From Use to Effective Use: A Representation Theory Perspective

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Abstract

Information systems must be used effectively to obtain maximum benefits from them. However, despite a great deal of research on when and why systems are used, very little research has examined what *effective* system use involves and what drives it. To move from use to effective use requires understanding an information system's nature and purpose, which in turn requires a theory of information systems. We draw on representation theory, which states that an information system is made up of several structures that serve to represent some part of the world that a user must understand. From this theory, we derive a high-level framework of how effective use and performance evolve, as well as specific models of the nature and drivers of effective use. The models are designed to explain the effective use of any information system and offer unique insights that would not be offered by traditional views, which tend to consider information systems to be just another tool rather than examining their unique characteristics. We explain how our theory extends existing research and can provide a new platform for research on this important topic.

Keywords: effective system use, performance, goals, representation theory, system structure.

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1. Introduction

Organizations rely heavily on information systems, with most investing over 50% of their capital expenditures on them, yet only 10% of systems deliver desired benefits (McAfee 2006). As a result, there is a significant need for researchers to learn how to increase the benefits obtained from information systems. Intuitively, these benefits depend on how effectively systems are *designed* and *used*. In this paper, we address how effectively systems are *used*.

The most heavily studied topic in IS research over the last 20 years has been when and why people use systems. This research has been motivated by the same concern driving ours. For example, researchers often begin their articles explaining that for organizations to reap benefits from systems, systems must be accepted and used (Venkatesh et al. 2003 p. 426). That body of work has been enormously beneficial in helping us learn how to get users to accept and use systems. However, system use alone is not sufficient to obtain benefits (Seddon 1997); the use must be *effective*. Perhaps for this reason, Marcolin et al. (2000, p. 52) predicted that researchers would move “from the study of use …to the study of effective use…” but their prediction has not yet been fulfilled. We believe it is important to take that step and study what *effective* use involves and how it can be improved.

Our approach to taking this step is driven by a second motivation: to consider the *unique* nature of information systems. In other words, we do not wish to propose a theory that will explain the effective use of any artifact. Rather, our guiding research question is “what is an information system and what does this imply for what effective use involves?” Different views on what constitutes an information system may imply different answers to what effective usage involves. We adopt a theory known as representation theory that suggests that an information system is made up of several structures that serve to represent some domain (Weber 2003). We draw on representation theory to build our theory of what effective use involves and what drives it.

In the next section, we situate our work within past research on system use and representation theory. We then propose our theory of the nature and drivers of effective use. We provide examples of the constructs and relationships in our theory by referring to several types of information systems and by drawing on several case studies. We conclude by highlighting how our work extends past research and how our theory can be tested and extended.

2. Background

Our work extends two research areas: research on the performance outcomes of system use and representation theory. After defining effective use, we briefly review both areas.

2.1 Defining Effective Use

We define effective use as *use of a system that increases a user's goal achievement*. Like Gasser (1986), we assume that systems are never used just to "use" them. Rather, they are used to achieve *other* goals, such as to buy products, process transactions, communicate, or simply have fun. Our definition is adapted from Burton-Jones and Straub's (2006) definition of system use. They suggested that system use involves a user, system, and task, where a task is a "goal-directed activity" (Burton-Jones and Straub 2006, p. 231). To move from use to effective use, we simply replaced their notion of goal-directed activity with the notion of goal achievement.

We should note three assumptions that underlie our definition. First, we recognize that users can exist at any level of analysis, e.g., individual, group, or organization. However, we focus our theory on the individual level for reasons of scope. Second, we adopt a broad view of goals. A goal is simply a "cognitive representation of a desired end-point" (Fishbach and Ferguson 2007 p. 491). Rather than limiting our view to any one type of goal (e.g., conscious utilitarian goals), we assume that a goal is simply whatever end-point the user wishes to achieve through using a system. Third, we assume that goal achievement has objective qualities, i.e., it may be hard to assess in some cases, but it is not completely subjective. Operationally, goal achievement is typically assessed in terms of performance (Sonnentag 2002). Thus, we view effective use and performance to be objective notions.

Our concept of effective use is closely related to and yet distinct from the concept of perceived usefulness (or performance expectancy), which is “the degree to which an individual believes that using the system will help him or her better attain significant rewards” (Venkatesh et al. 2003, p. 23). In a pre-adoption context, perceived usefulness can be thought of as a user’s *expectation* of his/her effective use; in a continued use context, it can be thought of as a user’s *perception* of his/her effective use. In either case, perceived usefulness is a *user’s* rating. Our concept of effective use is not defined in terms of any specific rater. We recognize that different raters (users, managers, researchers) may perceive it differently, but we view it as having objective elements. We leave the specific rater to researchers’ choice when testing the theory, and we return to this issue in our discussion section.

