MIS Quarterly

SPECIAL ISSUE: CRITICAL REALISM IN IS RESEARCH

CRITICAL REALISM AND AFFORDANCES: THEORIZING IT-ASSOCIATED ORGANIZATIONAL CHANGE PROCESSES[1]

Olga Volkoff
Beedie School of Business, Simon Fraser University,
Burnaby, BC V5A 1S6 CANADA {ovolkoff@sfu.ca}

Diane M. Strong
School of Business, Worcester Polytechnic Institute,
Worcester, MA 01609 U.S.A. {dstrong@wpi.edu}

Convincing arguments for using critical realism as an underpinning for theories of IT-associated organizational change have appeared in the Information Systems literature. A central task in developing such theories is to uncover the generative mechanisms by which IT is implicated in organizational change processes, but to do so, we must explain how critical realism's concept of generative mechanisms applies in an IS context. Similarly, convincing arguments have been made for using Gibson's (1986) affordance theory from ecological psychology for developing theories of IT-associated organizational change, but this effort has been hampered due to insufficient attention to the ontological status of affordances. In this paper, we argue that affordances are the generative mechanisms we need to specify and explain how affordances are a specific type of generative mechanism. We use the core principles of critical realism to argue how affordances arise in the real domain from the relation between the complex assemblages of organizations and of IT artifacts, how affordances are actualized over time by organizational actors, and how these actualizations lead to the various effects we observe in the empirical domain. After presenting these arguments, we reanalyze two published cases in the literature, those of ACRO and Autoworks, to illustrate how affordance-based theories informed by critical realism enhance our ability to explain IT-associated organizational change. These examples show how researchers using this approach should proceed, and how managers can use these ideas to diagnose and address IT implementation problems.

Keywords: Affordance, critical realism, generative mechanism, organizational change, case study

Introduction

Over the last decade, the argument for critical realism as the philosophical underpinning for information systems research has been cogently made by a number of authors (Dobson 2001; Mingers 2004b; Mutch 2010; Smith 2006; Wynn and Williams 2012). Our purpose is to advance this discussion by exploring in detail some of the elements that research informed by critical realism entails, and so help researchers developing theories consistent with critical realism take full advantage of what it offers. In particular, we explore critical realism's concept of generative mechanisms and propose that the concept of affordances (Gibson 1986; Kane et al. 2011; Markus and Silver 2008) helps us specify mechanisms and so enables us to build better theories of the effects of introducing new systems into organizations. Our arguments are consistent

[1]John Mingers, Alistair Mutch, and Leslie Willcocks served as the senior editors for this special issue and were responsible for accepting this paper.

with arguments in recent IS literature that a renewed focus on the concept of affordances that returns us to its roots in Gibson (1986) would provide IS researchers with an appropriate foundation for developing better theories of IT-associated organizational change (Kane et al. 2011; Leonardi 2011c; Markus and Silver 2008; Zammuto et al. 2007). While the claims about the value of critical realism and of affordances to IS researchers have both been argued persuasively, and despite their underlying similarities, there has been little to no connection developed between the two, and few suggestions about how IS researchers can make use of either of them.

Our paper addresses this gap by constructing the necessary theoretical bridges, while acknowledging that there are still many open research issues. Specifically, we suggest ways affordances as generative mechanisms can be used to understand IT-associated organizational change. To illustrate our ideas, we examine published case studies about two companies, namely ACRO (Elmes et al. 2005; Volkoff et al. 2005) and Autoworks (Leonardi 2009, 2011a, 2011b, 2011c), to show what further could be learned by identifying affordances. More generally, we argue that critical realism provides the appropriate philosophical underpinning for developing affordance-based theories of IT-associated organizational change that are better able to explain how information technology is implicated in organizational change.

Background Literature

To explore the concept of generative mechanisms, we start by providing a short overview of critical realism, highlighting three core principles that underlie our discussion. We then discuss some definitions and key points about generative mechanisms and affordances.

Principles of Critical Realism

First, critical realism presupposes a three-layer stratification (Bhaskar 1998a; Mingers 2004a). Specifically it takes the ontological position that social structures, natural objects, material artifacts, and conceptual entities such as language, opinions, and goals (all of which we will refer to collectively as *structures*) are real and exist independently of our perception of them (Fleetwood 2005). This is the first, or *real*, layer.

Under critical realism, this foundational layer of the real is associated with mechanisms that generate events/outcomes. These events constitute the layer of the *actual* but these actual events and outcomes may not be observed. The final layer, the *empirical*, contains the subset of the actual that is observed. Epistemologically our perception of the real is necessarily fallible as it depends on our interpretations of what we see. In other words, from a critical realist perspective, understanding the organizational effects/outcomes associated with introducing new structures (e.g., new information systems) and how they occur can be viewed as understanding the generative mechanisms associated with those structures (Mutch 2010). We uncover these mechanisms through retroduction, a process of working backward from the empirical events we observe to the underlying mechanisms that could logically have produced those events (Danermark et al. 2002). Through an iterative process, we can improve our understanding of those mechanisms.

The second core principle of critical realism is the distinction between agency and structure (Carter and New 2004; Mutch 2010). First, they are temporally separate: structures are assumed to preexist actions, creating the conditions for those actions. New or elaborated structures may or may not emerge from those actions, but those emergent structures necessarily post-date the associated actions (Archer 1995; Volkoff et al. 2007). This temporal separation implies that causal explanations must account for processes that occur through time. Second, structure and agency have very different properties and powers (Carter and New 2004). Unlike action, structures are to some extent enduring. They have the power, not to determine, but to motivate or discourage, to enable or constrain action—so-called "material causality" (Carter and New 2004, p. 12). This is not deterministic causality, but nevertheless, if those structures had not existed, or had been different, the process of change would not have happened in the same way. In contrast, the people who act (agents) have properties such as self-consciousness, reflexivity, intentionality, cognition, and emotionality. These agents can formulate plans, and pursue objectives, and thus have the power to maintain or modify the structures around them by doing things—so-called "efficient causality" (Catrter and New 2004, p. 12).

Finally, in addition to the real–actual–empirical stratification and the temporal separation of structure and action, structures themselves can be stratified. Specifically, they may consist of various components, but rather than being a simple aggregation of parts, they combine into "assemblages" (DeLanda 2006), whose causal properties emerge from the interactions between parts, and are not just an additive combination of the properties of the components (Elder-Vass 2005, 2007). Since the relations between parts matter, the mechanisms that arise from these nested structures are a complex web of interpenetrating effects that can loop back on themselves. As we discuss more fully later, both organizations and IT artifacts,

the key structures involved in IT-associated organizational change, are assemblages of nested structures with emergent causal properties. Because the interplay between various structures and between structures and actions lead to the emergence of new structures and new properties, our focus is on the relationships between the various components and how they evolve over time, not on any single structure. Thus, we must not only uncover the core generative mechanisms associated with the structures of interest, but must also understand how they interact to produce the observed events.

Generative Mechanisms

Those subscribing to critical realism as an appropriate philosophical underpinning for understanding organizations and how they operate have identified the central task of organizational theorists as uncovering generative mechanisms (Carter and New 2004; Hedstrom and Swedberg 1996; Mutch 2010). Predictive theories based on statistical correlations can only tell us ***what*** may happen, and even then depend on debatable assumptions of system closure, variable independence, and normal distribution (Mingers 2004b). In contrast, by going below the surface of the observable, the identification of generative mechanisms through retroduction provides us with causal explanations for ***how*** and ***why*** things happen. Despite their importance, however, there has been little discussion of exactly what mechanisms are, and how IS researchers can identify the generative mechanisms of interest.

