How Technology Is Changing Work and Organizations

Wayne F. Cascio[1] and Ramiro Montealegre[2]

[1]The Business School, University of Colorado, Denver, Denver, Colorado 80217; email: wayne.cascio@ucdenver.edu

[2]Leeds School of Business, University of Colorado, Boulder, Boulder, Colorado 80309; email: ramiro.montealegre@colorado.edu

Annu. Rev. Organ. Psychol. Organ. Behav. 2016. 3:349–75

The *Annual Review of Organizational Psychology and Organizational Behavior* is online at orgpsych.annualreviews.org

This article's doi: 10.1146/annurev-orgpsych-041015-062352

Keywords

technology, work, organizational change, ubiquitous computing, disruptive technology, OP/OB research review

Abstract

Given the rapid advances and the increased reliance on technology, the question of how it is changing work and employment is highly salient for scholars of organizational psychology and organizational behavior (OP/OB). This article attempts to interpret the progress, direction, and purpose of current research on the effects of technology on work and organizations. After a review of key breakthroughs in the evolution of technology, we consider the disruptive effects of emerging information and communication technologies. We then examine numbers and types of jobs affected by developments in technology, and how this will lead to significant worker dislocation. To illustrate technology's impact on work, work systems, and organizations, we present four popular technologies: electronic monitoring systems, robots, teleconferencing, and wearable computing devices. To provide insights regarding what we know about the effects of technology for OP/OB scholars, we consider the results of research conducted from four different perspectives on the role of technology in management. We also examine how that role is changing in the emerging world of technology. We conclude by considering approaches to six human resources (HR) areas supported by traditional and emerging technologies, identifying related research questions that should have profound implications both for research and for practice, and providing guidance for future research.

INTRODUCTION

We live in a global world where technology, especially information and communication technology, is changing the manner in which businesses create and capture value, how and where we work, and how we interact and communicate. Consider five technologies that are transforming the very foundations of global business and the organizations that drive it: cloud and mobile computing, big data and machine learning, sensors and intelligent manufacturing, advanced robotics and drones, and clean-energy technologies. These technologies are not just helping people to do things better and faster, but they are enabling profound changes in the ways that work is done in organizations. As Murray (2015, p. 6) contends, "Together these innovations are hurtling us toward a new industrial revolution. Savvy corporate leaders know they have to either figure out how these technologies will transform their businesses or face disruption by others who figure it out first."

Academic literatures not only in business (Turban et al. 2009, VanHoose 2011), but also in medicine (Demaerschalk et al. 2012, Ross et al. 2010), engineering (Kühnle 2010, Smite et al. 2010), sciences (National Research Council 1999) and social sciences (Castells 1996, Wellman & Haythornthwaite 2002) echo this observation. Barley (2015) suggests that although digital technology is rapidly becoming as infrastructural as electricity, there is surprisingly little research on how it is altering work systems or the work that people do.

The last great wave of technological innovation was all about social interaction. The next one may well feature the emerging general technology paradigm known as ubiquitous computing. This concept is not about one technology. Rather, it reflects information and communication environments in which computer sensors (such as radio frequency identification tags, wearable technology, smart watches) and other equipment (tablets, mobile devices) are unified with various objects, people, information, and computers as well as the physical environment. The combination of these developments is giving us a new kind of world, "one that is hyperconnected and data saturated, a world where an Internet of everyone is linked to an Internet of everything" (Wooldridge 2015, p. 29). These new technologies, disruptive as they are, did not just appear overnight. Rather, many other developments in technology preceded them, and their effects on work and organizations over the past several decades have been far-reaching, as we shall see.

Work is defined here as the application of human, informational, physical, and other resources to produce products/services (Alter 2013). Given the increasing reliance on technologies to get work done within and across organizations, the question of how technology is changing work and organizations is highly salient for scholars of organizational psychology and organizational behavior (OP/OB). If one accepts the premises that work does not exist without people and that OP/OB researchers are inherently concerned with the study of people within organizational settings, then OP/OB bears some responsibility for understanding the effects of technology on work and organizations. Research-based answers have profound implications both for research and practice about the kinds of organizational realities that might be produced. Thus, our goal here is to interpret the progress, direction, and purpose of current research on the effects of technology on work and organizations. Seven broad sections comprise this article. We begin with a review of key breakthroughs in the evolution of technology and its effects on work and organizations. In our second section, we focus on the disruptive effects of emerging information and communication technologies as they create further opportunities to unify physical and virtual workspaces. Our third section examines the numbers and types of jobs affected by developments in technology, and how this will lead to significant worker dislocation. A fourth section considers the effects of technology on how and where we work, including new types of work arrangements and work-life fit. In this section, we consider four technologies in some detail: electronic monitoring systems, robots, teleconferencing, and wearable computing devices. In the fifth section, we consider the role of management and how it is changing in the emerging world of technology. The sixth section looks toward the future. In it we consider approaches to six human resources (HR) areas supported by traditional and emerging technologies and identify related research needs. The seventh section provides guidance for conducting future research on the effects of technology on individuals, work, and organizations.

KEY DEVELOPMENTS IN TECHNOLOGY AND THEIR EFFECTS ON WORK AND ORGANIZATIONS

The effects of technology[1] over the course of human history are well documented (Beniger 1986, Bradley & Nolan 1998, Bradley et al. 2016). The growth and advancement of civilization can be divided into three eras according to their respective core technological infrastructures: the agricultural era, the industrial era, and the digital era. Each of these eras has been profoundly affected by the ability to acquire new information and knowledge. However, they have all required and enabled new economic structures, social revolutions, cultural transformations, and work models.

In the agricultural era, people focused primarily on the use of the power of natural elements, such as wind and water. The most important resources were land, livestock, and agricultural implements. The initiative to gain core economic power was in the hands of the owners of the resources (farmers who owned vast and fertile farm lands). During this era, the owner of the resources also controlled access to proprietary information.

In the industrial era, people concentrated on the application of industrial power, the procurement of traditional physical resources, and mass production operating in accordance with the law of increasing costs. That is, once all production factors (land, labor, capital) are at maximum output and efficiency, producing an extra unit will cost more than average. Vapor and steam engines, as well as fuel, comprised the core infrastructures. During this era, the richness of material civilization was amplified by increasing the productivity of the physical space—building factories and establishing industrial complexes. The relationships among manufacturers, distributors, and consumers; improved productivity; process efficiency; and attention to transaction costs were all critically important to the success of industrial societies.

In the digital era, people are focusing on the generation and trading of products and services via digitalized data, information, and knowledge. This era is based on an infrastructure comprising information and communication technologies. This new infrastructure is not just helping people do things better and faster than in previous eras, but it is enabling new ways of control, coordination, and collaboration on activities more readily, at lower costs, governed by the law of diminishing costs. That is, because of the properties of digital goods, the cost per unit of marginal or additional output incrementally decreases, whereas the amount of all other factors of production stays constant. As digital resources become accessible, processed, transferred, and stored regardless of location or time, borders and geographical distances are no longer as critical as they once were, and wholly new, invisible electronic spaces are now available.

Because the digital era began with the development of computers and communication technologies, we must appreciate that these technologies are also evolving. Indeed, the continuous

[1]The English-language Wikipedia includes the following description in its entry on technology: "Technology is the collection of techniques, methods or processes used in the production of goods or services or in the accomplishment of objectives, such as scientific investigation. Technology can be the knowledge of techniques, processes, etc, or it can be embedded in machines, computers, devices and factories, which can be operated by individuals without detailed knowledge of the workings of such things" (**http://en.wikipedia.org/wiki/Technology**).

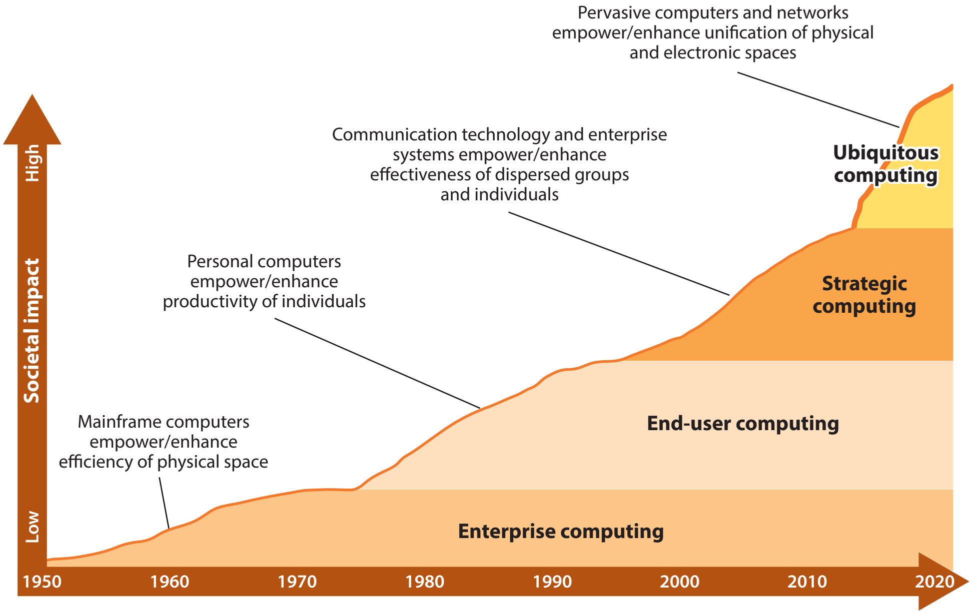

Figure 1

Stages of information and communication technology within the digital era.

advances of information and communication technology have enabled the scope of human activity to expand continuously in the electronic space and to create a variety of changes in the ways that economic activity is conducted. Hence, we now need to probe more deeply the four distinctive stages of information and communication technology within this era (Applegate et al. 2002, Cash et al. 1994, McKenney et al. 1995), as shown in **Figure 1**.

The first stage, enterprise computing, was based on mainframe computers. In this stage, the focus was on improving the efficiency of the physical world by analyzing its characteristics in the electronic space and then modifying the physical space. The administrative model followed was that of a regulated monopoly by centralizing all the computing resources within data-processing centers. Many users shared a single mainframe computer. It was infeasible at that time to supply expensive computing equipment to the multitude of potential users.

The second stage, end-user computing, was based on personal computers. The focus in this stage was on supporting productivity improvements of individuals, particularly business professionals. The administrative model followed was that of a free market enabled by each individual having her/his own personal computer/desktop computer. The notion of "one computer per person inside a company" became possible.