2.2 System Use and Performance Outcomes

After a detailed review of the literature, we found no in depth studies on the nature or drivers of effective use. The closest body of work involves studying the performance outcomes of system use. Table 1 outlines the main contributions in this stream. Although these studies have not studied effective use in the same way that we defined it, their motivation has been similar: to understand how systems need to be used to increase user’s performance. As Table 1 shows, these studies have identified: (1) *types* of use that increase users’ task performance, and (2) *contexts* in which system use increases users’ performance, e.g., when the system fits the task and when users are more competent.

Table 1: Research Linking System Use to Performance Outcomes

Focus of study	Description	Representative studies
Type of use		
Faithful use	Users’ task performance increases when they use an IS faithfully, i.e., in a way that is consistent with the system’s intended use.	(DeSanctis and Poole 1994; Chin et al. 1997)
Exploitive and exploratory use	Users’ short-run task performance increases when they exploit their knowledge of the IS; their long-run performance increases when they exploit their knowledge of the IS and explore new ways of using it.	(Subramani 2004; Burton-Jones and Straub 2006)
Applied and adapted use	Users’ task performance increases when they apply IS in their tasks and when they adapt the IS and adapt themselves (through learning).	(Barki et al. 2007)

Focus of study	Description	Representative studies
Effective use	Users' task performance increases when they employ ISs effectively in their tasks.	(Pavlou and El-Sawy 2006; Pavlou et al. 2008)
Quality use	Users' task performance is affected by the quality with which they employ the IS	(Boudreau and Seligman 2005; LeRouge et al. 2007)
Sophisticated, novel use	Users' task performance increases when they employ an IS in a sophisticated and novel way.	(Jain and Kanungo 2005)
Context of use		
Task-technology fit	System use (and faithful use) increase users' task performance when the IS fits the task.	(Goodhue and Thompson 1995; Dennis et al. 2001; Devaraj and Kohli 2003; Ahearne et al. 2008)
User-task-technology fit	System use increases users' task performance when the IS fits the task and the user is sufficiently competent to use it.	(Marcolin et al. 2000)

Although these studies have informed our understanding of effective use, most have addressed the nature or drivers of effective use in isolation. Thus, there is no seamless account of what effective use involves and how to improve it. In Table 1, for example, studies focusing on *types* of use have shown what effective use involves, but only a few have examined what drives it. DeSanctis and Poole (1994) discussed many drivers, but left the discovery of which ones would be important to future researchers (p. 128). Only two studies in Table 1 examined specific drivers. Boudreau and Seligman (2005) proposed that the quality with which users employ an enterprise resource planning (ERP) system at time 2 is a function of their quality of use at time 1, their perceptions of the system at time 2, and the extent to which they took actions to learn the system between times 1 and 2. Pavlou et al. (2008) proposed that users will employ collaboration systems effectively if they perceive them to be useful, easy to use, and customizable; if they trust their group members; if their use of the system is a habit; and if the environment is uncertain. Both studies demonstrate that it is feasible to identify what drives effective use, but only for specific systems (ERP and collaboration systems). We aim to extend their work by explaining the drivers of effective use for information systems in general.

The studies in Table 1 focusing on *contexts* have identified contexts that enable effective use but they have not conceptualized what effective system involves. For example, user-task-technology fit theory (Marcolin et al. 2000) proposes that use will increase task performance if the system fits the task and the user is competent. However, that research could be extended to reveal what effective use actually looks like in this context—that is, how do more competent users use systems differently than regular users that leads them to perform more effectively? Overall, we extend both streams of work in Table 1 by explaining what drives effective use and what effective use involves (i.e., its dimensions).

2.3 Representation Theory

As stated earlier, a motivation of our study is to take seriously the unique nature of information systems. Our basic premise is that the effective use of any artifact must stem in large part from the nature and purpose of that artifact. Thus, we need a theory that describes the nature and purpose of information systems. Working against this mandate is the reality that many types of systems exist with different purposes, and even single systems can have multiple, and at times conflicting, purposes. For example, a system can support workers while controlling them and rendering them substitutable (Orlikowski 1991). Thus, very few theories address this issue.

One exception is representation theory (Wand and Weber 1990; 1995; Weber 1997),[1] which says that information systems exist because "it is the human condition to seek better ways to understand and to represent the world" (Weber 1997, p. 59). That is, although information systems can be used for many task-specific reasons, the core purpose of *all* information systems is to help people understand the states of some real-world systems that are relevant to them, such as the states of their mind (represented, for example, in a word processing system), states of their organization (represented, for example, in a payroll system), or states of the organization's environment (represented, for example, in an environmental scanning system). Weber (2003 p. viii) writes,

> … "representation" [is] the essence of all information systems. The raison d'etre for information systems [is] that they track states of and state changes in other systems. By observing the behavior of an information system, we obviate the need to observe the behavior of the system it represents…. For example, with an order-entry information system, we track states of and state changes in customers, which means

[1] The clearest description of representation theory is found in Weber (1997, Ch. 3).

that we do not have to consult with each customer individually to determine the goods or services they wish to purchase. Moreover, in some cases an information system provides us with the only means we have available to observe the behavior of the represented system. For example, in a simulation, the represented system may not exist, except in our minds."