In broad terms, generative mechanisms have been variously described in the literature on critical realism as "the ways of acting of a thing" (Bhaskar 1998b, p. 38), "the causal powers and liabilities of objects or relations" (Sayer 2010, p. 104), "capacities for behaviour" (Bygstad 2010, p. 159), and "tendencies of structures" (Smith 2006, p. 202). While somewhat vague (and thus still hard to visualize), these descriptions offer considerable food for thought. In some ways the choice of language, particularly Bhaskar's, is surprising: he appears to suggest that mechanisms, which are associated with structures, are about action, yet critical realism holds structure and action as distinct. In this case,we probably need to interpret the word *acting* as "having an effect" (i.e., the causal powers). Second, we note that these mechanisms are capacities or tendencies, not powers with deterministic effect. In other words, a mechanism has the potential to cause an event, but may or may not do so. Furthermore, such mechanisms simultaneously offer powers and threaten liabilities: they can both enable and constrain action. Finally, mechanisms may arise from a structure, or from the relations between structures, or from the relations between structures and actors.

A recent review of the literature on mechanisms as applied to the social sciences provides nine different definitions for the term mechanism, and distills four core characteristics (Hedstrom and Ylikoski 2010). These characteristics are: (1) a mechanism is identified by the kind of effect or phenomenon it produces, (2) a mechanism is an irreducibly causal notion, (3) a mechanism has a structure, so mechanism-based explanation entails showing how the entities that comprise the structure, together with their properties, activities, and relations, produce the effect of interest, and (4) mechanisms form a hierarchy. With respect to these last two characteristics, there are three different types of social mechanisms involved in mechanism-based explanations (Hedstrom and Swedburg 1998). While the elemental causal agent of any social phenomenon is an individual actor, the evolution of social institutions entails a long historical process. To explain a specific phenomenon, it is valuable to bracket that history by taking the macro state at one point in time, generated earlier by many individual actions, as given. One type of mechanism, then, is the set of situational (or macro–micro) mechanisms whereby an individual is exposed to that macro state and is affected in a particular way. The second type is the set of action–formation (or micro–micro) mechanisms, whereby a combination of individual beliefs, desires, and action opportunities generates a specific action. The third type is the set of transformational (or micro–macro) mechanisms, whereby the actions and interactions of individuals generate collective outcomes. This three-part change process of Hedstrom and Swedburg (1998), based on the work of Coleman (1986), is consistent with the morphogenetic cycle of Archer (1995), which describes how existing *structural conditions* predate *social interaction*, which in turn leads to *structural elaboration or reproduction*.

While these elaborations help clarify the conceptual definition, we still lack a concrete sense of what a generative mechanism looks like. That gap can be partially filled by turning to the literature for specific examples. Hedstrom and Swedberg (1996) offer several from a variety of disciplines. For example, in biochemistry the mechanism through which strychnine causes morbidity is the set of biochemical processes that paralyzes the respiratory centers of the brain, while the mechanism underlying economic markets is the pursuit to maximize marginal utility. Within sociology they point to a belief-formation mechanism whereby an individual's personal belief in the value or necessity of performing an act is a function of the number of individuals who have already performed that act.

Bygstad (2010) provides the most notable example in the IS literature, identifying two generative mechanisms associated with information infrastructures to explain how innovation in

ICT-based services unfolds, namely the innovation mechanism and the service mechanism. Each of these consists of a number of steps. For example the innovation mechanism starts with a "space of possibilities" that arises from the infrastructure's architecture and operations and enables the emergence of ideas for new services. In turn, external partners help to develop these ideas into innovations that are included in the infrastructure as new services, which expands the space of possibilities and the cycle begins again. This is a fairly high level generative mechanism in that it incorporates both a structure-initiated aspect (the space of possibilities) and an actor-initiated aspect (the development of new ideas) that leads to new structures. This cycle corresponds to the three phases, namely structural conditioning, followed by social interaction, followed by structural elaboration or reproduction, described by Volkoff et al. (2007) in their theory of technology-mediated organizational change. This example clearly demonstrates both the processual nature of mechanisms, and the need to understand how the various mechanisms that are associated with a given structure interweave with the actions that lead to structural changes. That said, while Bygstad's two mechanisms serve his purpose well, identifying mechanisms at such a high level does not help us understand the details of how a specific technology is implicated in organizational change.

Generative mechanisms can be identified at whatever level of granularity offers empirical usefulness (Mahoney 2003), but Hedstrom and Swedberg (1996) urge us to provide fine-grained explanations of causality. Furthermore they suggest we develop middle-range theories rather than always trying to establish universal social laws. What, then, would the mechanisms associated with particular types of technology look like? We propose that the concept of affordances from ecological psychology (Gibson 1986) is a helpful way to conceive of the generative mechanisms associated with technical artifacts for use in organizations. We have several reasons for doing so. First, the term *affordance* has become popular in the IS literature, but is used inconsistently and with an often unclear ontology. We hope that by explicitly connecting the concept of affordances to its critical realist roots we can improve the theoretical work that employs it. Second, it is a more specific term: affordances are a subset of the more general set of generative mechanisms. As discussed below, they are particularly appropriate for middle-range theories that involve actors (with their intentions and skills) and technical objects (with their specific features).

Affordances

In the IS literature, the word *affordances* has for some time been used in the sense introduced by Norman (1988) to refer to the uses and/or ways of using an object as perceived by a user. He later expressed regret at how the term's use had started to refer to objects on a screen (Norman 1999), and further stated that from the start he should have used the term *perceived affordances* since his focus was on how easily a user could apprehend how to use an object. While affordance-based IS research has largely focused on how different visual cues support perception of affordances, or how perceptual cues can be learned as social conventions (Fayard and Weeks 2007), there is still much more to be learned by understanding the affordances themselves.

The word affordance as we use it in this paper (and as it has been used in the more recent papers, e.g., Kane et al. 2011; Leonardi 2011b, 2011c; Markus and Silver 2008; Zammuto et al. 2007) originated with Gibson (1986) to refer to what is offered, provided, or furnished to someone or something by an object. For example, a fallen log affords a person the opportunity of sitting. This original definition is somewhat ambiguous about whether an affordance is a property of an object or of the relationship between an object and an actor. After some debate, the consensus emerged among ecological psychologists that an affordance is a property of the relationship, and was defined as an opportunity for action (Hutchby 2001; Stoffregen 2003). Thus an affordance for sitting related to a log and the actors who encounter it exists for most people, but not a horse or an infant. Furthermore, just as a mechanism exists whether or not it is exercised (Sayer 2010), that affordance exists whether anyone sits down or not; the affordance may never be actualized (or even perceived). Thus an affordance exists at what critical realists refer to as the domain of the *real*. At the same time, someone who is capable of performing the actualization must exist for the affordance to have any meaning, but that person need not be identified (Chemero 2003). In addition, the affordance will not be actualized (brought into the domain of the actual) unless there exists someone who in addition to having the necessary capability also has an intention or goal that is served by actualizing the affordance (Stoffregen 2003).

Note that multiple affordances can arise from a single structure–actor relationship. For example a person may view a log as offering a sitting affordance, but might also view it as offering a standing-on affordance to help the person climb up onto something, or a barricading-a-path affordance to restrict passage. Because both the associated goal and the act of actualizing an affordance are tied to an actor, a resulting event or outcome in the *actual* domain is necessarily specific to the actor. Thus the sitting affordance that a log might offer a person may be related to a goal of resting or of putting on socks and shoes, and the act of sitting may involve sitting primly, cross-legged, or slouched.

While each instance of an actualized affordance in the realm of the actual is specific to an individual, in the realm of the real we can still speak of a generic sitting affordance which is a potential for action that will apply broadly to a variety of seat-like objects and people of a certain size and result in a recognizable concrete outcome, namely that the actor is no longer supporting weight on his or her own feet. The notion of a generic affordance parallels the concept of structural range whereby entities may exhibit a certain degree of variability and still retain their identity as long as they meet minimal compositional consistency requirements (i.e., they consist of a specific set of parts related in a characteristic pattern) (Elder-Vass 2010). For example, in the same way that no two flowers are perfectly alike, but are identifiably flowers, we can talk about a sitting affordance, although people may sit differently and for different reasons.