The third stage, strategic computing, was based on communication technology. The Internet became a global network of networks as heterogeneous computers and communication interfaces were connected with each other, thereby linking local area networks into a single, large communication network (Hauben & Hauben 1995). Companies combined the Internet and enterprise applications systems (such as enterprise resource planning, customer relationship management, supply chain management, material requirement planning, human resource management, and enterprise-form automation systems) to support business processes and interorganizational activities. The administrative mode adopted was a regulated free market structure like client-server architecture.

Today, information and communication technology is heading toward a new stage that is based on ubiquitous computing. The concept of ubiquitous computing refers to an environment in which computational technology permeates almost everything, thereby enabling people to access and control their environment at any time and from anywhere. During the beginning stages of the digital era, the dual nature of the environment was such that it did not unify the physical world and electronic space. This new stage, however, focuses on linking the physical world directly with the electronic space, thereby creating a ubiquitous space that allows a level of complexity, speed, and quality not possible before. The goal is to create an optimized space that links people, computers, networks, and objects, thereby overcoming the limitations of both the physical world and the electronic space. The administrative model is collaboration and entrepreneurship. Given that ubiquitous computing is paving the way for a new stage, we now expand on this stage and focus on understanding how it may disrupt the way work is done in organizations.

EFFECTS OF DISRUPTIVE TECHNOLOGY

Christensen (1997) coined the term disruptive technology. He separates new technology into two categories: sustaining and disruptive. Sustaining technology relies on incremental improvements to an already established technology. Disruptive technology lacks refinement, often has performance problems because it is new, appeals to a limited audience, and may not yet have a proven practical application. Although companies today have trouble capitalizing on the potential efficiencies, cost savings, and new opportunities created by ubiquitous computing, its various uses and its portfolio of underlying technologies are expanding. Thus, we analyze here its potential to disrupt the way work is done in organizations.

The term ubiquitous computing was coined by Mark Weiser of the Xerox Palo Alto Research Center in 1998 (see "In Memory of Dr. Mark Weiser" at **https://www.parc.com/services/focus-area/ubicomp/**). In Latin, ubiquitous means being everywhere. Ubiquitous computing incorporates concepts from the previous stages of information and communication technology development, so its basic elements are software, hardware, networks, and data. The ever-cheaper prices of computers, however, have resulted in the proliferation of computing devices such that now they are nearly everywhere. Here computing devices refer not only to the abundant supply of personal computers, but also to embedded (enabled by microminiaturization) and networked (empowered by increased speed and bandwidth of communication networks) devices. These include industrial sensors and processors, speech-recognition and eye-tracking devices, mobile devices, radio-frequency-identification and near-frequency-communication tags and labels, global positioning systems (GPS)–enabled devices, smart televisions, car navigation systems, drones, wearable sensors, robots, and 3D virtual reality, among others. Initially, the communication interfaces for these various pieces of computing equipment were inconvenient. Over time, however, the development of easy-to-use interfaces and their connection to communication networks have, in turn, brought about new ways of linking people, computers, and objects. This has created further opportunities to unify two separate spaces: (*a*) the physical space, which has always used information to try to make an inherently inefficient system more efficient, and (*b*) the electronic space, which has used information to overcome the limitations of the physical space.

The ubiquitous computing infrastructure is also allowing the collection of enormous amounts of structured and unstructured data—creating a need to use the adjective "big" to distinguish this new stage of information and communication technology development. As data have become increasingly digitized, everything from newspapers to music and movies can be produced and reproduced easier via digital technology and transmitted at a lower cost. Furthermore, ubiquitous computing is blurring the boundaries between industries, nations, companies, providers, partners, competitors, employees, freelancers, outsourcers, volunteers, and customers. Merging the physical and electronic spaces also has implications for privacy, security, and no less important, how companies are organized. New business models are sprouting up to change the way organizations create and capture value in important ways (e.g., Airbnb, Uber, Zipcar, MyTaxi, Car2go, Duolingo).

The widespread adoption of ubiquitous computing will take time, but the timeline is shrinking thanks to improvements in the underlying technologies mentioned above. No one can predict with certainty all of the ubiquitous-computing innovations that the coming years will bring, and realizing their full potential will not be easy. General predictions herald sizeable changes in knowledge acquisition, sharing and distribution, as well as massive ripple effects in the workplace (Andreessen 2011). We realize that computing in this stage does not manifest itself in a clear-cut form, but rather in a more nuanced manner. We provide here brief examples of some applications of ubiquitous computing to stimulate our understanding of how the advent of ubiquitous computing may disrupt work and work systems in organizations:

- As employees wear clothing and other wearables embedded with computer chips and sensors, they no longer need to carry a computer separately to meetings. They are armed with up-to-date information, their decisions are guided by analysis of the information provided by cloud computing, and they can resolve operational issues in creative ways that were not possible before.
- Computer networks allow employees to work from the office, their home, or anywhere. Employees are routinely collaborating with people they have never met, in places they have never visited, and staying connected with the office anywhere and anytime. This has enabled the emergence of ubiquitous working environments supporting different types of working styles and conditions.
- The same computer networks also allow for a variety of devices to be remotely controlled, as well as internal temperature, humidity, lighting, and even the opening and closing of windows.
- Computer programs, intelligent robots, and other devices are used to perform an increasing variety of tasks with a high level of technical skills, and with benefits that include lower costs, higher quality, improved safety, and environmental protection. People, however, participate in defining, creating, and maintaining these automated programs, machines, and other devices.
- Firms routinely capture publicly available information to monitor traffic conditions. They then use that information to find optimal delivery routes, to track vehicle locations, engine status, dangerous driving conditions, etc.
- Product, sales, and customer information can be monitored in real time, 24 hours a day, so that inventory can be supplemented in a timely manner to maintain freshness or to provide additional products and services.
- Employees can integrate their use of Facebook, Twitter, Google, and other social media into their daily routines, and companies can integrate social media into their intranets, so that they can share internal information and knowledge with employees, and even with suppliers and customers if desired.
- Through the use of smartphones, GPS, earphones, and microphones, employees can access online education and training materials anytime from their own companies, but also from universities in or outside their home countries.
- Attachable devices and microchips can be used to transmit information about wearers' levels of stress, physical disabilities, or injuries in real time to medical organizations, to facilitate preventive treatment as well as timely responses in emergency situations.

EFFECTS OF TECHNOLOGY ON JOBS

Ubiquitous computing, of course, is not the first technology to have effects on jobs. From steam engines to robotic welders and ATMs, technology has long displaced humans—often creating new and higher-skill jobs in its wake. The invention of the automobile threw blacksmiths out of work, but created far more jobs building and selling cars. Over the past 30 years the digital revolution has displaced many of the middle-skill jobs that underpinned twentieth-century middle-class life. The number of typists, travel agencies, bank tellers, and many production-line jobs has fallen dramatically, but there are ever more computer programmers and web designers. Displaced workers with obsolete skills are always hurt, but the total number of jobs has never declined over time (Aeppel 2015).

Paradoxically, although productivity—a crucial indicator of growth and wealth creation—is at record levels, and innovation has never been greater, over the past several decades, median wages have not risen (Galston 2014). This pattern is inconsistent with economic theory, which holds that when productivity increases, any automation that economizes on the use of labor will increase incomes. That will generate demand for new products and services, which, in turn, will create new jobs for displaced workers (*The Economist* 2014). One explanation for this inconsistency is that advances in information and communications technology are destroying more jobs in developed economies than the advances are creating. In short, technological progress is eliminating the need for many types of jobs, and leaving the typical worker worse off than before (Brynjolfsson & McAfee 2014, Rotman 2013).

Not everyone concurs with this conclusion, however (e.g., Jacoby 2015). Although labor economists generally agree that the digital revolution is creating a great divide between a skilled and wealthy few and the rest of society, hollowing out the middle class (Autor & Dorn 2013), it is not clear whether this can be attributed entirely to the effects of technology, and the data are, at best, far from conclusive. One reflection of this change is the simultaneous increase in both job openings and unemployment relative to the early 2000s (Elsby et al. 2010). This suggests that the types of skills now demanded by employers do not match those of the existing labor force (Katz 2010). Other plausible explanations, including events related to global trade and the financial crises of the early and late 2000s, could account for the relative slowness of job creation since the turn of the century. The problem is that it is difficult to separate the effects of technology from other macroeconomic effects (Rotman 2013).

The advent of machine learning, in which computers teach themselves tasks and rules by analyzing large sets of data (*The Economist* 2015a) will surely lead to large-scale worker dislocation as areas such as speech recognition, pattern recognition, and image classification eliminate wide swaths of white-collar workers (*The Economist* 2015b). We agree that many jobs currently performed by humans will be substantially taken over by robots or digital agents by 2025. Other jobs will disappear as a result of structural changes in the economy, such as the long-term drop in the demand for coal, as cleaner sources of energy become more popular.

Even if today's information and communication technologies are holding down employment, however, history suggests it is a temporary, although painful, shock. As workers adjust their skills and entrepreneurs create opportunities based on the new technologies, the number of jobs will rebound. At the same time, we believe that human ingenuity will create new jobs, industries, and ways to make a living, just as it has been doing since the Industrial Revolution (Mabry & Sharplin 1986, Smith & Anderson 2014; see also Bessen 2015 and Stiglitz & Greenwald 2014).

What about the demand for managers and executives? Unlike effective managers, machines have not yet learned to tolerate high levels of ambiguity or to inspire people at every level in organizations. Consider ambiguity. The bigger and broader the question to be addressed, the more likely it is that human synthesis will be central to problem solving because although machines can provide many pieces, they cannot assemble the big picture. This process of assembly entails discerning why a company is doing what it is doing, where it is trying to go, and how it is going to go about it. Success depends on the ability of executives to tolerate ambiguity, and to synthesize and integrate a variety of types and forms of information. The big picture represents the glue that holds a company together.

When it comes to engaging and inspiring people to move in the same direction, empathizing with customers, and developing talent, humans will continue to enjoy a strong comparative advantage over machines. As one observer noted, "I've still never seen a piece of technology that could negotiate effectively, or motivate and lead a team, or figure out what's going on in a rich social situation, or get people to move in the direction you want" (McAfee, quoted in Kirkland 2014). In short, no computer will ever manage by walking around, but inspirational leadership will always be in demand.

EFFECTS OF TECHNOLOGY ON HOW AND WHERE WE WORK

Technology can be used to enable or to oppress people at work (Coovert & Thompson 2014b). Indeed, the implementation of modern technology reflects both of these outcomes, as we shall see. Psychological research and theory can help inform solutions to this problem. At a conceptual level, self-determination theory (Deci & Ryan 2012, Ryan & Deci 2000) is a particularly useful guide. That theory holds that self-motivation and well-being will be enhanced when innate needs for autonomy, competence, and relatedness are satisfied, and diminished when these needs are thwarted. Autonomy is the need to control one's actions, to be a causal agent in one's life. Competence is the need to experience mastery and to affect one's outcomes and surroundings. Relatedness is the need to feel interpersonally connected with others (Greguras & Diefendorff 2009).