Representation theory describes the nature and purpose of an IS as follows. First, in terms of *nature*, representation theory states that information systems consist of three structures (Weber 1997, pp. 78-80). *Deep structure* is the representation provided by the system, such as the representation in an inventory system that there are 50 items in the warehouse. *Surface structure* is the facilities that allow users to access and interact with the representations, such as the inventory system's user interface, including its various screens, menus, and report layouts. *Physical structure* is the machine that support the other structures, such as the devices on which they are stored (computers, servers), viewed (monitors), transported (networks), and computed (circuits). There are subtleties in the definition of each structure, but they can be thought of, broadly, as information (deep structure), interface (surface structure), and machine (physical structure). Table 2 gives examples of each one.

Table 2: Illustrating Concepts from Representation Theory

Types of information system		**Examples of system structures**		
Category	**Example**	**Deep structure**	**Surface structure**	**Physical structure**
Function IT[1]	Word processing	Representations of thoughts in a user's mind	Interfaces through which a user can read, edit, and reorganize text	Computer(s) on which the program and document are stored and can be accessed
Network IT[1]	Email	Representations of messages sent and received among individuals over time	Interfaces through which a user can read and write emails and organize past emails, such as into folders	Clients, servers, and networks through which messages are copied, exchanged, and stored
Enterprise IT[1]	Enterprise-wide software	Representations of the state of a work process in a business (such as the state of an inventory supply chain)	Forms through which users enter data and the menus and screens that users access to perform tasks	Clients, servers, and networks on which data is stored, programs are executed, and messages are sent
About reality[2]	Accounting system	Representations of the financial situation of a person or business	Forms through which users enter data and menus and screens that users access to perform tasks	The computer(s) on which the program and data are stored and can be accessed

Types of information system		Examples of system structures		
Category	**Example**	**Deep structure**	**Surface structure**	**Physical structure**
For reality[2]	Decision support system	Representations of initial conditions (such as the decision situation and decision criteria), and suggested decisions and their explanations	Forms through which users enter data and output views provided to users to convey recommended decisions	The computer(s) on which the program and data are stored and can be accessed
As reality[2]	Video conferencing system	Representations of two or more people participating in a meeting	Viewing window through which users can view participants and icons they can click to change viewing settings	The physical screens, communication devices, and networks through which calls are made and viewed

Key: Categories of information systems: [1] McAfee 2006, [2] Borgmann 1999.

Second, representation theory states that the *purpose* of an information system is to faithfully represent a real world domain (Weber 1997, p. 73). The idea that systems provide representations is not unique to this theory. In IS, it can be seen in studies of IT-impacts (Ruhleder 1994), knowledge management (Walsham 2005), virtual work (Robey et al. 2003; Overby 2008), and organizational design (Yoo et al. 2006). This idea is also important in related fields such as database (Kent 2000), HCI (Suchman 1995; Bodker 1998), and AI (Davis et al. 1993). The unique aspect of representation theory is its focus on *faithful* representations (Weber 1997, p. 59). The theory assumes that people use systems to interact with the deep structure, and that they desire deep structures that faithfully represent some domain; the other structures of a system are used simply as a means to that end.

Representation theory supposedly applies to ***all*** information systems (Wand and Weber 1988). We recognize that this view could be criticized on two fronts. First, researchers might challenge its claim of generalizability, arguing that it cannot, in fact, account for all information systems, and suggest that we use an alternative general theory of information systems. Second, and in contrast, researchers might challenge our use of a general theory, and argue that we should, instead, use a theory that is tailored to specific systems and specific tasks. Both of these criticisms have merit. It is possible that representation theory might fail to account for all information systems and it is also possible that specific theories might provide more powerful explanations for any given system than a general theory.

Even so, we believe that exploring the implications of representation theory has merit. Within the scope of this paper, it is not possible to explore the implications of multiple general theories, nor the implications of both a general theory and a specific theory. Thus, we simply take the assumptions of representation theory as given and discuss later how researchers could pursue other general theories of information systems, or theories tailored to specific systems. Our justification for choosing representation theory simply lies in its long history in the IS field (Wand and Weber 1988), its focus on what makes information systems unique, and its untapped potential for explaining effective use. In Appendix 1, we provide further details about how our work extends research on this theory.

Overall, the main aim of our paper is to extend past research in three ways: (1) identify what effective use involves (i.e., its specific dimensions), (2) identify what drives it, and (3) derive both of these facets from a theory that takes seriously the unique characteristics of information systems (representation theory). In the next section, we outline a theory we developed to achieve these aims.

