of acknowledging the fusion of conceptual and material that constitute these programs (Bowker & Star, 1999; Orlikowski, 2007). Of particular importance are the negotiations that "make it work" and an acknowledgement that these can produce contradictory consequences. On the one hand, they can force convergence around standards, while on the other improvisations introduce contextual serendipity that surfaces in other times and places as randomness. Both eventualities store up potential significance for the future and represent challenges for management especially since their consequences reveal themselves only through performance.

Some salient research questions would include how particular, inherently sociomaterial, organizational forms pattern practice, for example: very-large-conversations using Web-based discussion forums; collaborative dynamics within e-Science Grids; habitats of connectivity formed through extensive use of Blackberries and wearable mobile technologies. The challenge in these examples is to find ways of establishing a corpus of data under fieldwork conditions that are distributed, constantly reconfiguring, fragmented into enclaves, or restricted by partial access (Law & Urry, 2004). Possibly promising approaches for addressing these include work on narrative (Czarniawska, 1998; Pentland & Feldman, 2007) and practice-order bundles (Schatzki, 2002).

Many of the methodological issues raised by a sociomateriality research agenda stem from the way in which research participants disappear from view, disrupting our routine methods of meaning-making. This is compounded by our habitual tendency to decompose fluid relationships into separate entities

(Mol & Law, 1994). If we can find a way to reveal the taken-for-granted, invisible dynamics of sociomateriality, it will enable us to generate deep insights into the contemporary world. We suggest that it is precisely the hidden-from-view characteristics of sociomateriality that imbue it with such far-reaching consequences. For example, when Internet search engine software "runs" or is executed, a set of choices-as-embedded-in-code shape the operation of the search engine, the databases and indexes that are built and maintained, and the results that are returned to users (Brin & Page, 1998). A Web search conducted with the Google search engine is sociomaterial "all the way down", entailing computer code written and updated by software engineers, executing on computers (configured with particular hardware and software elements which were designed and built by computer engineers and production workers), and whose operation depends on the millions of people who use computers to create and update Web pages every day, and the millions of people around the world who enter particular search criteria into their Web browsers running on still other computers designed and built by yet other people, and so on.

This is not a neutral process and an important position is accorded to political analyses within a research agenda for sociomateriality studies because (re)distribution of resources is one of its systemic consequences. To continue with the example used above, the performance of Web search sociomateriality is both inclusive and exclusive—including well-linked and highly-connected Web sites, and excluding poorly-linked and less-connected Web sites. This has considerable political and epistemic implications because it means that a part of the World Wide Web is completely unavailable to most people. For example, a study conducted by researchers from IBM (Butler, 2000) found that the Web includes considerable constellations of Web sites that are difficult to navigate and thus inaccessible by links. As Introna and Nissenbaum (2000) note: in this way search engines "are political … constitut[ing] a powerful source of access and accessibility within the Web" (p. 170).

The ideas proposed here are by no means exhaustive, but we believe that they may open multiple lines for research. Suchman (2007) offers two specific implications for conducting sociomaterial research. First, she argues that scholars need to attend to the boundary work through which entities are defined (2007): "Beginning with the premise that discrete units of analysis are not given but made, we need to ask how any object of analysis—human or nonhuman or combination of the two—is called out as separate from the more extended networks of which it is a part" (p. 283). Second, she suggests that scholars locate entities in extended spatial and temporal relations: "How far our analysis extends in its historical specificity and reach, or in following outlines of connection from a particular object or site to others, is invariably a practical matter. That is, it is a matter […] of drawing a line that is in every case enacted rather than given" (p. 284). Taking these implications on board is a critical matter, as Law and Urry (2004) note: "it is time for social science,

which grew up in the nineteenth century, to review much of its methodological inheritance. That inheritance in considerable measure reflects nineteenth-century preoccupations: with fixing, with demarcating, with separating" (p. 403). We believe moving beyond preoccupations of separation will help scholars take seriously notions of distributed agencies, sociomaterial practices, and performative relations as these play out in organizational realities.

Conclusion: Whither Technology in Management Research?