In practice, at least four considerations influence the adoption and implementation of workplace technologies (Coovert & Thompson 2014b). First, are they natural and easy to use? Usability concerns the interface between humans and technology (Hancock 2014), and it can be measured in terms of efficiency (time to complete a task), effectiveness (error rate), and user satisfaction (Gillan & Bias 2014). A second consideration is self-efficacy (Bandura 1997). People who feel competent to use, or to learn to use, new technology are likely to experience less anxiety when that new technology is introduced. A third consideration is economic. Does the new technology promise competitive advantage to an organization or to an individual in his or her personal life? If so, the organization or individual is more likely to implement it. Finally, it also is important to consider the role of social factors in the acceptance of technology. If friends, coworkers, or family members are using a particular technology, for example, a smartphone-payment system, peer pressure increases the likelihood of one's own adoption of it.

If technology is to enable people at work, it should foster self-motivation and well-being, key elements of self-determination theory; enhance productivity; and promote job satisfaction, organizational commitment, and citizenship behaviors among workers. Feelings of oppression occur when technology leads to a lack of autonomy, competence, and relatedness. In turn, these lead to stress, demotivation, and counterproductive work behaviors.

To illustrate how technology is changing the ways we work and live, consider just four examples: electronic monitoring systems, robots, teleconferencing, and wearable computing devices. Each of these technologies shares the expressed ubiquitous computing vision of interweaving technology into everyday life, making technology pervasive, and facilitating physical and virtual interactions. We analyze next how each of them can enable or oppress their users.

Electronic Monitoring Systems

Monitoring refers to systems, people, and processes used to collect, store, analyze, and report the actions or performance of individuals or groups on the job (Alge 2001, Ball 2010). Our focus here is on electronic monitoring and surveillance systems (Riedy & Wen 2010). Monitoring today may assume a variety of forms: telephone, video, Internet, and GPS. In the past, courts have generally sided with employers who have chosen to monitor their employees, arguing that because monitoring takes place during work using organizational assets (e.g., corporate computer networks, electronic mail), monitoring is acceptable (Kidwell & Sprague 2009).

Many organizations are equipping machinery, shipments, infrastructure, devices, and even employees with networked sensors and actuators that enable them to monitor their environment, report their status, receive instructions, and take actions based on the information they receive. This is what is meant by the expression "the Internet of Things." By monitoring these organizational resources in real time, companies can better control the flow of operations and avoid disruptions by taking immediate actions and engaging in preventive solutions when problems arise. Organizations are also developing policies about using blogs and social networks such as Facebook outside of work, and this can affect employees' perceptions of trust and loss of personal control (McNall & Stanton 2011). Although social media have fundamentally changed the ways people interact with information, it is important to note that the term social media does not refer to a specific technology, but rather to a family of technologies with a common set of ideals at the core of their design (Landers & Goldberg 2014). Such ideals include the following: Users should be able to generate their own content to share as they wish, information should be provided free and honestly, personal opinions from unbiased persons can be trusted, and the mob is wise. Obviously not all of these ideas are met in practice.

Monitoring per se is neither good nor bad; it depends on how it is implemented. Monitoring can certainly be beneficial, as self-initiated systems demonstrate. Systems that enable employees to track their activities at work have led to increases in productivity by helping people to understand better how they are allocating their time (Osman 2010). This understanding allows workers to reallocate their time, tasks, and activities to accomplish goals at work more effectively.

A comprehensive review of research in this area (Alge & Hansen 2014) concluded that attitudes in general, and attitudes toward monitoring in particular, will be more positive when organizations monitor their employees within supportive organizational cultures. Supportive cultures allow employee input on the monitoring system's design, and focus on groups of employees rather than singling out individuals, and on performance-relevant activities. Theoretical and empirical researchers have identified three additional features of monitoring systems that contribute to employee perceptions of fairness or invasiveness (Ambrose & Alder 2000; Kidwell & Bennett 1994a,b). These are consistency in how data are collected and used, freedom from bias (e.g., selective monitoring), and the accuracy of data collected. Conversely, when monitoring systems are perceived as invasive or unfair, organizations run the risk that employees may not comply with rules and procedures, slack off on the job, or engage in deviant behaviors (Alge et al. 2010, Zweig & Scott 2007).

One additional factor that can be associated with electronic monitoring systems is stress. When organizations impose control they reduce autonomy and increase perceived job demands—both factors that contribute to burnout (Maslach & Leiter 2008, Nixon & Spector 2014, Schaufeli et al. 2009). Evidence indicates that close supervision is associated with increased stress (Lu 2005). With electronic monitoring a supervisor or higher-level manager need not even be present to monitor. As a result the potentially unceasing, continuous capability to monitor creates an unrelenting type of control that employees often regard as particularly stressful. As a general conclusion, when electronic monitoring is seen as control-based rather than developmental, employees are likely to experience more negative outcomes (Castanheira & Chambel 2010).

Robots

Robots[2] have been on factory floors for decades. Years ago they were mostly big, expensive machines that had to be surrounded by cages to keep them from smashing into humans. Furthermore, they could perform only a single task (e.g., spot welding) over and over, albeit extremely fast and precisely. They were neither affordable nor practical for small businesses. Today, however, so-called collaborative machines are designed to work alongside people in close settings (Davenport & Kirby 2015). They cost as little as $20,000 and offer small businesses incentives to automate in order to increase overall productivity and to lower labor costs (Aeppel 2014). Furthermore, advances in artificial intelligence, combined with improved sensors, are making it possible for robots to make more complex judgments and to learn how to execute tasks on their own, enabling them to manage well in uncertain and fluid situations.

Not only are robots becoming embedded into organizational social systems, they are becoming social actors in those systems. As noted by Coovert & Thompson (2014b), consider the terms coworker and teammate. Historically, they implied other humans, but this may no longer be the case as cobots (coworker robots) enter the workplace as team members. As robots evolve, they are likely to become more adaptable to the work environment, with multimodal interfaces enabling them to communicate more efficiently and effectively with human teammates, receiving as well as transmitting information (Redden et al. 2014).

A key challenge to human factors specialists is to design human-robot control interfaces that are simple and easy to use, yet robust, because the connections that allow remote robots to take action without a human operator could be subject to hacking. As Redden et al. (2014) have noted in their comprehensive review of human factors and ergonomic issues associated with the design and implementation of robots in workplaces, social acceptance is critical. If robots are truly to become team members, humans must accept them, communicate effectively with them, develop shared mental models with them, and perhaps most importantly, trust them. As robots perform more and more autonomous tasks, in theory an operator's workload should decrease, freeing him or her to perform other tasks. However, the allocation of functions between humans and robots is an area that needs considerable research attention because automation has been shown to create its own set of problems. These include decreased situation awareness; distrust of automation; misuse, abuse, and disuse; complacency; decrements in vigilance; and negative effects on other facets of human performance (Redden et al. 2014). Research and theory in areas such as work analysis, teams, selection, training, motivation, and performance management can aid the successful design and integration of robots into work teams and organizations (Coovert & Thompson 2014b, Miles & Hollenbeck 2014).

There is an additional concern that managers must deal with, namely, that workers will view robots as competitors for jobs and will fight their installation. For workers who remain, robots can certainly augment their capabilities, but the fear of job loss is real. Four people comprise the entire staff of Fanuc Corporation's 86,000-ft^2 factory in Oshino, Japan, where industrial robots are made. In another Fanuc factory, robots can assemble an industrial motor in just 40 s (Pfanner 2015).

[2]The Oxford Dictionary offers the following definition of a robot: "A machine capable of carrying out a complex series of actions automatically, especially one programmable by a computer" (**http://www.oxforddictionaries.com/us/definition/american_english/robot**).

Robots threaten the jobs of white-collar workers as well. As an example, consider that robots now perform work in corporate finance departments that used to require whole teams of people, as software automates many corporate bookkeeping and accounting tasks. Between 2004 and 2015, the median number of full-time employees in the finance departments of big companies declined 40%, from 119 to approximately 71 people for every $1 billion of revenue. Jobs most in jeopardy include accounts-payable clerks, inventory-control analysts, and accounts-receivable clerks, who send invoices to customers, track payments, and forecast customer default rates (Monga 2015).

Not all robots or robot makers will displace humans. For example, the Kiva robot, owned by Amazon, is designed to scurry across large warehouses, fetching racks of ordered goods and delivering the products to humans who package the orders. A warehouse equipped with Kiva robots can handle up to four times as many orders as a similar unautomated warehouse, where workers might spend as much as 70% of their time walking about to retrieve goods. Most of Kiva's customers are e-commerce retailers, some of which are growing so rapidly that they cannot hire people fast enough. By making distribution operations cheaper and more efficient, the robotic technology has helped many of these retailers survive and even expand. Advances such as these illustrate that although some aspects of work can be automated, humans still excel at certain tasks, such as packaging various items together. Kiva's robots are cleverly designed and built to work with people, taking over tasks that humans do not want to do or are not very good at. Although they can enhance the productivity of these workers, clerical and some professional jobs could be more vulnerable, as the marriage of artificial intelligence and big data gives machines more human-like abilities to reason and to solve many new types of problems (Rotman 2013).

Teleconferencing

Teleconferencing is an interactive group communication (three or more people in two or more locations) through an electronic medium (Rogan & Simmons 1984). The concept was first introduced in the 1960s with American Telephone and Telegraph's Picturephone. There are at least five types of teleconferencing: audio, audiographic, video, web, and business television. Virtual teams, where members are not physically colocated, represent just one type of extended work arrangement where teleconferencing has facilitated the unification of the physical and electronic spaces. Perhaps the biggest advantage of virtual teams is that by crossing geographical, cultural, organizational, and time boundaries, organizations can leverage a larger pool of intellectual resources and diverse talent to solve problems (Potosky & Lomax 2014). Virtual teams represent just one type of work arrangement where technology has facilitated the seamless movement of work in dimensions of time and space. Today, most large organizations and many smaller ones use them (Farr et al. 2014).

There are many types of teams that could be classified as virtual teams, however (Martins et al. 2004). Although virtual teams have altered the way that many people work, and they have facilitated global talent management, they also present numerous knotty management problems (Cascio & Shurygailo 2003, Golden & Veiga 2008). Such problems include, for example, how to structure a virtual team (domestic or global), how to create trust and motivation among team members who are not physically colocated, how to deal with introverts on a team, how to structure meetings and other virtual interactions, how to provide feedback, and how to deal with team members who do not all speak a common language (Cascio 2011).