3. A Theory of Effective Use

To build the theory, we followed a three-step approach suggested by Ostrom (2005 pp. 27-29), a noted theorist: (1) propose a high-level framework that defines the kinds of variables to be included in the theory and associated metatheoretical assumptions; (2) apply the framework in the context of some specific phenomenon, and (3) propose empirically testable models.

3.1 Framework

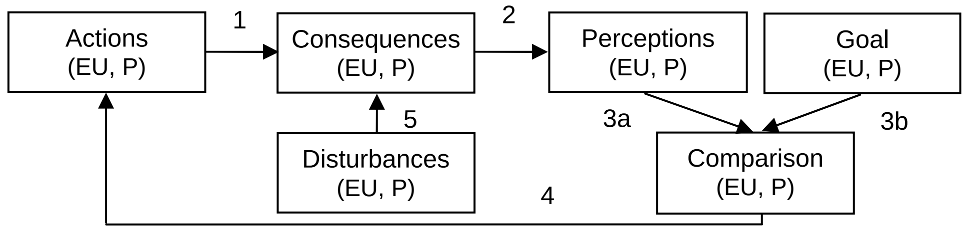
The first step was to identify a high-level framework that would reflect the metatheoretical assumptions of representation theory and that could help us analyze effective use. The main metatheoretical assumptions of representation theory are *critical realism*, which it uses to explain the nature of representations, and *teleology*, which it uses to explain their purpose.

Critical realism says that the world exists independent of our perceptions but that we know the world only through our perceptions, which are partial and fallible (Weber 1997, p. 174). The implication of adopting critical realism is that representation theory assumes that the representations provided by information systems are fallible, and that their fallibility may be difficult to determine (Weber 1997, p. 175). *Teleology* is the view that human behavior is goal-driven. This can be seen in the theory's position that information systems are created and used to meet basic human needs:

> "…sentient things often seek better ways of obtaining information about other things…. Our ability to survive in the world is often associated with how well we conceive the world and how we then use information to represent the world….And nothing is more certain than these efforts will continue. It is the human condition to seek better ways to understand and to represent the world!" (Weber 1997, p. 59).

The fact that representation theory adopts both critical realism and teleology has an important implication. Specifically, it implies that people will try to improve how they create and use systems because they benefit from having better representations. However, because representations are fallible, there is always room for improvement, and because fallibility is difficult to determine, there is always the potential that users may overinvest, underinvest, or misdirect their efforts in creating and using systems. In sum, these assumptions imply that although the creation and use of information systems can improve over time, the process is likely to be never-ending and error-prone.

Upon identifying this implication, we set out to identify a framework that could reflect it. One such framework is the cybernetic framework underlying self-regulation theory (Carver and Scheier 1998), which has been used to study IT use-related topics before (Liang and Xue 2009). We illustrate it in Figure 1. Using Figure 1, representation theory can be explained as follows: people create and use information systems to obtain better representations than available elsewhere, such as manual systems (Link 1); they then perceive the consequences of creating and using the systems (Link 2); if the consequences do not match those desired (Links 3a and 3b), they conduct actions to improve their design and use (Link 4). Finally, disturbances can affect consequences at any stage (Link 5), for example, changes in a business could mean that a system no longer provides an adequate representation of the domain, necessitating further corrective action. Because this framework can account for the arguments of representation theory quite well, and is consistent with its metatheoretical assumptions, we used it as the basis for our theory, outlined next.



Key: ***Meaning of links:*** 1. Peoples' actions have consequences; 2. People perceive the consequences of their actions; 3a,b: People compare their perceptions to their goals; 4. People conduct corrective actions if goals have not been achieved; 5. External disturbances can also affect consequences.

EU, P: Performance and effective use are included inside each element to indicate that performance and effective use are relevant for each one, e.g., people can take actions to improve effective use, but they can also take other independent actions to improve performance (as explained next in §3.2).

Figure 1: A General Framework for Studying Effective Use

3.2 Applying the framework

The second step was to apply the high-level framework in the context of effective use and performance. The letters "EU" and "P" in Figure 1 illustrate how we did this. They reflect the concept of a goal hierarchy, which is that people can have goals at different levels that contribute to each other (Carver and Scheier 1998). This flows from the assumption we mentioned earlier that systems are always used to achieve some other goal, i.e., they are used as a means to an end rather than used for their own sake (Gasser 1986). Goal theories tell us that any means can also be considered a goal (Vallacher and Wegner 1987). Thus, we apply the notion of a goal hierarchy to propose two goals in our theory—effective use and performance—where effective use is the lower-level goal (the means) and performance is the higher-level goal (the desired end). Thus, including the words "performance" and "effective use" in each box in Figure 1 implies that each box can be viewed in terms of both aspects. That is, people can have goals for both, conduct actions to improve both, perceive consequences for both, compare consequences to their goals for both, and so on.