Recent IS literature has described affordances as emerging from the relation between IT systems and organization systems (Zammuto et al. 2007), and defined them as "the possibilities for goal-oriented action afforded to specified user groups by technical objects" (Markus and Silver 2008, p. 622). The relational nature of affordances has been reaffirmed by Kane et al. (2011) who identified four affordances whereby social media support intellectual capital creation. For example, one of the affordances is metavoicing, the potential for individuals in an online social collective to provide feedback on online content. Similarly Leonardi (2011c) describes affordances as "not exclusively properties of people or of artifacts...[but] constituted in relationships between people and the materiality of the things with which they come in contact" (p. 153).

These descriptions also highlight an important extension required for importing the idea of affordances from ecological psychology to IS research, namely recognizing that we are no longer dealing with just individual goals and actions, but also group or organizational goals, and the coordinated actions of groups of people to support them (Strong et al. forthcoming). The potential for coordinated action by a group can be thought of as an organizational affordance. Zammuto et al. (2007) identify five affordances framed as capabilities (i.e., the "simulation/synthetic representation affordance is defined as the capability to conduct what-if scenarios" (p. 757)).

Taking these various definitions and descriptions together, we define affordances as *the potential for behaviors associated with achieving an immediate concrete outcome and arising from the relation between an object (e.g., an IT artifact) and a goal-oriented actor or actors.* In this definition we have highlighted four aspects of affordances: their status as the potential for action rather than the action itself, their relational aspect, their connection to an immediate concrete outcome resulting from goal-directed behaviours, and their application at multiple levels. The immediate concrete outcome, which is the consequence associated with actualizing the affordance, captures Hedstrom and Ylikoski's (2010) first characteristic of a mechanism as listed earlier.

Critical Realism and Affordances

Affordances as Generative Mechanisms

The definition above suggests that the immediate concrete outcome in the domain of the empirical provides evidence of the existence of an affordance in the domain of the real. Thus, researchers seeking to identify affordances need to uncover the immediate concrete outcomes the actors experienced or expected to experience. Through observation and/or interviews with questions such as "what did the technology enable you to do," "what did it make it more difficult to do," "what did you use the technology for," "what happened once you started to use the technology," or "were there things you expected to be able to do that were not in fact possible," the actual events that allow for retroduction back to the affordances can be uncovered.

Since ecological psychologists have realist roots (Markus and Silver 2008; Michaels 2003), it is not surprising that there are clear parallels between the description of affordances and the description of generative mechanisms. For example, both are seen as a potential for an event to occur, rather than the event itself. That said, as already pointed out, generative mechanisms are a broader concept. An affordance arises from the relation between a structure or object and a goal-directed actor or actors. It needs to be triggered or actualized by that actor. Generative mechanisms may arise from structures alone, and their causal powers triggered without the intervention of an actor. Thus, affordances are a type or subset of generative mechanisms. When the object of study is information technology, and the question relates to how the introduction of that technology affects an organization, the more focused nature of the affordance concept is useful. As we will discuss in our analysis of the cases, recognition that the properties of entities (such as their generative mechanisms) emerge from the relations between component parts, but are not reducible to the properties of the parts (Elder-Vass 2005, 2007) will allow us to explain organizational level affordances in a manner consistent with critical realism. For example, one affordance arising from the relation between an IT artifact and the organization in which it is used is the potential for sharing work. Shared work as an immediate concrete outcome emerges from the relation between tech-

nology features such as common templates, reports, and notifications and organizational actors who must work together to accomplish a joint task. Just as generative mechanisms are nondeterministic, different actors may actualize the work-sharing affordance differently.

Similarly the understanding that mechanisms are both powers and liabilities reminds us that affordances can both enable and constrain. For example, to return to the barricading affordance arising from the relationship between a person and a fallen log, someone wanting to walk along a path may consider a barricading affordance constraining, whereas someone wishing to prevent passage would consider it enabling.

Finally, while affordances are often discussed in isolation, the notion of a web of mechanisms arising from the nested nature of structures reminds us that multiple affordances exist and may interact with each other. Furthermore, the actualization of affordances occurs over time. It is to these issues that we now turn.

Multiple Affordances and Their Actualization

Identifying single affordances present in a particular situation is only the first step in any attempt to explain the causes of organizational events of interest. Multiple affordances are present at the same time, so in addition to uncovering these affordances, we must understand the nature of their relationships (Elder-Vass 2010). As already mentioned, an actor looking at an object such as a technical artifact is likely able to identify a variety of possible affordances. Not only does the technical artifact have multiple features that can be combined in various ways, but individuals operate simultaneously on their own behalf and as role incumbents in an organization, so have a variety of goals associated with their use of the technology. Furthermore, an organizational actor may be an individual or a collective such as a team. The affordances that exist for the team may be different from the affordances that exist for individual members of the team.

One way to explore the relationships between affordances is to examine the different structural levels from which they emerged. An affordance arises from the relation between an object and a goal-directed actor, but both of those have themselves emerged from the relations between constituent parts (Elder-Vass 2005). As we shall show in the cases and discussion below, different affordances arise from different parts of this vertical structure.

In addition to these vertical distinctions, we need to account for the way in which affordances as actualized unfold temporally. One approach is to focus on a single affordance, and view the others as part of the context or conditions within which it operates (Demetriou 2009; Sayer 2010). This allows us to focus on the way this focal affordance might unfold through time should an actor attempt to actualize it. As with any mechanism, the causal chain of an affordance has various "moments" or aspects that reflect differences in the nature of actualization at any given time. While Bhaskar (1994) and Fleetwood (2011) provide details of eight such moments, for the sake of this discussion we will consider a simpler three-moment classification from Bhaskar (1998a), namely an affordance that is possessed but unexercised, exercised but unactualized (or partly actualized), and actualized but not necessarily empirically observed. Where one is on this causal chain (and certainly it is not the case that all actualization journeys need to pass through the full set of all moments) depends on the contextual conditions, some of which may support or restrict the start of the actualization process, and others which may stimulate or restrain its progress or release associated constraints. These contextual conditions are other affordances or mechanisms that interact with the focal affordance.

One way to visualize an affordance is thus as an ongoing strand of action potential, which is interwoven with other strands in patterns that can be explored to understand how information technology might be implicated in organizational change as those affordance strands are actualized. Before developing this perspective further, we first present two case studies that provide concrete material for the discussion.

Case Studies

We use two published case studies, the implementation of a comprehensive enterprise system at ACRO (Elmes et al. 2005; Volkoff et al. 2005) and the implementation of a custom-built software system to support finite element model analysis at Autoworks (Leonardi 2009, 2011a, 2011b, 2011c), to illustrate how critical realism in general and affordances in particular can inform the study of IT-associated organizational change processes.

Selection and Analysis of the Cases

These two case studies are similar in ways that suit our purpose well. For both cases, the original data were collected through intensive observation and interviews over a relatively long period of time, which enabled fairly detailed understanding of the post-implementation processes as they unfolded. Because these cases have each formed the basis of a number of papers, the information available publicly (in-

cluding details of the respective methodologies and lengthy quotes from the original data) is quite extensive. Furthermore, while neither of these cases were presented from the perspective we propose, all of the authors seem sympathetic to the approach: Leonardi, while not identifying himself as a critical realist, does discuss affordances; Strong, Volkoff, and Elmes, while not presenting any affordances for ACRO, in more recent papers do self-identify as critical realists (Strong and Volkoff 2010; Volkoff et al. 2007) and have used affordances in their analysis of a different case (Strong et al. forthcoming). Both cases involve several sites or groups within a single organization, and thus provide observations of different outcomes from the same technology in very similar sites.