As Miles & Hollenbeck (2014) note, adding a requirement that all team members adapt to the technology involved imposes a learning and socialization task that is separate from any team tasks that might be required. This generally requires additional organizational support, particularly in the areas of motivation and psychological safety (Gibson & Gibbs 2006). In addition, and perhaps most fundamentally, teleconferencing has often resulted in five types of communication problems (Driskell et al. 2003). Specifically, team members tend not to communicate local context to others, fail to distribute the same information to all team members, have difficulty understanding and communicating the relative importance of information, access information at different speeds, and have difficulty interpreting the meaning of silence. A different study confirmed these findings, which resulted in virtual teams having higher levels of confusion and lower levels of satisfaction than their face-to-face counterparts, as well as less accuracy recording their decisions (Thompson & Coovert 2003).

The end result of these communication problems is a reduction in mutual knowledge among team members. A further issue in virtual teams is a lack of social and status cues. These have both positive and negative effects when it comes to team effectiveness (Miles & Hollenbeck 2014). Miles & Hollenbeck (2014) found that these three differences—technical adaptation, lack of mutual knowledge, and reduction in social- or status-cue information—characterize virtual versus face-to-face teams. Moreover, they found that five dimensional scales, each expressed with continuous variables, are sufficient to describe all teams, face-to-face or virtual. These are skill differentiation, authority differentiation, temporal stability, interaction frequency, and interaction quality. The Team Descriptive Index (Lee et al. 2015) includes the first three of these dimensions. The use of such scales now makes it possible to examine more precisely how virtual teams differ from face-to-face teams, to compare virtual teams with different teleconferencing technologies and different team profiles to one another in a meaningful fashion, and to discern their effects on team effectiveness or team performance.

Wearable Computing Devices

Wearable computing devices, also known as wearables, is the term that refers to electronic technologies or computers that are incorporated into items of clothing and accessories that can comfortably be worn on the body (Tehrani & Michael 2014). Wearables can be networked or might store data that can be transferred later to other devices. In many cases, the technology need not be activated; it simply functions as part of the item. Wearables can gather data—from the body of the wearer or from the environment—or provide information, or both (Educase 2013). They generally comprise three broad categories (Wooldridge 2015). The first is quantified self products that allow people to measure activities that they engage in, such as physical activity and sleep (think Fitbit and Jawbone). The second category is enhancement technologies. Google Glass is one example, but prosthetic devices and exoskeletons are others. They allow elderly people or those with handicaps to overcome their disabilities. The third category is virtual reality devices, including headsets and telepresence systems. Architects who use them will be able to slip on headsets to see what their designs will look like in practice. Telepresence systems enable executives to get the feeling of "being there"—attending meetings without the need to travel. These devices are now possible thanks to four developments: improvements in computing power, the increasing speed of broadband access, the spread of sensors, and cloud computing (Wooldridge 2015). As just one example of how the nature of work is changing, consider smart vending machines. Sensors embedded in the machines, combined with broadband access and cloud computing, allow employees to monitor them remotely for items out of stock, temperature changes, or thievery (Shoot 2014). Although the promise of wearable computing devices is obvious, there are also downsides. The first is distraction, as people are half present and half absent, constantly checking their smartphones as they walk along or stand in line. How often? They check them an average of 150 times a day (Meeker 2013). Obviously this can wreak havoc on work/life integration, as there is no boundary by time or geography on when or where people work (Vanderkam 2015). The second downside is that digital devices make human interaction more difficult as the devices compete constantly for people's attention.

Despite the downsides, there are many emerging uses of wearable technology beyond consumers. It is becoming popular in industries as varied as construction, building maintenance, medicine, manufacturing, energy, and oilfield services. As just one example, consider how a company in the field of building maintenance is using wearables to preserve and transmit institutional memory. Workers nearing retirement are not always suited to climb to significant heights, where mechanical equipment is often stored. They leave that task to younger workers, who wear special safety glasses equipped with a camera, microphone, speaker, detachable flash drive, and wireless antenna. Through Bluetooth connections to their phones, the younger workers transmit live video feeds of their actions back to a ground-based command center, staffed by veteran older workers who monitor the videos and offer further instructions (Griffith 2014). There is almost no research on the behavioral effects or impact of wearable computing devices. However, opportunities abound to conduct research on wearers' attitudes and their use of this technology, as well as its impact on organizational outcomes such as acceptability, productivity, safety, and potential cost savings.

TECHNOLOGY AND THE CHANGING ROLE OF MANAGEMENT

In the previous stages of information and communication technology development, hoarding information was a source of power, and information moved in one direction only—up the corporate hierarchy. In today's ubiquitous-computing stage, the contrast could not be starker. The implications of these technological developments in changing the nature of competition, work, and employment are profound and cannot be ignored.

Although the changes made possible by today's technology may be impressive, and digital innovations will continue for the foreseeable future, technology by itself is not enough. Fulfilling its potential will require leaders to recreate the way their organizations operate in a world of digital ubiquity. This includes framing right questions, responding to exceptional circumstances highlighted by intelligent algorithms, and doing things that machines cannot (Dewhurst & Willmott 2014).

A comprehensive review of research at the junction of leadership and technology concluded that researchers have tended to treat technology either as a contextual aspect relevant to the leadership process, or as a set of tools that leaders and followers can use to communicate with each other (Potosky & Lomax 2014). Similarly, an earlier review expressed disappointment over the extent to which leadership researchers have incorporated technology into the study of leadership (Gardner et al. 2010). At a broader level, we now consider some lessons from the management literature on technology and organizations.

Orlikowski and Scott's (Orlikowski 2009, Orlikowski & Scott 2008) 50-year review of the ways that the management literature has addressed and accounted for technology in organizations identified four distinctive conceptual positions: (*a*) absent presence, (*b*) exogenous force, (*c*) emergent force, and (*d*) entanglement in practice. In the first perspective, absent presence, technology is unacknowledged by researchers; that is, it is unaccounted for in their studies.[3] Thus, Zammuto et al. (2007, p. 750) found that only 2.8% of the research articles published in the *Academy of Management Journal*, *Academy of Management Review*, *Administrative Science Quarterly*, and *Organization Science* focused on technology and organizations. Researchers who adopt this perspective

[3]Orlikowski (2009) draws on Gergen's (2002) idea of absent presence introduced by describing a group of people sitting in a room together, absorbed in their own thoughts and activities, and not acknowledging each other's presence.

Table 1 Examples of research topics and authors who have adopted the exogenous-force perspective in studying technology in organizations

Research topic	Author(s)
Examination of the meanings or attitudes toward computing at the individual level	Davis 1989, Griffith 1999, Rafaeli 1986, Rice & Aydin 1991
Research into changes in communication and decision making related to technology use at individual and group levels	Daft & Lengel 1986, Hinds & Kiesler 1995, Huber 1990, Treviño et al. 2000
Studies of shifts in firm structure associated with technology	Blau et al. 1976, Burkhardt & Brass 1990, Fry 1982, Pfeffer & Leblebici 1977
Examinations of transformations in market or industry conditions attributed to the diffusion of new technological capabilities	Malone et al. 1987, Tushman & Anderson 1986
Productivity improvements at both individual and enterprise levels linked to the adoption of or investment in new technologies	Aral & Weill 2007, Brynjolfsson & Hitt 1996, Kraut et al. 1989
Examination of various supply chain partnership configurations that exist based on differences in capabilities of information technology infrastructures	Malhotra et al. 2005

give priority to human actors and social structures, and as a result, technology tends to disappear into the background or is taken for granted. They do not work on questions about technology, and their research underestimates the role and significance of technological artifacts.

In the second perspective, exogenous force, technology is posited to be a powerful and relatively autonomous driver of organizational change. Thus, it has significant and predictable impacts on various human and organizational outcomes, such as governance structures, work routines, information flow, decision making, individual productivity, and firm performance (e.g., Blau et al. 1976, Brynjolfsson & Hitt 1996, Carter 1984, Huber 1990, Pfeffer & Leblebici 1977). Researchers in this tradition tend toward a positivistic research approach; they are interested in deriving generalizable laws from statistical, empirical studies. Second, they explore the relationship between general aspects of technology and organizations, so that they can make predictions across types of organizations and technologies. Third, they tend to draw from contingency theory, conducting empirical research that includes variables believed to influence technology's impact on organizations. Research in this perspective has been criticized for ignoring or downplaying the role of history, social context, and human agency in shaping technology, production, use, and change (Orlikowski 2009). **Table 1** presents examples of research studies that have adopted this perspective.

In the third perspective, emergent force, technology is viewed as fundamentally social, grounded in specific historical and cultural contexts, and dependent on specific meanings and contingent processes. The focus is on the dynamic interactions between people (or organizations) and technology over time. Research that adopts this perspective has been criticized for minimizing the role of technology, in particular, the physical characteristics and capabilities entailed in particular technological objects (Faulkner & Runde 2009). It has tended to downplay specific technological properties, focusing primarily on human interpretations and social actions. More generally, by focusing on the specifics of situated microinteractions, it is unable to offer widely applicable insights into the ways in which technologies broadly shape organizations and societies. **Table 2** presents examples of research studies that have adopted this perspective.

The fourth perspective, entanglement in practice, focuses on how technology is intrinsic to everyday activities and social relations. From this view, people and technology only exist in relation to each other, and, as Slife (2005, p. 159) explains, "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. Scholars in this

Table 2 Examples of research topics and authors who have adopted the emergent-force perspective in studying technology in organizations

Research topic	Author(s)
What meanings emerge to make sense of a new information system	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?	Markus 1994, Yates et al. 1999
How does the design and use of technology shift the nature of work?	Zuboff 1988
How does electronic surveillance affect team dynamics?	Sewell 1998
How do lead users shape the nature of capabilities of new technologies?	von Hippel 1994
How does the use of technology restructure organizational relations?	Barley 1986, 1990; DeSanctis & Poole 1994; Walsham 1993
How do computer technologies shape, and how are they shaped by, technologies-in-practice?	Orlikowski 2000
When and how do the design, implementation, and adoption of a new industry-wide information system shift relations among stakeholders?	Barrett & Walsham 1999
How does technology come to be institutionalized (or not), rendering new rules and meanings during systems design with those already existing in the organization?	Silva & Blackhouse 1997
How do particular interests and actions by various social groups shape the designs, meanings, and uses of new technologies over time?	Ciborra & Lanzara 1994, Fulk 1993, Heath & Luff 2000
How does technology serve to enable knowledge sharing across disparate communities?	Bechky 2003, Carlile 2002
How do firms develop, manage, and deploy capabilities to influence strategy formation and implementation?	Montealegre 2002
How do computer technologies shape, and how are they shaped by, improvised learning?	Boudreau & Robey 2005
How do workers use and interpret a personal digital assistant as a resource for boundary management?	Golden & Geisler 2007
How do consumers' information needs and online information retrieval influence their shopping process?	Kuruzovich et al. 2008
How do email and other communication technologies contribute to the stress that people experience?	Barley et al. 2011
Which mechanisms contingently lead to the evolution of digital infrastructure?	Henfridsson & Bygstad 2013

tradition posit that any distinction of humans and technologies is analytical only, and done with the recognition that these entities necessarily involve each other in practice. Although this stream of research is relatively new, **Table 3** presents examples of research studies that have adopted this perspective, showing the breath and fluidity of its intellectual ideas and substantive themes.