Although the framework in Figure 1 is set at a relatively high-level, it accounts for several complexities involved in studying effective use. For example, similar to task-technology-fit theory (Goodhue and Thompson 1995), Figure 1 shows that users can adjust their use of a system based on feedback. However, Figure 1 also allows us to account for the fact that using a system might not be the only or even the best way to improve performance (Haas and Hansen 2005). In particular, including both effective use and performance in each element of Figure 1 suggests that:

- users can take several actions to improve their performance; they are not limited to improving it only through effective use of a system
- users can attend to feedback from effective use as well as from performance; and
- when responding to feedback, users can take actions to improve their use of the system, their performance, or both.

Although Figure 1 provides an integrative perspective on effective use, it is not specific enough to provide concrete explanations. It simply reflects how effective use and performance evolve and does so in a way that matches the assumptions of representation theory (critical realism and teleology). In light of recent discussions (e.g., Ortiz de Guinea and Markus 2009), it is worth noting that teleology assumes that users can seek goals consciously and/or unconsciously (Austin and Vancouver 1996). Thus, Figure 1 does not assume that users continually and consciously monitor feedback and take corrective action. It just assumes that improving effective use and performance is a cyclical, error-prone process influenced by the self-regulatory mechanisms of the user and external disturbances.

To facilitate our next step—developing testable models—we took a closer look at one part of the overall framework. We focused on link 1 in Figure 1. Figure 2 provides a closer view of this link. Figure 2 shows that users can take *actions* to improve both effective use and performance and that these have *consequences* for both effective use and performance. At first glance, it might seem more intuitive to think of effective use as an action and performance as a consequence. However, consistent with how we defined them in §2.1, we conceive both constructs to be *consequences* because we view them as actual (objective) states that can be assessed at any given time. As Figure 2 shows, these consequences contribute to each other in a means-end relationship, and can be improved by conducting actions. Overall, Figure 2 can be explained as follows. First, the ‘Actions’ box implies that users can take actions to improve effective use, performance, or both. Whereas Figure 1 showed the global influence of all of these actions (in Link 1), Figure 2 shows a narrower scope, indicating that although both sets of actions are important, the models we will propose focus on those actions taken to improve effective use (i.e., Link 1a). Second, Figure 2 shows a link from effective use to performance in the 'Consequences' box (Link 1b) to depict this means-end causal relationship.[2]

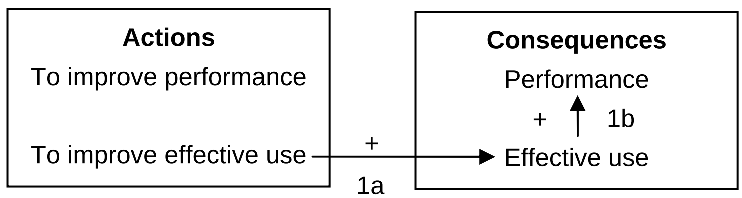


Figure 2: A Closer Look at Link 1 in the General Framework (Figure 1)

3.3 Models

Many empirically testable models could be derived from our overall framework. In this section, we derive two, one focused on the nature of effective use, and one focused on its drivers.

3.3.1 The Nature of Effective Use

In Figure 2, Link 1b shows how effective use improves performance. Figure 3 provides a testable model of this link, identifying two dimensions for each construct. The specific dimensions of effective use that we show here are important because without them, the link between effective use and performance is simply a tautology (because we defined effective use in §2.1 as use of a system that increases a user's goal achievement). We avoid this tautology by deriving the dimensions of effective use from representation theory. That is, these dimensions should increase performance according to representation theory, but whether they do or not is an empirical question.

Each dimension in Figure 3 reflects a state that can vary from high to low. The

[2] For completeness, we should note that causal arrows could also be shown within all the elements of our high-level framework. For example, in the 'Actions' box in Figure 2, we could include a link from 'actions to improve performance' to 'actions to improve effective use' to show that users may decide upon their actions to improve effective use in light of their actions to improve performance. We leave these relationships for another time.

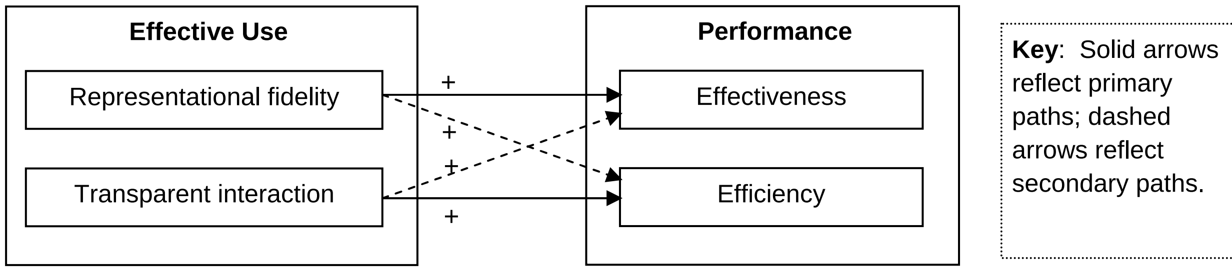


Figure 3: The Nature of Effective Use and Its Effect on Performance (Link 1b in Figure 2)

performance dimensions, effectiveness and efficiency, are well known (Campbell 1990; Beal et al. 2003). *Effectiveness* is typically assessed in terms of goal achievement and *efficiency* in terms of the level of goal achievement for a given level of input (e.g., effort or time) (Sonnentag 2002). The novel contribution in Figure 3 lies in the dimensions of effective use and their relations with performance. We derived both dimensions from representation theory. Our rationale is as follows.