Our approach in reanalyzing these cases was first to identify the underlying generic affordances. Because we had access to the ACRO data, and because those data were collected through interviews where questions included asking about the immediate concrete outcomes of using the technology, we were able to retroduce candidate affordances. Although we did not have access to the Autoworks data, Leonardi has identified a number of affordances, and the various papers written about this case include considerable information about a wide range of outcomes. While any situation presents a very large number of potential affordances, the central ones that are salient for understanding the organizational change that occurred are best revealed through a comprehensive examination of the daily events that occurred over time. Because both cases are based on just this type of detailed data, collected through observation and interviews using questions such as those suggested earlier, we believe we have captured a core set of affordances for both scenarios.

Once the affordances were identified, we examined how they had been actualized in the specific cases, as well as examining how the different affordance strands interacted and affected each other. This allowed us to highlight how affordances as generative mechanisms serve to identify the potential for organizational change offered by a specific technology, and also to explain how and why the process might unfold differently under a variety of circumstances.

ACRO Case

Our first case examines the affordances associated with implementing an enterprise system (ES) in a manufacturing organization named ACRO (Elmes et al. 2005; Volkoff et al. 2005). While pre-implementation baseline data were collected, the primary focus throughout the three year period of data collection was on the post implementation period (until one year after go-live) at different sites as they came on line with SAP. This time period was long enough to indicate some of the interactions and temporal relationships among affordance strands.

The affordances in the ACRO case are listed in Table 1 and discussed below. The technology is an ES, implemented as a single instance with a common database. The primary goals of the organization's managers were to increase visibility into organizational operations and to better control those operations. The ES implementation generally achieved those goals. Individuals, while acknowledging and broadly supporting these organizational goals, were primarily concerned with successfully executing their own work responsibilities.

At a basic level, the ES provided users with affordances for recording (Affordance (Aff) 1 in Table 1) and accessing (Aff 3) data that were created through performing transactions (see "Basic Affordances" in Table 1). Because the ES is an organization-wide system designed to cover many work operations, users of the ES were able to perform most of their tasks via this single system (Aff 2) and store the associated data in a common database. As a result, users across the organization could access cross-functional and global data (Aff 3), rather than only being able to access the data in their local legacy systems. For the first two basic affordances in Table 1, ES users had little choice as to whether or not to actualize the affordance because use was mandated. Their work could not be accomplished other than through the ES because each transaction in the ES generated the data and conditions for performing the next work step. That said, the specific details of how an affordance was actualized differed across individuals depending on their abilities and understanding. Users had more choices about when and whether they accessed cross-functional and global data (Aff 3) and for which purposes they used those data.

While these basic affordances may seem trivial, an ES is complex. Some groups at ACRO, even months after implementation, were still attempting to actualize the basic affordances in ways that fulfilled organizational goals. For example, the transaction to accept a part into inventory required that all records (e.g., the records about the part ordered and about the part received) matched (Elmes et al. 2005). At ACRO's plants, there was a pile of parts in the receiving area that the ES would not accept into inventory because of differences across individual actualizations. Although accepting a part is a simple transaction, the receiving departments could not get the transactions to work regularly. At one plant, they reordered parts that were already sitting unrecognized in the receiving well, resulting in a large increase in inventory costs. They also used parts that had arrived but had not been formally accepted resulting in lost revenue because customers

Table 1. ACRO-SAP Affordances
Basic Affordances:
1. Recording data associated with performing transactions
2. Performing "all" work through a single system
3. Accessing cross-functional, global, and historical information in real-time
Standardizing and Integrating Affordances:
4. Standardizing processes and data
5. Integrating processes and data
Visibility Affordances:
6. Monitoring organizational operations across boundaries
7. Making decisions using cross-functional, global information
Controlling Affordances:
8. Controlling which individuals can perform each transaction
9. Guiding and constraining how work is done
10. Exercising real-time control over processes and outcomes using real-time data about organizational operations

could not be charged for parts not in the system. At another plant, they worked to determine the cause of problems, which required retraining a number of users about how to enter data about parts correctly, and revising procedures related to suppliers. Thus, while an ES provides users with affordances for recording data (e.g., about inventory), actualizing those affordances in a way that provides accurate inventory data is difficult.

Actualizing the standardizing and integrating affordances (Aff 4 and 5) requires that the ES be configured in particular ways (i.e., with a common database and common processes), and that it be used in standard ways (i.e., avoiding work-arounds), illustrating how specific IT features (e.g., the common database and embedded inventory handling processes) are associated with affordances and how the immediate outcomes of actualization actions may differ across individuals and groups. While ACRO's senior managers actively supported the standardizing and integrating affordances, the constraints that standardized work processes and data placed on how work could be done led to some customizations of work processes. For example, ACRO's attempt to have one standard process for managing inventory for building products, whether those were routine customer-ordered products or experimental prototypes built during product design and development, led to problems for design engineers, and a subsequent decision to develop some tailored transactions for building prototypes (Volkoff et al. 2005).

Actualizing the first five affordances in Table 1 provided consistent and standard global data through which users and managers had visibility and transparency to operations throughout the organization. Such data could be used to monitor operations across organizational boundaries (Aff 6); for example, ACRO customer service representatives used their visibility into plant operations to provide information to customers about the progress of their orders (Elmes et al. 2005), or to make decisions based on global data (Aff 7) (e.g., to manage inventory globally rather than locally).

In addition, at ACRO, control was enhanced by actualizing the three controlling affordances listed in Table 1. For example, managers chose controls that were much more restrictive than before in terms of which transactions users could perform (Aff 8), so that many users' jobs were narrowed substantially. Previously, organizational units were running their own legacy systems, in which users typically could perform any transactions within their system. The system as configured also restricted users to fewer choices about how each transaction could be executed (Aff 9). Finally, managers, and even other users, could use the real-time data from the system to manage and control operations in real-time (Aff 10).

Autoworks Case

The second case is Autoworks' implementation of a custom-built software system called CrashLab. This proprietary software supports pre- and post-processing for a finite element solver package that engineers use to assess the crashworthiness of vehicles designed at Autoworks. Like the ES at ACRO, a single version of the system was rolled out to all relevant users. Unlike the ES, CrashLab is a proprietary system intended to provide specific functionality and integrate with existing systems. Use of CrashLab was highly recommended but not required. Table 2 presents some key affordances experienced by users at and after CrashLab go-live, as gleaned from the publically available case material (Leonardi 2009, 2011a, 2011b, 2011c).

Table 2. Autoworks-CrashLab Affordances
Basic Affordances:
1. Setting up models for automated analysis by the solver
2. Generating output reports from the solver output
Standardizing Affordances:
3. Standardizing model setup routines
4. Standardizing output of post-processors
Communication Affordances:
5. Consulting more easily with other engineers
6. Sharing work
7. Communicating with engineering clients
Analysis Affordances:
8. Comparing multiple iterations of model tests
9. Analyzing and evaluating solver outputs to improve design approaches

As with the ES, engineers using CrashLab could actualize basic affordances, in this case related to preparing inputs and formatting outputs for a commercial finite element solver. CrashLab assisted users in setting up models for automated analysis by the solver (Aff 1). At the other end of the process, CrashLab also supported users in the generation of reports that presented the output of the solver in a more understandable form (Aff 2). Unlike ACRO, users seemed to be able to actualize the basic affordances correctly.

During CrashLab's construction, features to support standardization of engineering work related to finite model analysis became a key deliverable of the system, especially for standardizing how models were specified (Aff 3), but also for standardizing the outputs of model analysis (Aff 4) (Leonardi 2011a, 2011c). Actualizing these standardizing affordances was expected to fulfill a variety of goals. CrashLab was expected to eliminate some manual tasks related to model setup and testing, thus increasing the speed and productivity of engineers, but engineers discovered that the time required when using the tool was no shorter than doing the same tasks using existing tools. CrashLab also helped engineers to standardize how they performed these tasks and actually guided them through all of the steps. Thus, its use was also expected to reduce errors, and increase the quality, accuracy, and consistency of results. While these goals are important benefits themselves, equally important in hindsight is that actualizing the standardizing affordances provided the enabling conditions for additional affordances.