In sum, the alternative perspectives adopted in management research on technology and organizations provide valuable insights regarding what we know about the effects of technology for OP/OB scholars that they might usefully draw upon to enhance our understanding of specific aspects of the relationship between technology and organizations.

Whether emphasizing individual, stable entities or ongoing, interactive processes, existing perspectives in the management research literature each generate distinctive blind spots in dealing with technology in organizational life. We hope that future research will help to illuminate some

Table 3 Examples of research topics and authors who have adopted the entanglement-in-practice perspective in studying technology in organizations

Research topic	Author(s)
How does the production and use of information technology within organizations entail an ongoing "double mangling" of human and technological agencies?	Jones 1998
What is the flow of situated action as expressed through organizational routines, global product development, strategizing, and communities of practice?	Feldman & Pentland 2003, Jarzabkowski 2005, Orlikowski 2002
How are the social-life spheres of university rankings, claims regarding accounting knowledge, government regulations, and the practices of credit ratings agencies entangled with the implementation of an enterprise resource planning package?	Scott & Wagner 2003
What have been the effects of the emergence of new sociotechnical relations and domains—digital formations—that exhibit dynamics of their own, derived from technological capacities that enable specific patterns of interaction?	Latham & Sassen 2005
How did the Black-Scholes pricing formula—the first to describe option pricing—come to enact, over time, the world through its inscriptions in computer algorithms, professional skills, and financial institutions?	MacKenzie 2006
Will an exploration of information growth challenge the assumption that there is a straightforward connection between an objectified domain of technology and a normative world of institutions?	Kallinikos 2006
What are the sociotechnical dynamics of everyday practices, drawing on such cases as photocopiers, robots, and cyborg information systems?	Suchman 2007
How does the process of delegation in the distribution of work between social and technical elements over time reconfigure the organization of work and transform the way outcomes are accomplished?	Ribes et al. 2013
What are the dynamics of mutual constituency of social and material arrangements as they play out in the practice of NASA scientists?	Mazmanian et al. 2014
How have meaning and materiality been entangled in the practices of evaluation and ranking in the hospital industry through the use of social media?	Scott & Orlikowski 2014
How do key sociomaterial themes (materiality, inseparability, relationality, performativity, and practices) apply in the implementation and use of a new clinical information system in a critical care unit of a hospital?	Jones 2014
How did corporate directives and structure, business activities, and technology in the development of information services coevolve?	Montealegre et al. 2014
What were the key tensions related to digital coordination in the use and development of a computing grid infrastructure at CERN (The European Organization for Nuclear Research)?	Venters et al. 2014
How and why has the Internet transformed the work systems in which cars are sold?	Barley 2015

of these blind spots more clearly, and to provide a deeper understanding of the role of management and how it is changing in the emerging world of technology. The next section addresses this issue in more detail.

TOWARD THE FUTURE: RESEARCH NEEDS ON THE EFFECTS OF TECHNOLOGY ON WORK AND ORGANIZATIONS

It has been more than 25 years since Zuboff (1988) published her seminal book, *In the Age of the Smart Machine: The Future of Work and Power*, an insightful study of the work implications associated with the adoption of information technology in organizations. She was among the first scholars to weave together the technological, sociological, and psychological processes that converged to shape the modern workplace. The book is based on empirical relationships explored through in-depth ethnographic involvement in eight different organizational contexts in which comprehensive computerization of work processes had been undertaken. Zuboff's key insights are about the nature of information and its significance in restructuring and redefining the patterns and meanings of work—even though at the time she conducted her study the diffusion of the Internet had not yet occurred.

More recently, Barley (2015) observed that a complex, pliable, changing, and ever-expanding portfolio of Internet tools, information, and media is altering how we act in situations where we previously would have acted differently. Before the Internet, for example, it was impossible to communicate instantaneously as well as asynchronously across time and space, or to access vast bodies of information without visiting a library or other repository. With the Internet, people have easy access to information that previously they could not have found. Barley's (2015) study drew on ethnographic data collected over a two-year period in two car dealerships, and used role theory and dramaturgical analysis of sales encounters to show how the Internet has changed the relationship between car salespeople and their customers. This study revealed how and why the Internet transformed the work system in which cars are sold. It changed the "rules of engagement" in which salespeople and customers met to sell and buy vehicles. It eliminated the need for initial face-to-face interactions, thereby changing scripted interactions during sales encounters. Those changes altered the definition of the situation in ways that required salespeople and allowed customers to play their roles differently.

In many ways research at the intersection of technology, work, and organizations is still in its infancy. However, the manner in which technology is altering work settings and the work that people do, particularly in this new stage of ubiquitous computing, raises compelling questions as well as a need to revisit prior research in this area in the face of the emerging digital ubiquity. What existing perspectives might they draw on to address these questions? What new or alternative perspectives might be more relevant? To be sure, there is great potential for OP/OB researchers to deepen our understanding and prediction of behavior in this domain, while also generating important implications for practice. Drawing on conventional OP/OB research domains identified by Cascio & Aguinis (2008a), we end our review with a discussion of approaches to these domains that are supported by traditional and ubiquitous computing technologies and that identify related research questions (see **Table 4**)

SOME GUIDANCE FOR RESEARCHERS

As researchers continue to study the effects of technology on individuals, work, and organizations, we offer some important guidance. First, select your philosophical stance. Is the purpose of the research to study the dynamic interactions between people (or organizations) and technology over time? This is Orlikowski's (2009) emergent-force perspective. Or is the purpose to focus on how technology is intrinsic to everyday activities and relations (Orlikowski's entanglement-in-practice perspective)?

In either case, it is helpful to study in situ performance. Cascio & Aguinis (2008b) defined this construct as the specification of the broad range of effects—situational, contextual, strategic, and environmental—that may affect individual, team, or organizational performance. To appreciate such effects, consider pre-employment testing. Traditionally candidates took tests at the employer's site, in a quiet, distraction-free, and comfortable place, where employers could prevent breaches of security by checking candidate identification, eliminating opportunities for collusion, and controlling test materials at all times (Tippins 2015).

Now consider unproctored, Internet testing, where the candidate, not the employer, decides which conditions work best for him or her. Technology can deliver simulations or pre-employment

Table 4 Approaches to six HR areas supported by traditional and ubiquitous computing technologies and some related research questions

HR area	Supported by traditional technology[a]	Supported by ubiquitous computing[b]	Research questions (in moving from traditional to ubiquitous computing technologies)
Job analysis and design	Technology is part of the "how," a feature of the context in which work is performed. Employees often pool resources to accomplish tasks.	Based on context-aware technology that delivers the right information to the right person at the right place and time. Technology is an integral component and fundamental feature of jobs.	How does the unlimited access to computing, data, automation, and communication networks change the processes and dynamics of the work activities of communication, document sharing, knowledge exchange, and collaboration? How do these changes affect the nature of the work? How can technology enable job designs that advance, rather than threaten, innovation, fulfilling work, and value creation? How might the design of jobs balance advances in technology to preserve employee attention and to avoid information saturation? How might the design of work reduce the stress associated with constant connectivity?
Workforce planning	Traditional technology is based on descriptions of work supported by documents, charts, and schematics used by supervisors relying on past patterns and expected changes in the business.	Ubiquitous computing is based on digitized inventories of talent. Teams of people that might be geographically distributed pool their knowledge to solve immediate problems. As information can change instantly, supply and demand forecasts rely on multiple variables, allowing what-if scenario planning.	What are the desired and undesired effects on workforce planning of the removal of time and space constraints in doing work, improved access to decision makers, and increased ability to receive and process rich streams of data about the organization and its environment? Under what circumstances do ubiquitous computing-related technologies affect workforce collaboration, cohesion, and performance? How can organizations leverage technology to enhance company, team, and individual performance?
Recruitment and staffing	Traditional technology is based on locating, attracting, selecting, and retaining capable employees through media advertising, broadcast postings, yield pyramids, staffing graphs, onsite testing, face-to-face interviewing, on-boarding, and historical background checks that rely on individuals' past performance and expected business needs.	Ubiquitous computing is based on individuals and companies exchanging continuous data through social media, mobile devices, electronic boards, and other means that create mutual awareness to transmit the right message to the right person at the right time.	What are the legal, ethical, privacy, and fairness issues associated with filtering and tracking individuals inside and outside an organization, via the volume of digitalized data that might be available? How do applicant reactions and evaluations of procedural justice change in response to ubiquitous computing technology? How is the role of the recruiter changing in a world of constant connectivity? What are the effects of technology-based staffing on productivity at both individual and enterprise levels?

(*Continued*)

Table 4 ***(Continued)***

HR area	Supported by traditional technology[a]	Supported by ubiquitous computing[b]	Research questions (in moving from traditional to ubiquitous computing technologies)
Training and development	New employees learn from experienced ones through in-house, face-to-face instruction, lectures, simulations, or programmed instruction, and also through apprenticeship programs whose focus is on-the-job training.	Ubiquitous computing is based on access to instantly available knowledge, on-demand development of skills and intellectual abilities through boundaryless delivery of instruction materials, virtual reality simulations, asynchronous training, educational games, chat rooms, and knowledge-management systems.	What are effective and efficient ways of enabling and supporting employee-centric training and development? Just as there are smart cars and smart buildings, how can organizations enable and support smart workers? How can OP/OB researchers build on their knowledge of effective training and transfer of learning to the job (Blume et al. 2010) to enhance the impact of new training technologies (e.g., virtual reality, e-learning, games)?
Performance management and compensation management	Periodic performance appraisals are based on historical tracking, behavioral checklists, graphic rating scales, and behaviorally anchored rating scales; pay systems are based on manual job evaluation, pay-survey analyses, spreadsheets to analyze bonus and commission structures.	Ubiquitous computing is based on instant and on-demand appraisal, guidance, support and alerts enabled by digital traces of embedded and context-aware technologies tracking work and movements of goods as well as of roaming employees. Software manages job evaluation, pay-survey analyses, complex bonus and commission structures, reports, and analytics. Pay is based on specific work output.	What strategies promote workable, sensible performance management and fair compensation in digital, ubiquitous working environments? How do factors such as employee tenure, social ties, and nonwork-related communication affect organization and employee performance in a world of unlimited connectivity? What are ways of enhancing employee retention in an environment in which barriers to interruption are reduced and expectations of availability are increased? What are effective and efficient ways to supervise employees in ubiquitous technology work environments?
Career management	Traditional technology is based on a joint effort of employee and company in matching career goals through career-path planning, in-house library, intranets for career self-service, and online self-assessments.	Ubiquitous computing is based on employee-centric career arrangements in recognition that wants and needs vary over the span of an individual's career. Untethered workers are able to perform tasks anywhere at any time.	What are effective and ineffective ways of coaching employees to self-manage their careers? What kinds of technology might enhance this process? What strategies might improve work/life integration? What is the role of personal control, collaboration, and coordination of career management in a world of digital ubiquity? What does HR leadership mean in this new digital era?