First, representation theory states that people use representations to understand a domain and that representations meet this purpose most effectively when they reflect that domain faithfully (Weber 1997, p. 73). This leads us to propose our first dimension of effective use—*representational fidelity*—the extent to which a user is obtaining representations from the system that faithfully reflect the domain being represented. Representation theory assumes that no representation can be perfectly faithful but that better representations are highly sought after (Weber 1997, p. 59). We know that there will be a limit to such seeking because people routinely trade off accuracy for effort when performing tasks (Payne et al. 1993; Todd and Benbasat 1999). Thus, even if a system can provide faithful representations, if those representations are too difficult to access, they will not necessarily be used effectively or efficiently. This leads to the second dimension of effective use—*transparent interaction*—the extent to which a user is accessing the deep structure of the system (that is, the representations) unimpeded by the surface and physical structures.

Two points should be noted about these dimensions of effective use, particularly representational fidelity. First, we have defined both dimensions in terms of assessments of *use*, not assessments of a *system* or *user*. This is clear in the case of transparent interaction but might be less so for representation fidelity. To clarify, note that system use involves a user, system, and task (Burton-Jones and Straub 2006). Thus, to assess use, an observer should rate how well the user is using the system in that task. In the case of representation fidelity, an observer will rate how well the representations that the user obtains from the system faithfully reflect the domain being represented. This is an aspect of *use* because different users may use the same system and yet obtain different levels of representation fidelity because one uses it more effectively than the other (e.g., one may make errors when using it or one may not know how to detect and correct for infidelity when it exists). Of course, representational fidelity could be viewed differently, as a property of a system (preceding or following use), but our definition of representational fidelity focuses on the representations obtained *during use*.

Second, representation fidelity is assessed based on users' needs rather than being a universal assessment. For example, one way to assess whether a representation faithfully reflects a domain is to assess whether it is 'complete' (Wand and Wang 1996). Completeness can be measured universally (does the system represent *all* elements in the domain in *all* their detail?) or in a manner that is specific to users' needs (does the system represent all elements in the domain *that are relevant to the user's needs?*). In semiotics, which is the discipline that studies representations formally, this reflects the distinction between assessing a representation purely in terms of semantics (e.g., is a sign correct?) and assessing it in terms of pragmatics as well as semantics (e.g., is a sign as correct as it needs to be?) (Chandler 2002). Our definition of representational fidelity takes the latter view because it accords with the purpose of an IS in representation theory, which is to provide representations that meet users' needs.

Although our dimensions are untested, prior case studies suggest their applicability in practice. Zuboff's (1988) cases are especially useful because she focused on the efforts that workers undertake to verify representational fidelity. At one paper mill she studied, operators were so concerned about fidelity that they "would run back and forth between the control room and the production area in order to verify the system's readings" (Zuboff, 1988, p. 85). Other cases show that users will employ very creative efforts to improve representational fidelity, e.g., entering incorrect data into a system to make a faulty program work properly (Gasser 1986) and entering one type of data into a field for a different type of data when they can find nowhere else to record it (Boudreau and Robey 2005).

Zuboff's (1988) case studies also stress the importance of transparent interaction. Users who had difficulty navigating complex systems felt "lost…just floating" (p. 209), "plunged into darkness" (p. 63), and unsure of where things on their screens "came from" and where they "went" (p. 130). One mill worker had such difficulty explaining to Zuboff the state of the plant shown in his system that he took Zuboff on a tour of the plant instead. He demurred that using the system might be easier if "the screens were arranged like the physical things on the floor" (p. 88). HCI researchers have long recommended that interfaces be designed in this way to facilitate interaction (Hutchins et al. 1986).

We propose that representational fidelity and transparent interaction *form* the higher-order construct of effective use (Law et al. 1998). That is, each dimension can move up or down independently, but when both increase, users will be interacting more effortlessly with better representations. According to representation theory, an information system will then be fulfilling its purpose more effectively, providing more effective representations in a more efficient manner.