In particular, because engineers started to follow a standard practice, they could more easily consult each other (Aff 5) and even work on each other's tasks (Aff 6). In addition to these communication affordances for within-department exchanges, the system provided some output documents that helped engineers explain their model results to their clients, namely the automobile designers (Aff 7).

The final set of affordances for Autoworks supported engineers in performing different types of analysis. Because it had become easier to run multiple versions of a model with minor changes to parameters, engineers needed a way to compare results from different runs (Leonardi 2011c). While not originally part of CrashLab, a request was made for new functionality to help engineers produce a single output report across model runs (Aff 8). As the input process became easier and more standard, engineers began focusing more attention on model outputs and in so doing realized that the data being captured by their modeling runs could be mined to discover design trends and analyze which designs led to either successful or unsuccessful outcomes (Aff 9). This affordance was discovered about a year after CrashLab implementation, and its actualization required additional software features.

Applying a Critical Realist Perspective to the Cases

With this background on the key affordances at ACRO and Autoworks, we now use these cases to illustrate how viewing the effects of introducing technology into an organization as a pattern of interacting strands of affordances enables us not only to understand the variety of outcomes that a single organization experiences, but also to diagnose problems and recommend solutions.

Strands of Interacting Affordances

In the real domain, affordances exist as a potential for goal-directed action at any and every instant. That is why they are best viewed as strands spanning time; the potential is always there. For example, at any instant, ES users at ACRO can view global data and CrashLab users at Autoworks can generate output reports; those potentials exist whether or not any user views the data or any engineer chooses to generate a report. Similarly, at every instant, this potential for goal-directed action is conditioned by the structures that exist before action is taken, and any actions taken may either reinforce or elaborate that structure—the classic morphogenetic cycle (Archer 1995; Mutch 2010; Volkoff et al. 2007) or Hedstrom and Swedberg's (1998) macro–micro–macro mode, as described earlier. For example, an existing structural condition at ACRO at the time the ES was implemented was that customer service representatives were the first line of contact for customers, but the process they followed when a customer had questions about an invoice or an order was to refer them to the appropriate department (e.g., accounting for invoicing questions or manufacturing for order progress questions). As customer representatives actualized Affordance 3, and accessed the global data, they realized they had the information they needed to respond to such questions themselves. Over time, answering such questions became part of their job responsibilities (structural elaboration). Similarly, at Autoworks, original procedures for communicating with fellow engineers evolved once the standardizing model setup routine affordance was actualized, resulting in less individualized and more coordinated work practices.

While at any point in time the potential for action exists, the extent to which that potential is exercised or realized may vary; these are the "moments" of the affordance mentioned earlier. Thus we noted at ACRO that while all individuals using the ES "possessed" Affordance 1 (recording data associated with their transactions), at times users failed to exercise it, and some of those who exercised it did not actualize it completely or appropriately. The extent to which affordances are (or can be) actualized or even simply exercised depends on the presence of appropriate enabling, stimulating, and releasing conditions. These conditions are in fact the presence and degree of actualization of other affordances, as well as other mechanisms arising from broader organizational and environmental structures. The particular concatenation of different affordance strands/mechanisms is what leads to the observed phenomenon (Gambetta 1998).

For example, ACRO's customer service representatives could have failed to recognize the opportunities they had from the global data, they could have failed to actualize the basic affordances sufficiently to understand how to find and access the global data, they could have actualized the affordances so poorly that customers complained, they could have met resistance from accounting or manufacturing, who might then have withheld the needed data from the system, etc. Any of these conditions from other affordances or from non-affordance-based mechanisms (e.g., resistance from accounting) would have led to different immediate concrete outcomes of any attempts to actualize Affordance 3. At Autoworks, two different outcomes were observed: the Strut group changed to more coordinated work practices, but the Piston group, using the same technology, failed to recognize and realize the standardizing model setup affordance.

Affordance-based theories fulfill the demands in the IS literature for mid-range theories that provide explanations of causality at a level of granularity that is specific with respect to the technology while also providing some generality beyond individual case examples. Tables 1 and 2 not only list the affordances identified for the two cases, but also provide a start on specifying the interrelations and interactions among strands. In these tables, each grouping of affordances (e.g., visibility affordances) lists related affordances that provide related immediate concrete outcomes when actualized and that arise from the relation between similar technology structures and actors at similar organizational levels. Thus, they form a bundle of similar affordance strands. These bundles interact, providing the enabling, stimulating, or releasing conditions for other bundles of affordances. For example, in both case organizations, appropriately actualized basic affordances were the enabling conditions for exercising the remaining affordances. Similarly, appropriately actualized standardizing affordances served to stimulate and release the more advanced communicating and controlling affordances. As such, Tables 1 and 2 are preliminary affordance-based theories. While not fully developed, they still lead to some interesting observations consistent with the goals for mid-range theories of being technology specific, but also producing some generalizable results. In our two cases, we have two different technologies, one a package used by many organizations, and the other, a proprietary, internally developed software application. We also have two different organizations using the technology, one involving the routine work in a manufacturing organization, and the other involving specialized engineering groups within a larger organization.

For the packaged software, we argue that the list of affordances and their interrelations in Table 1 would also apply to the use of an enterprise system at other manufacturing companies. Of course, because initial structural conditions vary from one case to the next, and actors have various goals and skills, the actualization of these affordances can lead to quite

different outcomes. How dissimilar from ACRO those organizations would have to be before the affordances in Table 1 were no longer applicable is an empirical question that could be tested.

From these two cases, we also note the possibility for generalizing across technologies. While the specific details of the affordances are different between the two cases, in both cases we identified what we called *basic* affordances related to input and output (and we expect there would always be such basic affordances). Similarly, both cases had standardizing affordances. While the details are different, at a high level the immediate concrete outcome was that something (e.g., data definitions, processes, or output formats) became the same across all users. An interesting question for IS researchers is whether we can learn something about the standardizing affordance that can be applied broadly. To study this and other questions about more advanced affordances, we need a deeper understanding of how organizational level affordances emerge.

Emergence of Organizational Level Affordances

In the traditional affordance literature, ecological psychologists focused on affordances that arose from the relation between simple objects and individual actors with personal goals. To extend the affordance concept for use at an organizational level requires that we explore how higher level entities and properties emerge. We do this by noting that an affordance, as an emergent property of the relation between an object (IT artifact) and an actor, can arise from complex objects and organizational actors.

On the object (technology) side of the relation, an entity such as an IT artifact is itself formed from a set of component parts, structured by the relations between those parts, and in turn, each part formed by its subparts and their relations (Elder-Vass 2005). While some properties of an object are the result of the sum of the properties of the parts, other properties emerge from the relations between those parts, and are not properties of any of the parts. Thus the various physical components of an IT artifact each have their own characteristic properties, but when they are related in a specific way, a set of "deep" and "surface" structures emerge in the form of coded transactions, data structures, and user screens. Furthermore, from those structures and the way they are related emerge a set of latent structures, such as role and control structures (Strong and Volkoff 2010). For example, the latent control structures emerging from ACRO's ES in relation with the managers at ACRO who wanted more control provided the control affordances listed in Table 1.

On the actor side of the relation, an actor may be an individual, with personal goals, or an individual filling an organizational role intended to support organizational goals. Furthermore, the actor may be a group of people such as a team or a business unit. The characteristics of a group are more than simply the sum of the characteristics of the members of the group, emerging through the actions and negotiations of the individuals. For example, at Autoworks, individual engineers perform crashworthiness tests. These engineers are organized into groups, for example, the Strut group, where CrashLab was successfully implemented (Leonardi 2011a, 2011b) and the Piston group, a nearly identical group that failed in implementing exactly the same software (Leonardi 2009, 2011b).