[a]Traditional technology is characterized by interactions based on keyboards, computer mice, joysticks, monitors, and devices that assume a fixed physical relationship between the employee and her/his work environment. Even mobile devices are not context aware—thus creating distraction problems given that the employee is often preoccupied with walking, driving, or other essential interactions with the real world.
[b]Ubiquitous computing technology is characterized by interactions based on sensors and devices embedded in products, processes, individuals, and buildings, and the unlimited access to computing, data, and communication networks from any location at any time. Context-aware technology is alert to an employee's physical surroundings as well as his/her cognitive and social states, and makes decisions in a proactive fashion, anticipating the employee's needs.

assessments to any location at any time, and this raises numerous other issues that might affect outcomes of interest (e.g., reliability and validity of the measures, adverse impact, size of the applicant pool, differences in means and standard deviations, applicant reactions, perceptions of procedural justice).

A researcher who wishes to study the effects of technology on test performance must consider not only differences in the mode of administration (e.g., paper-and-pencil versus computer), but also the mode of test delivery (e.g., face-to-face interviews versus remote, videoconference interviews). Either of these might affect the construct(s) being measured as well as assessment outcomes; other contextual, strategic, or environmental effects may, as well. Potosky (2008) proposed four such attributes. These are transparency (the extent to which the medium facilitates the communication exchange), social bandwidth (the capacity for data transfer), interactivity (the pace of mutual or reciprocal exchange between communicating parties), and surveillance (the extent to which an outside party can monitor messages carried by the medium for test administration). Such specification of the broad range of effects that might affect performance—that is, in situ performance—provides a richer, fuller, context-embedded description of the outcomes that researchers wish to predict.

Another consideration is research methodologies. For those interested in studying the effects of technology on work systems and organizational structures, role theory may be especially useful. Barley (1990, 2015) argued that technologies trigger change by altering workers' nonrelational roles, that is, the tasks they perform and how they perform them. Such changes may then lead to changes in the nature of interactions workers have with members of their role set (those with whom they interact while doing their work) and who comprises their role set (e.g., robots as coworkers, or cobots). If role relations change in either way, then the social network may change. If it does, one can say that technology has altered the work system. Changes in role relations are therefore key to changes in work systems.

Role-based studies of how technologies alter work systems usually involve ethnography. Ethnography provides insights about who interacts with whom, and potentially about what, but not how they enact their relationships (Barley 2015). To study how people play their roles, researchers need to document repetitive patterns of typical encounters. A method that facilitates this is dramaturgical analysis (Goffman 1959, 1983). Relying on observations rather than interviews, dramaturgy highlights roles, scripts, interactions, and role relations, including those with whom users interact regardless of whether they also use the technology. Dramaturgy asks a simple question, namely, has the technology shaped role relations within the work system in which it resides? The combination of role theory and dramaturgical analysis allows researchers to address holistically yet systematically both social and material features of technology-based changes in work systems.

An additional methodological alternative for studying how technologies alter work systems is experience sampling (Beal 2015). Experience sampling methods (ESM), a family of approaches, attempt to capture a wide range of each individual's experiences as they occur in daily life, as close to the moment that they occur as possible. Typically, ESM designs involve intensive, repeated assessments with brief intervals (e.g., several hours to a day, or even 1–2 weeks). Because ESM attempts to capture fluctuations in one's daily experiences, it is clearly a within-person process, but Beal (2015) has shown that ESM can also link to higher levels of analysis that are aggregated versions of individual-level variables, such as customer service or store sales per work hour.

ESM clearly offers several advantages in the form of reductions in memory and method biases, as well as ease of study implementation and data collection. For example, the use of participants' own smartphones facilitates signaling, survey administration, and the collection of responses. At the same time, however, the use of ESM may create problems that do not ordinarily exist in more traditional research designs (Beal 2015). For example, high-intensity, repeated assessments can lead to participant fatigue, reduced or careless responding, or within-subject manipulation of affect. Measurement equivalence is another concern, that is, whether the same construct is being assessed at each measurement occasion in the same manner. However, to allay concerns about internal validity, the certainty with which inferences are made for observed effects, researchers might usefully incorporate elements of experimental or quasi-experimental designs (Shadish et al. 2002).

ESM data, which capture individual experiences, for example, as new technology is introduced into a work setting, might usefully be combined with naturalistic observations of conversations in the form of audio clips. There are many other potential uses of ESM data to paint an extremely comprehensive, dynamic assessment of an individual's or work group's daily life, either from the perspective of technology as an emergent force or as entanglement in practice. The possibilities are limited only by the imagination and ingenuity of researchers.

SUMMARY AND CONCLUSIONS

This review offers three main contributions. First, it presents an up-to-date treatment of the role that technology, particularly information and communication technology, is playing in changing work and organizations. Second, it summarizes and interprets the progress, direction, and purpose of the current research related to technology and work in organizations. Third, it illustrates the implications for future research and for the OP/OB discipline as a whole that go far beyond the fundamental effort to align technology and the work done in organizations.

Ultimately, as noted by Coovert & Thompson (2014b), the critical issue to consider is not technology in and of itself; rather, it is how to create and use psychological theory and research to deepen our understanding about how to manage the impact and implementation of emerging developments. The objective is clear: Maximize the positive consequences for individuals and organizations and minimize the negative effects. This will be a stimulating and ongoing challenge for the field of OP/OB.

DISCLOSURE STATEMENT

The authors are not aware of any affiliations, memberships, funding, or financial holdings that might be perceived as affecting the objectivity of this review.

LITERATURE CITED

Aeppel T. 2014. Robots work their way into small factories. *The Wall Street Journal*, Sept. 18. pp. B1–2

Aeppel T. 2015. What clever robots mean for jobs: Experts rethink belief that tech always lifts employment as machines take on skills once thought uniquely human. *The Wall Street Journal*, Feb. 24. **http://www.wsj.com/articles/what-clever-robots-mean-for-jobs-1424835002**

Alge BJ. 2001. Effects of computer surveillance on perceptions of privacy and procedural justice. *J. Appl. Psychol.* 86:797–804

Alge BJ, Anthony EA, Rees J, Kannan K. 2010. Controlling A while hoping for B: deviance deterrence and public versus private deviance. In *The Dark Side of Management*, ed. L Neider, C Schriesheim, pp. 115–41. Charlotte, NC: Inf. Age Publ.

Alge BJ, Hansen SD. 2014. Workplace monitoring and surveillance research since "1984": a review and agenda. See Coovert & Thompson 2014a, pp. 209–37

Alter S. 2013. Work system theory: overview of core concepts, extensions, and challenges for the future. *J. Assoc. Inf. Syst.* 14(12):72–121

Ambrose ML, Alder GS. 2000. Designing, implementing, and utilizing computerized performance monitoring: enhancing organizational justice. *Res. Personnel Human Resources Manag.*18:187–219

Andreessen M. 2011. Why software is eating the world. *The Wall Street Journal*, Aug. 20. **http://www.wsj.com/articles/SB10001424053111903480904576512250915629460**

Applegate LM, Austin RD, McFarlan FW. 2002. *Creating Business Advantage in the Information Age*. Boston: McGraw-Hill

Aral S, Weill P. 2007. IT assets, organizational capabilities and firm performance. *Organ. Sci.* 18(5):763–80

Autor DH, Dorn D. 2013. The growth of low-skill service jobs and the polarization of the U.S. labor market. *Am. Econ. Rev.* 103(5):1533–97

Ball K. 2010. Workplace surveillance: an overview. *Labor Hist.* 51:87–106

Bandura A. 1997. *Self-Efficacy: The Exercise of Control*. New York: Freeman

Barley SR. 1986. Technology as an occasion for structuring: evidence from observation of CT scanners and the social order of radiology departments. *Adm. Sci. Q.* 31:78–108

Barley SR. 1990. The alignment of technology and structure through roles and networks. *Adm. Sci. Q.* 35:61–103

Barley SR. 2015. Why the Internet makes buying a car less loathsome: how technologies change role relations. *Acad. Manag. Discov.* 1:31–60

Barley SR, Meyerson DE, Grodal S. 2011. E-mail as a source and symbol of stress. *Organ. Sci.* 22(4):887–906

Barrett M, Walsham G. 1999. Electronic trading and work transformation in the London insurance market. *Inf. Syst. Res.* 10(1):1–22

Beal DJ. 2015. ESM 2.0: State of the art and future potential of experience sampling methods in organizational research. *Annu. Rev. Organ. Psychol. Organ. Behav.* 2:383–407

Bechky BA. 2003. Object lessons: workplace artifacts as representations of occupational jurisdiction. *Am. J. Sociol.* 109(3):720–52

Beniger JR. 1986. *The Control Revolution: Technological and Economic Origins of the Information Society*. Cambridge, MA: Harvard Univ. Press

Bessen J. 2015. *Learning by Doing: The Real Connection Between Innovation, Wages, and Wealth*. New Haven, CT: Yale Univ. Press

Blau PM, Falbe CM, McKinley W, Tracy PK. 1976. Technology and organization in manufacturing. *Adm. Sci. Q.* 21:20–40

Blume B, Ford JK, Baldwin T, Huang J. 2010. Transfer of training: a meta-analytic review. *J. Manag.* 36:1065–105

Boudreau MC, Robey D. 2005. Enacting integrated information technology: a human agency perspective. *Organ. Sci.* 16(1):3–18

Bradley SP, Madnick SE, Kim C. 2016. *Digital Business*. Chicago: Chicago Bus. Press

Bradley SP, Nolan RL, eds. 1998. *Sense and Respond: Capturing Value in the Network Era*. Cambridge, MA: Harvard Bus. Sch. Press

Brynjolfsson E, Hitt L. 1996. Paradox lost? Firm-level evidence on the returns to information systems spending. *Manag. Sci.* 42(4):541–58

Brynjolfsson E, McAfee D. 2014. *The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies*. New York: W.W. Norton

Burkhardt ME, Brass DJ. 1990. Changing patterns or patterns of change: the effects of a change in technology on social network structure and power. *Adm. Sci. Q.* 35:104–27

Carlile PR. 2002. A pragmatic view of knowledge and boundaries: boundary objects in new product development. *Organ. Sci.* 13(4):442–55

Carter NM. 1984. Computerization as a predominate technology: its influence on the structure of newspaper organizations. *Acad. Manag. J.* 27:247–70

Cascio WF. 2011. *The virtual global workforce: leveraging its impact*. Presented at Annu. SIOP Leading-Edge Consort, 7th, Louisville, KY

Cascio WF, Aguinis H. 2008a. Research in industrial and organizational psychology from 1963 to 2007: changes, choices, and trends. *J. Appl. Psychol.* 93:1062–81

Cascio WF, Aguinis H. 2008b. Staffing twenty-first century organizations. *Acad. Manag. Ann.* 2(1):133–65

Cascio WF, Shurygailo S. 2003. E-leadership in virtual teams. *Organ. Dyn.* 31(4):362–76

Cash JI Jr, Eccles RG, Nohria N, Nolan RL. 1994. *Building the Information-Age Organization: Structure, Control, and Information Technologies*. Boston: Irwin. 3rd ed.