We began this paper by highlighting a paradox in the management literature. Despite the substantial empirical evidence of technology's central role in organizational affairs, technologies remain largely understudied in organizational research. Whatever the reasons, we believe that such an absence of attention to technological issues in organizational research is a serious concern.

It is important that we appreciate that it is not a question of whether technology forms part of organizing or not; technology is an integral part of the fact of work and its performance in the world. If we do not take this into consideration in the way that we study organizations, we may not arrive at an understanding of how work is "made to work". Indeed, we believe that to the extent that the management literature continues to overlook the ways in which organizing is critically bound up with material forms and spaces, our understanding of organizational life will remain limited at best, and misleading at worst.

We have proposed sociomateriality as part of a palette of approaches that we believe may advance the way we study technology, work, and organizations. As these are multiple, distributed, emergent, dynamic, and unprecedented phenomena, we believe a range of different and flexible lenses and tools is appropriate for studying them. There will be studies for which existing theory and approaches will be suitable, but there will be many more that necessitate a fresh perspective. Our call for research to move beyond separating technology from people, work, and organizations makes the research challenge ahead of us both substantial and generative. This is a fast-moving field; just as what we study changes over time, so the theoretical lens or method that we use to approach it needs to develop over time. As Weick (1996) reminds us, we should "hold our concepts lightly and update them frequently".

While the significance of management instruments and canonical practices has been recognized in organization studies, attention has tended to focus on technological effects, occasions of change, or processes of sensemaking and interaction with little recognition of the deeply constitutive entanglement of humans and organizations with materiality. Yet, evidence from contemporary organizations suggests that work practices are constituted by an array of sociomaterial agencies, for example, space, devices, standards, categories, algorithms, expert judgements, physical mechanisms, and so on.

We make our proposal for the way forward in the spirit that ideas help us to explicate the world around us. It has become commonplace for studies of

technology in organizations to combine metaphors of networks and infrastructures with the language of mediation and enabling. However, if we let go of the methodological assumption that we should think of relationships as moulded into networks and frame our analysis in terms of practices instead, we can more effectively examine the specific forms of sociomateriality that are entailed in performing everyday work. We suggest that this is a particularly relevant perspective in an era when sociomateriality is so much part of our everyday organizational experience that it becomes taken-for-granted. Work practices are inherently sociomaterial, and so to understand work, we must understand its sociomaterial (re)configurations. The implications for organizations are particularly important; these practices don't just mediate work, they perform organizational realities.

Different forms of sociomateriality in practice not only increase the capacity for transactions to be disembedded from time and space, but also disappear from the attentions of users and observers. Such increased invisibility in the technological entailments of everyday work practice is troubling, as it limits our capacity to understand, monitor, reflect on, and change them. It suggests that additional and alternative ways of examining these entailments are required in organization studies, particularly given the relative absence of attention paid to materiality in recent organization scholarship. We believe that a sociomaterial perspective may offer one promising approach for reconsidering the status of technology in organizational research, and that a grounding in relationality, performativity, and sociomaterial assemblages (rather than either discrete entities or mutually dependent ensembles) may afford some empirical and conceptual innovations that will increase our understandings of the practices of contemporary organizational life.

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Endnotes

1. A similar conclusion was reached by Zammuto et al. (2007), who surveyed these four journals specifically for studies of the relationship between technology and organizational from and function. They found that only 2.8% of articles between 1996 and 2005 addressed this phenomenon.

2. While both TIM and OCIS members may of course focus on non-technological phenomena in their research, the relative interest among organization scholars to affiliate with these AoM divisions offers something of a benchmark in terms of the level of attention to technology we might expect in the mainstream management literature.
3. While our interest is in technology, broadly defined, it is the case that much of the organizational literature on technology (and particularly the more recent literature) focuses largely on computer-based or information technologies. This tendency is consequently reflected in our discussion of the literature.
4. Part of the difficulty in discussing this perspective is that our language makes it difficult to express indissolubility. We are used to dividing, separating, and distinguishing. Thus, even terms such as "mutual constitution", "entanglement", "assemblage", and "relationality" allude to separateness, even as they try to move beyond it.

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