Each dimension can affect performance in two ways. For *representational fidelity*, we propose that it primarily improves users' understanding of the domain being represented, which is usually essential to performing effectively (March 1999). A secondary benefit is that when representational fidelity is high, users can afford to spend less time verifying fidelity (unlike the workers who had to run back and forth between the system and the plant), thus increasing efficiency. For *transparent interaction*, we propose that it primarily improves performance by saving users time when working on the system, increasing their efficiency. A secondary benefit is that when individuals interact with their system more seamlessly, they are likely to stay focused on what they are doing, which is often critical to performing effectively (Eysenck 1982; Zuboff 1988 pp. 188-192; Burton-Jones and Straub 2006). In extreme cases, a lack of transparent interaction could also reduce effectiveness by impeding task execution, for example, if users are unable to find and use the features they need to perform their work.

Table 3 illustrates how these effects could apply to the range of systems described in Table 2. In addition to clarifying how effective use improves performance, the examples make it clear that users are not the sole determinant of effective use. For example, the representational fidelity obtained from an accounting system might be low because the user omitted records *or* the system omitted records. Either way, system use could still impair performance if the problem is not overcome, for example, if the user makes poor decisions on the basis of incomplete records. This underscores our earlier point that ineffective use is an assessment of *use* rather than an assessment of the user, or the system. This is also consistent with our view of performance. That is, users are not the sole cause of their performance in our model, as other factors affect whether or not users achieve their goals (in Figure 1, 'external disturbances'). We have taken this view on effective use and performance because it invites a consideration of what actions users can take to improve effective use, regardless of the context in which they find themselves. This is the topic addressed next.

3.3.2 The Drivers of Effective Use

In Figure 2 above, Link 1a shows how users can take actions to improve effective use. We propose that there are two major types of actions: adaptation and learning. Table 4 gives examples of each one. We define *adaptation actions* as any action a user takes to improve the representations in a system (its deep structure), or his/her access to them, through surface and physical structures. Like Barki et al. (2007), we assume users can conduct these actions in the system, for example, by changing data or programs directly, or if not in the system, around it, for example, by sending change requests to the IT department. We define *learning actions* as any action a user takes to learn the domain the system represents, the system itself (including any of its structures), or the extent to which the system faithfully represents the domain (i.e., their mapping). Again, we assume users can conduct these actions in the system, for example, by experimenting with features or reading online help manuals, or around it, for example, by asking colleagues or taking training courses (per Barki et al. 2007).

Table 3: Examples of How Effective Use Enhances Performance

Type of IS		Benefit of Representational Fidelity		Benefit of Transparent Interaction[3]	
Category	**Example**	**Effectiveness**	**Efficiency**	**Effectiveness**	**Efficiency**
Function IT[1]	Word processing	If an academic writing a paper in a word processing system can write precisely what he wants to say, readers of the report (including him) should understand his ideas more clearly and the paper will therefore be a more effective communication vehicle.	If an academic writing a paper in a word processing system can write precisely what he wants to say, he will not have to spend as much time rewriting the paper as he would have if his writing was initially imprecise or vague.	If an academic upgrades his word processing system, he may find it difficult to locate and use features that he is familiar with (SS). This could take his attention away from his ideas, thereby hindering his ability to express and understand his arguments.	If an academic upgrades his word processing system, he may find it difficult to locate and use features that he is familiar with (SS). This could force him to spend longer writing the paper than he would have normally.
Network IT[1]	Email	If a user has not updated her contact database to include recipients' latest contact addresses, she may send emails to dated email accounts, and those people may fail to receive her messages.	If a user has not updated her contact database to include the latest contact addresses, she may not receive replies to some emails and then have to spend time checking if these people received her email and did not reply, or if they never received it.	A user may try to write an email on a new and very small cellular phone. Because of the small screen and lack of a proper key pad (SS and PS), she may have difficulty writing in the way that she would like to write.	A user may try to write an email on a new and very small cellular phone. Because of the small screen and lack of a proper key pad (SS and PS), she may have to spend more time writing the message than she would have normally.
Enterprise IT[1]	Enterprise wide software	If an organization requires supervisory approval for purchases of a certain type but the ERP system does not enforce the control properly, a clerk may process some purchases that should have been authorized first or even denied.	If an organization requires supervisory approval for purchases of a certain type but the ERP system does not enforce the control properly, a clerk may have to spend more time checking each purchase, reducing the numbers of orders he can process in a day.	If a purchasing manager needs to find multiple pieces of data in the system but is obstructed by confusing menus or screens (SS), this may divert his attention from the meaning and implications of the data, impairing his decision-making ability.	If a purchasing manager needs to find multiple pieces of data but is obstructed by confusing menus or screens (SS), he will have to spend extra time searching for the data to ensure that he has the right information to make decisions.
About reality[2]	Accounting system	If an accountant mistakenly charges certain types of payment to an incorrect account, the financial records will not accurately reflect the organization's expenses, which could lead managers to make different decisions than they would have made.	If an accountant mistakenly charges certain types of payment to an incorrect account, the accounts may not balance or may differ materially from past periods' accounts, forcing the accountant to spend time determining the reasons for the difference.	An accountant may have difficulty understanding the output options in a new reporting system (SS) and may fail, as a result, to produce reports that have all of the information needed to make good decisions.	An accountant may have difficulty understanding the output options in a new reporting system (SS) and consequently have to spend extra time learning the different options and discovering which option is more appropriate.