Castanheira F, Chambel MJ. 2010. Reducing burnout in call centers through HR practices. *Hum. Resour. Manag.* 49:1047–65

Castells M. 1996. *The Rise of the Network Society*. Oxford, UK: Blackwell

Christensen CM. 1997. *The Innovator's Dilemma: The Revolutionary Book that Will Change the Way You Do Business.* New York: HarperBusiness

Ciborra C, Lanzara GF. 1994. Formative contexts and ICT: understanding the dynamics of innovation in organizations. *Account. Manag. Inf. Technol.* 4(2):61–86

Coovert MD, Thompson LF, eds. 2014a. *The Psychology of Workplace Technology*. New York: Routledge

Coovert MD, Thompson LF. 2014b. Toward a synergistic relationship between psychology and technology. See Coovert & Thompson 2014a, pp. 1–17

Daft RL, Lengel RH. 1986. Organizational information requirements, media richness and structural design. *Manag. Sci.* 32(5):554–71

Davenport TH, Kirby J. 2015. Beyond automation: strategies for remaining gainfully employed in an era of very smart machines. *Harvard Bus. Rev.* 93(6):58–65

Davis FD. 1989. Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Q.* 13(3):319–40

Deci EL, Ryan RM. 2012. Self-determination theory. In *Handbook of Theories of Social Psychology*, Vol. 1, ed. PAM Van Lange, AW Kruglanski, ET Higgins, pp. 416–37. Thousand Oaks, CA: Sage

Demaerschalk BM, Vargas JE, Channer DD, Noble BN, Kiernan TJ, et al. 2012. Smartphone teleradiology application is successfully incorporated into a telestroke network environment. *Stroke* 43:3098–101

DeSanctis G, Poole MS. 1994. Capturing the complexity in advanced technology use: adaptive structuration theory. *Organ. Sci.* 5(2):121–47

Dewhurst M, Willmott P. 2014. Manager and machine: the new leadership equation. *McKinsey Quarterly*, Sept. **http://www.mckinsey.com/insights/leading_in_the_21st_century/manager_and_machine**

Driskell JE, Radke PH, Salas E. 2003. Virtual teams: effects of technological mediation on team performance. *Group Dyn.: Theory, Res. Pract.* 7(4):297–323

Educase. 2013. 7 Things you should know about wearable technology. *Educase Learning Initiatives*, Nov. **https://net.educause.edu/ir/library/pdf/eli7102.pdf**

Elsby M, Hobijn B, Sahin A. 2010. The labor market in the great recession. In *Brookings Papers on Economic Activity: Spring 2010*, ed. D Romer, J Wolfers. Washington, DC: Brookings Inst.

Farr JL, Fairchild J, Cassidy SE. 2014. Technology and performance appraisal. See Coovert & Thompson 2014a, pp. 77–98

Faulkner P, Runde J. 2009. On the identity of technological objects and user innovations in function. *Acad. Manag. Rev.* 34(3):442–62

Feldman MS, Pentland BT. 2003. Reconceptualizing organizational routines as a source of flexibility and change. *Adm. Sci. Q.* 48:94–118

Fry LW. 1982. Technology-structure research: three critical issues. *Acad. Manag. J.* 25:532–52

Fulk J. 1993. Social construction of communication technology. *Acad. Manag. J.* 36:921–50

Galston WA. 2014. Countering tech's damaging effect on jobs. *The Wall Street Journal*, Oct. 14. **http://www.wsj.com/articles/william-galston-countering-techs-damaging-effect-on-jobs-1413328435**

Gardner WL, Lowe KB, Moss TW, Mahoney KT, Cogliser CC. 2010. Scholarly leadership of the study of leadership: a review of *The Leadership Quarterly's* second decade, 2000–2009. *Leadersh. Q.* 21(6):922–58

Gergen KJ. 2002. The challenge of absent presence. In *Perpetual Contact*, ed. JE Katz, M Aakhus, pp. 227–41. Cambridge, UK: Cambridge Univ. Press

Gibson CB, Gibbs JL. 2006. Unpacking the concept of virtuality: the effects of geographic dispersion, electronic dependence, dynamic structure, and national diversity on team innovation. *Adm. Sci. Q.* 51:451–95

Gillan DJ, Bias RG. 2014. Usability science II: Measurement. See Coovert & Thompson 2014a, pp. 162–82

Goffman E. 1959. *The Presentation of Self in Everyday Life*. Garden City, NY: Doubleday

Goffman E. 1983. The interaction order. *Am. Sociol. Rev.* 48:1–17

Golden AG, Geisler C. 2007. Work–life boundary management and the personal digital assistant. *Hum. Relat.* 60(3):519–51

Golden TD, Veiga JF. 2008. The impact of superior-subordinate relationships on the commitment, job satisfaction, and performance of virtual workers. *Leadersh. Q.* 19(1):77–88

Greguras GJ, Diefendorff J. 2009. Different fits satisfy different needs: linking person-environment fit to employee commitment and performance using self-determination theory. *J. Appl. Psychol.* 94:465–77

Griffith E. 2014. Wearable technology. *Fortune*, Oct. 27, pp. 57–60

Griffith TL. 1999. Technology features as triggers for sensemaking. *Acad. Manag. Rev.* 24(3):472–88

Hancock PA. 2014. Human factors. See Coovert & Thompson 2014a, pp. 149–61

Hauben M, Hauben R. 1995. *The Netizens and the World of the Net: An Anthology on the History and Impact of the Net*. New York: Columbia Univ. Press. **http://www.columbia.edu/~rh120/**

Heath C, Luff P. 2000. *Technology in Action*. Cambridge, UK: Cambridge Univ. Press

Henfridsson O, Bygstad B. 2013. The generative mechanisms of digital infrastructure evolution. *MIS Q.* 37(3):907–31

Hinds P, Kiesler S. 1995. Communication across boundaries: work, structure, and use of communication technologies in a large organization. *Organ. Sci.* 6(4):373–93

Huber GP. 1990. A theory of the effects of advanced information technologies on organizational design, intelligence, and decision making. *Acad. Manag. Rev.* 15(1):47–71

Jacoby T. 2015. Technology isn't a job killer. *The Wall Street Journal*, May 20. **http://www.wsj.com/articles/technology–isnt–a–job–killer–1432161213**

Jarzabkowski P. 2005. *Strategy as Practice*. London: Sage

Jones M. 1998. Information systems and the double mangle: steering a course between the scylla of embedded structure and the Charybdis of material agency. In *Information Systems: Current Issues and Future Challenges*, ed. T Larsen, L Levine, JI DeGross, pp. 287–302. Laxenburg, Austria: Int. Fed. Inf. Process

Jones M. 2014. A matter of life and death: exploring conceptualizations of sociomateriality in the context of critical care. *MIS Q.* 38(3):895–925

Kallinikos J. 2006. *The Consequences of Information: Institutional Implications of Technological Change*. Cheltenham, UK: Edward Elgar

Katz L. 2010. Long-term unemployment in the great recession. Presented to US Congress Joint Economic Comm. **http://www.jec.senate.gov/public/index.cfm?a=Files.Serve&File_id=e1cc2c23-dc6f-4871-a26a-fda9bd32fb7e.%2520**

Kidwell RE, Bennett N. 1994a. Electronic surveillance as employee control: a procedural justice interpretation. *J. High Technol. Manag. Res.* 5:39–57

Kidwell RE, Bennett N. 1994b. Employee reactions to electronic control systems: the role of procedural fairness. *Group Organ. Manag.* 19:203–18

Kidwell RE, Sprague R. 2009. Electronic surveillance in the global workplace: laws, ethics, research, and practice. *N. Technol, Work, Employ.* 24:194–208

Kirkland R. 2014. Artificial intelligence meets the C-suite. *McKinsey Quarterly*, Sept. **http://www.mckinsey.com/insights/strategy/artificial_intelligence_meets_the_c-suite**

Kraut R, Koch S, Dumais S. 1989. Computerization, productivity, and quality of employment. *Commun. ACM* 32(21):220–38

Kühnle H, ed. 2010. *Distributed Manufacturing: Paradigm, Concepts, Solutions and Examples*. London: Springer

Kuruzovich J, Viswanathan S, Agarwal R, Gosain S, Weitzman S. 2008. Marketspace or marketplace? Online information search and channel outcomes in auto retailing. *Inf. Syst. Res.* 19(2):182–201

Landers RN, Goldberg AS. 2014. Online social media in the workplace: a conversation with employees. See Coovert & Thompson 2014a, pp. 284–304

Latham R, Sassen S. 2005. *Digital Formations: IT and New Architectures in the Global Realm*. Princeton, NJ: Princeton Univ. Press

Lee SM, Koopman J, Hollenbeck JR, Wang LC, Lanaj K. 2015. The team descriptive index (TDI): a multidimensional scaling approach for team description. *Acad. Manag. Discov.* 1(1):91–116

Leonard-Barton D. 1988. Implementation as mutual adaptation of technology and organization. *Res. Policy* 17(5):251–67

Lu JL. 2005. Perceived job stress of women workers in diverse manufacturing industries. *Hum. Factors Ergon. Manuf.* 15:275–91