The set of possible combinations of artifact and actor give rise to various affordances. Some may be classical in form (i.e., simple object/single actor in nature), but others may emerge from higher level relations. We refer to those affordances that arise from a complex artifact and either a role-based or multiperson actor motivated by organizational goals as organizational affordances. Thus, when we look at the set of affordances from the two cases (Tables 1 and 2), we can see that basic affordances arise from the relation between role-based individuals working to achieve role-based goals and the deep and surface structures of the artifact. At ACRO, this involved recording transactions and subsequently accessing the data, while at CrashLab the actors could set up models and later generate reports. Each actor may actualize the affordance somewhat differently, but role-based actors will generally be acting to serve organizational-level goals.

More complex affordances emerge from higher levels of the objects on both sides. Thus, for example, standardizing affordances are a relation between deep structures and a multiperson actor, namely the group of individuals performing similar tasks who need to negotiate the outcomes. For ACRO, the ES provides features that support users in achieving an organizational goal of standardizing and integrating data and processes, primarily through the ES's common database and through how deep structures are related to form work processes. As users actualize ACRO's basic affordances, they jointly contribute to standardizing and integrating, provided they perform the transactions correctly and without work-arounds, because much of the standardization and integration is embedded in the deep structures of each transaction. For Autoworks, CrashLab embeds routines to encourage the standardizing of model setup and provides a common output format to support standardizing of outputs, each of these being built into the deep structures and the relationships among them. As compared to the use of SAP at ACRO, CrashLab users have more choices in how they perform the basic affordances, and may even perform these

functions with tools other than CrashLab. As a result, Autoworks' users are not necessarily contributing to actualizing standardizing affordances as they use CrashLab or other tools to actualize basic affordances. With this flexibility, the engineers in the Piston group worked individually and did not contribute to actualizing the standardizing affordances, whereas the engineers in the Strut group started to follow common practices and did actualize the standardizing affordances.

When both the object on one side is itself a high-level emergent structure (e.g., a latent structure such as the embedded control structures of SAP) and the actor is a group (another emergent structure), then the result is a higher level affordance such as the controlling affordances at ACRO or the communication and analysis affordances at CrashLab. Because they do depend on the higher level structures on both sides, they also depend on the lower level structures and the associated affordances (Elder-Vass 2005). Thus they cannot emerge until the lower level affordances are to some extent successfully actualized.

This vertical stratification, which allows us to simultaneously consider affordances at different levels, enables a more nuanced and multi-layered account of how IT-associated organizational change occurs. By drawing our attention to higher level affordances, such as those that arise from relations with latent structures of IT artifacts, we are encouraged to look beyond the software functionality as designed and consider those relations. The multi-affordance view also enables us to explore how affordances interact rather than only considering each of them individually.

Comparing the Strand and Imbrication Metaphors

The use of a strand metaphor to understand affordances, informed by critical realism, is highly related to but also differs in important ways from Leonardi's (2011c) use of the imbrication metaphor. Both metaphors are consistent with asserting the existence of two types of agency, human and material, that are distinct but interact. Furthermore they are also consistent with stating that action leaves a residue that affects future action. From this starting point, the imbrication metaphor leads us to focus on two kinds of events or processes, those that change organizational routines and those that change the IT. Change, then, is a sequence of imbrications; that is, changes to routines until the IT becomes constraining, followed by changes to the IT, followed yet again by changes to routines to accommodate the new IT until it again becomes constraining, etc. In developing this change model, Leonardi uses the imbrications metaphor of tiling with two types of tiles. He then compares the structuring of routines and technology to the flow of current in a river (Leonardi 2011c, p.165), with the tiles as the visible pattern of how those changes occurred, much as the rock imbrication in fluvial sediments provides evidence of the invisible currents.

To extend Leonardi's metaphor to the next stage, our strands could be thought of as the currents themselves. The difference is that a change model built on the imbrication metaphor, by looking at events, focuses on the domain of the empirical, whereas a model built on the strand metaphor, by identifying affordances, focuses on the domain of the real, which allows us to speak more generically. While Leonardi does identify several affordances, they are treated as part of specific phases rather than as continuous action potentials. The challenge of tiles/rocks/events is that we see specific instances, which does not capture the potential for various actions to exist as continuous strands. The specific events are the empirical data that enables us to retroduce the affordances that produce them.

The imbrications-based model of change presents an effective explanation of how both material and human agency exist and are distinct, yet interact, a view with which we largely concur. That said, the neat pattern of alternating imbrication types may be too tidy for explaining the reality of change arising from the actions of many people engaging with a variety of affordances, each in their own way. Thinking in terms of strands over time enables us to explore how different strands/currents become intertwined to form an entire river. The strands may become intertwined in a variety of patterns. Over time, strands/currents join the structure, other strands become stronger or weaker, and still others end.

The strands, as they are becoming intertwined or concatenated, represent the continuous process of structuring and organizing. While there may be major events or discontinuities, which may show up as tiles on the surface, the process is a continuously dynamic one, not discrete or static. As the morphogenetic cycle indicates, structures are continuously being reinforced or changed.

An Affordance-Based Analysis of IT-Associated Organization Change

Having developed this image of affordances as a thick bundle of interacting strands, we can now talk about how an affordance-based theory helps us analyze problems experienced during IT-associated organizational change. Specifi-

cally, there are sources of change-related problems experienced during system implementation that can be more easily anticipated or diagnosed through an affordance-based analysis. One source of implementation problems is the inherent nature of affordances as simultaneously enabling and constraining, particularly as they interact. In this, our perspective differs from the way some IS literature treats affordances as only enabling. For example, Leonardi (2011c) treats affordances and constraints as distinct. In contrast, the cases described in this paper show a more paradoxical result. At ACRO, the two visibility affordances (the potential for users to monitor organizational operations across boundaries and to make decisions using global data) empowered users to do more than they could previously, while at the same time, the control affordances that emerged from visibility put restraints on the users that they found unwelcome, an effect Elmes et al. (2005) called "panoptic empowerment." ACRO's managers similarly experienced the double-sided nature of Affordance 9, the potential to control access to transactions. On one hand, such control was seen as an advantage in that it reduced risk, but at the same time it limited role flexibility, and reduced mangers' ability to dynamically reassign workers. This aspect of affordances suggests that both managers and researchers would do well to examine each affordance and explore the possible outcomes. Since individuals and organizations tend to hold simultaneously a variety of frequently conflicting goals, it is not surprising that the same affordance would be enabling on one hand and constraining on the other.

A second source of implementation problems is constraints that arise from the absence of a desired affordance. Thus, for example, a person wishing to sit might search in vain for something to sit on, or the user of an IT artifact may not find functionality that will serve to support a desired activity. This may be the type of constraint Leonardi (2011c) had in mind when distinguishing between affordances and constraints (e.g., that CrashLab does not provide functionality for easy comparisons across model runs), and certainly an obvious solution to this issue is to change the technology, as he suggests. Because affordances arise from the relationship between an object and an actor, affordances may be missing either due to missing features in the technology or missing characteristics of the organization or the actors (e.g., lack of individual skills).

A third source of implementation problems is the incomplete or inappropriate actualization of affordances. In other words, the affordance may exist and have the potential to provide advantages, but those advantages may not be realized—in fact, the affordance may not even be perceived despite being available. Unwillingness to change behavior, or an insufficient level of skill or knowledge, may also impede actualization. Inability to actualize an affordance may also arise because an associated affordance needs to be actualized first. All of these different reasons for incomplete or inappropriate actualization were seen in the two cases. For example, at Autoworks, the Piston group did not recognize the value from actualizing the standardizing affordances, and they gradually reduced their use of the system. Although the Strut group also seemed not to initially recognize the value of standardizing, as individual engineers discussed model setup problems, they gradually appreciated the value of using common model setup practices. If managers at ACRO and Autoworks had understood the affordances available and recognized the potential sources of problems, they may have been able to guide their implementations and achieve better outcomes.

Generally, identifying and examining the affordances that arise from actors' use of technology, and understanding the various sources of problems in terms of affordances, will provide valuable insights for both managers and researchers. Without the affordance lens, the sources of observed problems would be more difficult to diagnose. Furthermore, as researchers, we should not only identify the individual affordance strands, but also the ways in which strands interact. Assessing the relation between new IT and its potential users in such a way could produce guidelines for the process of actualizing affordances and provide managers and researchers with insights for recognizing how and why actualization is succeeding or failing, and what successful interventions might be.

Conclusion

To conclude, we first summarize the key contributions of our analysis, followed by their implications for practitioners and researchers. We then highlight the issues we have not addressed, and thus the many opportunities for further research.

Research Contributions

Paralleling the three core principles of critical realism identified in the introduction, we discuss our contributions in terms of the three dimensions of stratification, namely, real–actual–empirical, horizontal (temporal), and vertical (emergent), and show how they come together for the creation of technology-specific affordance-based theories of IT-associated organizational change.

The first dimension of stratification helps us clarify that affordances reside in the domain of the real, and thus they

represent the potential for action rather than action itself. Moreover, as real mechanisms, they exist whether we are aware of them or not; they need not be perceived, despite the fact that most affordance literature is about how they are perceived. The phenomena we observe are actualized affordances that allow us to retroduce the underlying real affordances. While the actualized phenomena are unique and specific to individual cases, the underlying real affordances are more generic, specific to a technology type in relation to a related type of organization. This more generic, yet technology and organization related view, allows us to build better mid-range theories of IT-associated organization change and avoids the common trap of only discussing surface events.

The horizontal or temporal dimension of stratification, derived from the morphogenetic cycle, reminds us that our theories must differentiate between agency and structure yet capture how the two interact over time. Specifically, through the strand metaphor introduced in this paper, we capture the way the actualization of an affordance achieves organizational change through cycles of macro structures conditioning individual actions that then lead to subsequent reinforcement or elaboration of those structures. Analyzing the moments of actualization along these strands provides a way of studying why and how an actualization process might become stalled.

Using critical realism's vertical concept of emergent entities that arise from lower level component structures, we developed the theoretical rationale for organizational level affordances. While affordances, as defined in the ecological psychology literature, are a relation between an individual and a simple object, we needed to show how the concept of affordances also applies to the relations between the structures emerging from the complex relations within an IT artifact and the structures emerging from complex relations with an organization. We have explicated the missing theoretical rationale, so that the concept of affordances now has the necessary theoretical foundation to be used for building affordance-based theories of IT-associated organizational change.

Many of the existing references to affordances in the IS literature either ignore or deny the critical realist underpinnings of the original concept. We linked the concept of affordances more firmly and thoroughly to its critical realist roots by explaining how affordances are a special case of generative mechanisms. Specifically, unlike generative mechanisms, which can arise from individual structures or the relations between different structures or the relations between structures and actors, affordances arise specifically from the relation between objects such as IT artifacts and goal-directed actors. This both clarifies the ontological status of affordances, and allows us to take advantage of ideas from critical realism.

Of particular value for IS researchers, we illustrated and supported our theoretical arguments with empirical evidence from two published cases. We examined the cases to discover the affordances that were evident in the IT implementation and use process, which served to concretely illustrate what affordances are and how to think about IT-associated organizational change in terms of the actualization of affordances. In identifying 19 specific affordances, grouped into 7 more general affordances, we demonstrated how to engage in such research. We used the concept of affordances and a critical realist perspective to explain some of the observed outcomes in the two cases in terms of the types of problems encountered during IT implementation and use, and to show how taking this perspective could aid organizational managers in developing the understanding needed to intervene appropriately in IT-associated organizational change processes.

Implications for Practitioners and Researchers

In various places throughout the paper, we have noted the value of a critical realist perspective and affordance-based theories on IT-associated organizational change—sometimes for practitioners attempting to ensure that an organization achieves useful outcomes from IT and sometimes for researchers attempting to develop mid-range theories of IT-associated organizational change. For practitioners, this approach should help them plan for the implementation process and recognize and intervene when there are problems. Specifically, understanding that higher level affordances are emergent properties that typically first require actualization of lower level affordances can help in planning the implementation and managing expectations. Understanding the different sources of problems (i.e., those that arise from the inherent nature of the affordance, those that arise from missing affordances either in the form of missing technology features or missing individual abilities, and those that arise from poor or incomplete actualization) can help professionals determine how and whether intervening can produce better outcomes. Researchers can use such knowledge to compare implementations of similar IT artifacts in different organizations in a more systemic way and to build better mid-range theories of how IT-associated change unfolds in organizations.

Limitations and Future Research

While we have developed a foundation for affordance-based theories of IT-associated organizational change and linked it

to critical realism to provide a philosophical underpinning for such theories, there are still a number of open issues we did not address or only partially addressed. First, we briefly mentioned, but did not really address, how non-technology-related generative mechanisms interact with affordances during an IT-enabled change process. Because affordances and the various problems in actualizing those affordances are unlikely to be a complete explanation of organizational outcomes, affordance-based theories of IT-associated organizational change must include or acknowledge such non-technology-related mechanisms. Second, while we illustrated our theoretical arguments with an analysis of two rich case studies that matched our needs well, we did not start from scratch to collect and analyze data from our new theoretical perspective. Doing so is likely to provide more insights and more guidelines to researchers for conducting such studies.

In summary, we have made significant contributions and theoretical progress in filling the gap between (1) the calls for affordance-based and critical realist-informed IS research and (2) the theoretical foundations needed to conduct such research. We have also provided some clear examples of affordances to help others understand what they are looking for in their empirical work, but there is still much to be done. One of the best ways to continue this research stream is to conduct empirically based studies to develop such mid-range theories.

Acknowledgments

We thank the special issue editors, our associate editor, and our reviewers for their helpful comments and suggestions. We also thank Bendik Bygstad for his insightful discussions on critical realism with one of us. While we were only involved in developing the ACRO case, we thank the interviewees at both ACRO and Autoworks for sharing the information that provided such rich case studies for our analysis. The research leading to each of these cases was funded by the National Science Foundation, under Grant No. SES-0114954 (ACRO case) and ITR-0427173 (Autoworks case). Any opinions, findings, conclusions, or recommendations expressed in this paper are those of the authors and do not necessarily reflect the views of the National Science Foundation, nor of Paul Leonardi. We especially thank Paul Leonardi, not only for his publications on the Autoworks case, but also for reading the accepted version of our paper to identify any glaring errors in our interpretation of his data. We are solely responsible for any remaining errors.

References

Archer, M. S. 1995. *Realist Social Theory: The Morphogenetic Approach*, Cambridge, UK: Cambridge University Press.

Bhaskar, R. 1994. *Plato Etc*., London: Verso.

Bhaskar, R. 1998a. "General Introduction," in *Critical Realism: Essential Readings*, M. S. Archer, R. Bhaskar, A. Collier, T. Lawson, and A. Norrie (eds.), London: Routledge, pp. ix-xxiv.

Bhaskar, R. 1998b. "Philosophy and Scientific Realism," in *Critical Realism: Essential Readings*, M. S. Archer, R. Bhaskar, A. Collier, T. Lawson, and A. Norrie (eds.), London: Routledge, pp. 16-47.

Bygstad, B. 2010. "Generative Mechanisms for Innovation in Information Infrastructures," *Information and Organization* (20:3/4), pp. 156-168.

Carter, B., and New, C. (Eds.). 2004. *Making Realism Work: Realist Social Theory and Empirical Research*, London: Routledge.

Chemero, A. 2003. "An Outline of a Theory of Affordances," *Ecological Psychology* (15:2), pp. 181-195.

Coleman, J. S. 1986. "Social Theory, Social Research, and a Theory of Action," *American Journal of Sociology* (91:6), 1309-1335.