Mabry RH, Sharplin AD. 1986. *Does more technology create unemployment?* Policy Analysis 68, Cato Inst. **http://www.object.cato.org/sites/cato.org/files/pubs/pdf/pa068.pdf**

MacKenzie D. 2006. *An Engine not a Camera: How Financial Models Shape Markets*. Cambridge, MA: MIT Press

Malhotra A, Gosain S, El Sawy OA. 2005. Absorptive capacity configurations in supply chains: gearing for partner-enabled market knowledge creation. *MIS Q.* 29(1):145–87

Malone TW, Yates J, Benjamin RI. 1987. Electronic markets and electronic hierarchies. *Commun. ACM* 30(6):484–97

Markus ML. 1994. Electronic mail as the medium of managerial choice. *Organ. Sci.* 5(4):502–27

Martins LL, Gilson LL, Maynard MT. 2004. Virtual teams: What do we know and where do we go from here? *J. Manag.* 30(6):805–35

Maslach C, Leiter MP. 2008. Early predictors of job burnout and engagement. *J. Appl. Psychol.* 93:498–512

Mazmanian M, Cohn M, Dourish P. 2014. Dynamic reconfiguration in planetary exploration: a sociomaterial ethnography. *MIS Q.* 38(3):831–48

McKenney JL, Copeland DC, Mason RO. 1995. *Waves of Change: Business Evolution Through Information Technology*. Cambridge, MA: Harvard Bus. Sch. Press

McNall LA, Stanton JM. 2011. Private eyes are watching you: reactions to location-sensing technologies. *J. Bus. Psychol.* 26:299–309

Meeker M. 2013. Internet trends report. *Kleiner, Perkins, Caulfield, and Byers*, May 29. **http://abcnews.go.com/blogs/technology/2013/05/cellphone-users-check-phones-150xday-and-other-Internet-fun-facts/**

Miles J, Hollenbeck JR. 2014. Teams and technology. See Coovert & Thompson 2014a, pp. 99–117

Monga V. 2015. The new bookkeeper is a robot. *The Wall Street Journal*, May 5, pp. B1–7

Montealegre R. 2002. A process model of capability development: lessons from the e-commerce strategy at Bolsa de Valores de Guayaquil. *Organ. Sci.* 13(5):514–31

Montealegre R, Hovorka D, Germonprez M. 2014. A coevolutionary view of information services development: lessons from the U.S. National Oceanic and Atmospheric Administration. *J. Assoc. Inf. Syst.* 15(9):577–613

Murray A. 2015. The new industrial revolution. *Fortune*, May 1, p. 6

National Research Council. 1999. *Collaboratories: Improving research capabilities in chemical and biomedical sciences*. Washington, DC: National Academies Press

Nixon AE, Spector PE. 2014. The impact of technology on employee stress, health, and well-being. See Coovert & Thompson 2014a, pp. 238–60

Orlikowski WJ. 2000. Using technology and constituting structures. *Organ. Sci.* 11(4):404–28

Orlikowski WJ. 2002. Knowing in practice: enacting a collective capability in distributed organizing. *Organ. Sci.* 13(4):249–73

Orlikowski WJ. 2009. The sociomateriality of organizational life: considering technology in management research. *Camb. J. Econ.* 9:125–41

Orlikowski WJ, Scott SV. 2008. Sociomateriality: challenging the separation of technology, work and organization. *Ann. Acad. Manag.* 2(1):433–74

Osman M. 2010. Controlling uncertainty: a review of human behavior in complex, dynamic environments. *Psychol. Bull.* 136:65–86

Pfanner E. 2015. Secretive robot maker emerges—a bit. *The Wall Street Journal*, March 27, pp. B1–2

Pfeffer J, Leblebici H. 1977. Information technology and organizational structure. *Pac. Sociol. Rev.* 20(2):241–61

Potosky D. 2008. A conceptual framework for the role of the administration medium in the personnel assessment process. *Acad. Manag. Rev. 33*:629–48

Potosky D, Lomax MW. 2014. Leadership and technology: a love-hate relationship. See Coovert & Thompson 2014a, pp. 118–46

Prasad P. 1993. Symbolic processes in the implementation of technological change: a symbolic interactionist study of work computerization. *Acad. Manag. J.* 36:1400–29

Rafaeli A. 1986. Employee attitudes toward working with computers. *J. Occup. Behav.* 7(2):89–106

Redden ES, Elliott LR, Barnes MJ. 2014. Robots: the new teammates. See Coovert & Thompson 2014a, pp. 185–208

Ribes D, Jackson S, Geiger S, Burton M, Finholt T. 2013. Artifacts that organize: delegation in the distributed organization. *Inf. Organ.* 23:1–14

Rice RE, Aydin C. 1991. Attitudes toward new organizational technology: network proximity as a mechanism for social information processing. *Adm. Sci. Q.* 36:219–44

Riedy MK, Wen JH. 2010. Electronic surveillance of Internet access in the American workplace: implications for management. *Inf. Commun. Technol. Law* 19:87–99

Rogan RG, Simmons GA. 1984. Teleconferencing. *J. Extension* 22:(5). **http://www.joe.org/joe/1984september/a4.php**

Ross P, Sepper R, Pohjonen H. 2010. Cross-border teleradiology-experience from two international teleradiology projects. *Eur. J. Radiol.* 73:20–25

Rotman D. 2013. How technology is destroying jobs. *MIT Technology Review*, June 12. **http://www.technologyreview.com/featuredstory/515926/how-technology-is-destroying-jobs/**

Ryan RM, Deci EL. 2000. Self-determination theory and the facilitation of intrinsic motivation, social development, and wellbeing. *Am. Psychol.* 55:68–78

Schaufeli WB, Leiter MP, Maslach C. 2009. Burnout: thirty-five years of research and practice. *Career Dev. Int.* 14(3):204–20

Scott SV, Orlikowski WJ. 2014. Entanglements in practice: performing anonymity through social media. *MIS Q.* 38(3):863–93

Scott SV, Wagner EL. 2003. Networks, negotiations, and new times: the implementation of enterprise resource planning into an academic administration. *Inf. Organ.* 13(4):285–313

Sewell G. 1998. The discipline of teams: the control of team-based industrial work through electronic and peer surveillance. *Adm. Sci. Q.* 43:397–428

Shadish WR, Cook TD, Campbell DT. 2002. *Experimental and Quasi-Experimental Designs for Generalized Causal Inference*. Boston: Houghton Mifflin

Shoot B. 2014. The smart vending machine. *Fortune*, Nov. 17, p. 49

Silva L, Backhouse J. 1997. Becoming part of the furniture: the institutionalisation of information systems. In *Information Systems and Qualitative Research*, ed. AS Lee, J Liebenau, JI DeGross, pp. 389–414. London: Chapman & Hall

Slife BD. 2005. Taking practice seriously: toward a relational ontology. *J. Theor. Philos. Psychol.* 24(2):157–78

Smite D, Moe NB, Agerfalk PJ, eds. 2010. *Agility Across Time and Space: Implementing Agile Methods in Global Software Projects*. Berlin: Springer

Smith A, Anderson J. 2014. AI, robotics, and the future of jobs. *Pew Res. Center.* **http://www.pewInternet.org/2014/08/06/future-of-jobs**

Stiglitz JE, Greenwald BC. 2014. *Creating a Learning Society*. New York: Columbia Univ. Press

Suchman LA. 2007. *Human-Machine Reconfigurations: Plans and Situated Actions*. Cambridge, UK: Cambridge Univ. Press

Tehrani K, Michael A. 2014. Wearable technology and wearable devices: everything you need to know. *Wearable Devices Magazine*, March. **http://www.wearabledevices.com/what-is-a-wearable-device/**

The Economist. 2014. The future of jobs: the onrushing wave. *The Economist*, Jan. 18. **http://www.economist.com/news/briefing/21594264-previous-technological-innovation-has-always-delivered-more-long-run-employment-not-less**

The Economist. 2015a. Rise of the machines: Artificial intelligence scares people—excessively so. *The Economist*, May 9, pp. 17–21

The Economist. 2015b. The dawn of artificial intelligence. *The Economist*, May 9, p. 11

Thompson LF, Coovert MD. 2003. Teamwork online: the effects of computer conferencing on perceived confusion, satisfaction, and post-discussion accuracy. *Group Dyn.: Theory, Res. Pract.* 7(2):135–51

Tippins NT. 2015. Technology and assessment in selection. *Annu. Rev. Organ. Psychol. Organ. Behav.* 2:551–82

Treviño LK, Webster J, Stein EW. 2000. Making connections, complementary influences on communication media choices, attitudes, and use. *Organ. Sci.* 11(2):163–82

Turban E, Lee JK, King D, Peng LT, Turban D. 2009. *Electronic Commerce 2010*. Upper Saddle River, NJ: Prentice Hall

Tushman M, Anderson P. 1986. Technological discontinuities and organizational environments. *Adm. Sci. Q.* 31(3):439–65

Vanderkam L. 2015. Work/life integration is the new normal. *Fortune*, March 15, p. 139

VanHoose DD. 2011. *E-commerce Economics*. Milton Park, UK: Routledge

Venters W, Oborn E, Barrett M. 2014. A trichordal temporal approach to digital coordination: the sociomaterial mangling of the CERN grid. *MIS Q.* 38(3):927–49

von Hippel E. 1994. "Sticky information" and the locus of problem solving, implications for innovation. *Manag. Sci.* 40(4):429–39

Walsham G. 1993. *Interpreting Information Systems in Organizations*. Chichester, UK: Wiley

Wellman B, Haythornthwaite C, eds. 2002. *The Internet in everyday life*. Oxford, UK: Blackwell

Wooldridge A. 2015. The Icarus syndrome meets the wearable revolution. *Korn/Ferry Briefings Talent Leadersh.* 6:27–33

Yates J, Orlikowski WJ, Okamura K. 1999. Explicit and implicit structuring of genres, electronic communication in a Japanese R&D organization. *Organ. Sci.* 10(1):83–103

Zammuto RF, Griffith TL, Majchrzak A, Dougherty DJ, Faraj S. 2007. Information technology and the changing fabric of organization. *Organ. Sci.* 18(5):749–62

Zuboff S. 1988. *In the Age of the Smart Machine: The Future of Work and Power*. New York: Basic Books

Zweig D, Scott K. 2007. When unfairness matters most: supervisory violations of electronic monitoring practices. *Hum. Resour. Manag. J.* 17:227–47

Annual Review of Organizational Psychology and Organizational Behavior

Volume 3, 2016

Contents

Errata

An online log of corrections to *Annual Review of Organizational Psychology and Organizational Behavior* articles may be found at http://www.annualreviews.org/errata/orgpsych