Danermark, B., Ekstrom, M., Jakobsen, L., and Karlsson, J. C. 2002. *Explaining Society,* New York: Routledge.

DeLanda, M. 2006. *A New Philosophy of Society: Assemblage Theory and Social Complexity*, London: Continuum.

Demetriou, C. 2009. "The Realist Approach to Explanatory Mechanisms in Social Science," *Philosophy of the Social Sciences* (39:3), pp. 440-462.

Dobson, P. J. 2001. "The Philosophy of Critical Realism: An Opportunity for Information Systems Research," *Information Systems Frontiers* (3:2), pp. 199-210.

Elder-Vass, D. 2005. "Emergence and the Realist Account of Cause," *Journal of Critical Realism* (4:2), pp. 315-338.

Elder-Vass, D. 2007. "For Emergence: Refining Archer's Account of Social Structure," *Journal for the Theory of Social Behaviour* (37:1), pp. 25-44.

Elder-Vass, D. 2010. *The Causal Power of Social Structures*, Cambridge, UK: Cambridge University Press.

Elmes, M. B., Strong, D. M., and Volkoff, O. 2005. "Panoptic Empowerment and Reflective Conformity in Enterprise Systems-Enabled Organizations," *Information and Organization* (15:1), pp. 1-37.

Fayard, A.-L., and Weeks, J. 2007. "Photocopiers and Water-Coolers: The Affordances of Informal Interaction," *Organization Studies* (28:5), pp. 605-634.

Fleetwood, S. 2005. "Ontology in Organization and Management Studies: A Critical Realist Perspective," *Organization* (12:2), pp. 197-222.

Fleetwood, S. 2011. "Powers and Tendencies Revisited," *Journal of Critical Realism* (10:1), pp. 80-99.

Gambetta, D. 1998. "Concatenations of Mechanisms," in *Social Mechanisms*, P. Hedstrom and R. Swedberg (eds.), Cambridge, UK: Cambridge University Press, pp. 102-124.

Gibson, J. J. 1986. *The Ecological Approach to Visual Perception*, Hillsdale, NJ: Lawrence Erlbaum Associates.

Hedstrom, P., and Swedberg, R. 1996. "Social Mechanisms," *Acta Sociologica* (39:3), pp. 281-308.

Hedstrom, P., and Swedberg, R. 1998. "Social Mechanisms: An Introductory Essay," in *Social Mechanisms,* P. Hedstrom, and R. Swedberg (eds.), Cambridge, UK: Cambridge University Press, pp. 1-31.

Hedstrom, P., and Ylikoski, P. 2010. "Causal Mechanisms in the Social Sciences," *Annual Review of Sociology* (36), pp. 49-67.

Hutchby, I. 2001. "Technologies, Texts and Affordances," *Sociology* (35:2), pp. 441-456.

Kane, G. C., Bijan, A., Majchrzak, A., and Faraj, S. 2011. "The Paradoxical Influence of Social Media Affordances on Intellectual Capital Creation," paper presented at the Academy of Management Annual Meeting, San Antonio, TX.

Leonardi, P. M. 2009. "Why Do People Reject New Technologies and Stymie Organizational Changes of Which They Are in Favor? Exploring Misalignments Between Social Interactions and Materiality," *Human Communication Research* (35:3), pp. 407-441.

Leonardi, P. M. 2011a. "Innovation Blindness: Culture, Frames, and Cross-Boundary Problem Construction in the Development of New Technology Concepts," *Organization Science* (22:2), pp. 347-369.

Leonardi, P. M. 2011b. "When Does Technology Enable Organizational Change? Convergent Feature Use and Collective Affordances," paper presented at the Academy of Management Annual Meeting, San Antonio, TX.

Leonardi, P. M. 2011c. "When Flexible Routines Meet Flexible Technologies: Affordance, Constraint, and the Imbrication of Human and Material Agencies," *MIS Quarterly* (35:1), pp. 147-167.

Mahoney, J. 2003. "Tentative Answers to Questions about Causal Mechanisms," paper presented at the American Political Science Association Annual Meeting, Philadelphia, PA.

Markus, M. L., and Silver, M. S. 2008. "A Foundation for the Study of IT Effects: A New Look at DeSanctis and Poole's Concepts of Structural Features and Spirit," *Journal of the AIS* (9:10/11), pp. 609-632.

Michaels, C. F. 2003. "Affordances: Four Points of Debate," *Ecological Psychology* (15:2), pp. 135-148.

Mingers, J. 2004a. "Re-establishing the Real: Critical Realism and Information Systems," in *Social Theory and Philosophy for Information Systems*, J. Mingers and L. Willcocks (eds.), Chichester, UK: John Wiley & Sons Ltd., pp. 372-406.

Mingers, J. 2004b. "Real-izing Information Systems: Critical Realism as an Underpinning Philosophy for Information Systems," *Information and Organization* (14:2), pp. 87-103.

Mutch, A. 2010. "Technology, Organization, and Structure—A Morphogenetic Approach," *Organization Science* (21:2), pp. 507-520.

Norman, D. A. 1988. *The Psychology of Everyday Things*, New York: Basic Books.

Norman, D. A. 1999. "Affordance, Conventions, and Design," *Interactions* (6:3), pp. 38-43.

Sayer, A. 2010. *Method in Social Science: A Realist Approach* (revised 2nd ed.), New York: Routledge.

Smith, M. L. 2006. "Overcoming Theory–Practice Inconsistencies: Critical Realism and Information Systems Research," *Information and Organization* (16:3), pp. 191-211.

Stoffregen, T. 2003. "Affordances as Properties of the Animal-Environment System," *Ecological Psychology* (15:2), pp. 115-134.

Strong, D. M., and Volkoff, O. 2010. "Understanding Organization–Enterprise System Fit: A Path to Theorizing the Information Technology Artifact," *MIS Quarterly* (34:4), pp. 731-756.

Strong, D., Volkoff, O., Johnson, S., Pelletier, L., Tulu, B., Bar-On, I., Trudel, J., and Garber, L. Forthcoming. "A Theory of Organization-EHR Affordance Actualization," *Journal of the AIS.*

Volkoff, O., Strong, D. M., and Elmes, M. B. 2005. "Understanding Enterprise Systems-Enabled Integration," *European Journal of Information Systems* (1:42), pp. 110-120.

Volkoff, O., Strong, D. M., and Elmes, M. B. 2007. "Technological Embeddedness and Organizational Change," *Organization Science* (18:5), pp. 832-848.

Wynn, D. J., and Williams, C. K. 2012. "Principles for Conducting Critical Realist Case Study Research in Information Systems," *MIS Quarterly* (36:3), pp. 787-810.

Zammuto, R. F., Griffith, T. L., Majchrzak, A., Dougherty, D. J., and Faraj, S. 2007. "Information Technology and the Changing Fabric of Organization," *Organization Science* (18:5), pp. 749-762.

About the Authors

Olga Volkoff, Ph.D., University of Western Ontario, is an associate professor and Associate Dean at the Beedie School of Business, Simon Fraser University. Her research focuses on the organizational changes associated with the introduction of large packaged software such as enterprise systems and electronic health record systems. She is currently looking at effective use of systems, and is also particularly interested in the use of critical realism as the philosophical underpinning of IS research. Papers published with Diane Strong include articles in such journals as *MIS Quarterly, Organization Science, European Journal of Information Systems,* and *Information and Organization*.

Diane M. Strong, Ph.D., Carnegie Mellon University, is a professor in the School of Business at Worcester Polytechnic Institute and director of its IT Programs. Her research focuses on advanced information technologies, such as enterprise systems and electronic health record systems, and how their design, implementation, and use affect integration, standardization, and other outcomes in organizations. Recently, she has been focusing on health IT. With NSF funding, she is investigating how electronic health record systems can improve the delivery of primary care and how mobile devices can help patients better manage their chronic conditions. She is a founding member of WPI's Healthcare Delivery Institute.