Type of IS		Benefit of Representational Fidelity		Benefit of Transparent Interaction[3]	
Category	**Example**	**Effectiveness**	**Efficiency**	**Effectiveness**	**Efficiency**
For reality[2]	Decision support system	If a rule was entered incorrectly, the system may recommend suboptimal decisions whenever a user provides it with specific input data, leading the user to take inappropriate actions.	If a rule was entered incorrectly and the system makes suboptimal decisions as a result, a user may lose trust in it and spend extra time checking if its decisions are appropriate.	The decision support system may offer a pivot table as an output device (SS), but the user may have difficulty using it, preventing her from understanding the reasons for the decisions being made.	The decision support system may offer a pivot table as an output device (SS), but the user may have difficulty using it, forcing her to spend more time interacting with the output than she should have had to.
As reality[2]	Video conferencing system	Because of a configuration problem, a person may be able to see and hear other participants but they may be unable to see and hear him. Consequently, participants may fail to learn his perspectives on some issues, resulting in poor meeting outcomes.	Because of a configuration problem, a person may be able to see and hear other participants but they may be unable to see and hear him. This may delay the meeting while participants try to determine the nature and cause of the problem.	A meeting participant may have difficulty setting up his viewer so that he can see multiple participants at once (SS and/or PS). This may divert his attention from what people are saying leading him to miss important parts of the conversation.	A meeting participant may have difficulty setting up his viewer (SS and/or PS). As a result, he may ask everyone to stop while he sorts out the problem, making the meeting longer than it would have been.

Key: [1, 2] Categories of information systems: [1] McAfee 2006, [2] Borgmann 1999.

[3] Problems with transparent interaction can be due to difficulties with the surface structure (SS) and/or physical structure (PS). Rather than provide separate examples for each type of problem, we use examples of one or the other and specify the type in parentheses.

Table 4: Examples of Adaptation and Learning Actions

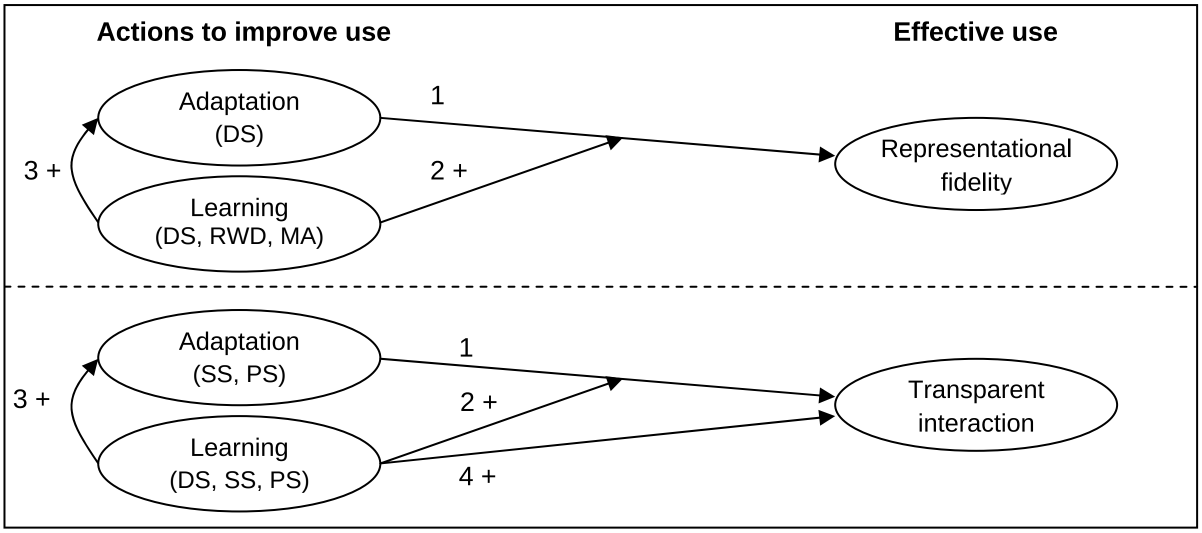
Type of IS		Adaptation Actions			Learning Actions		
Category	**Example**	**Deep structure**	**Surface structure**	**Physical structure**	**System**[3]	**Domain**	**Mapping**
Function IT[1]	Word processing	A user changes text in his report so that it more accurately reflects his thoughts.	A user uses the split-screen feature so that he can edit one part of the report while viewing another part.	A user changes his monitor for a larger one so that he can see more of the report at one time.	A user accesses the help function to learn what "track changes" does and how to use this feature (DS, SS).	A user reads papers on the topic of the report to help him learn what to write.	A user reflects on the arguments he has written to check if they reflect his thoughts.
Network IT[1]	Email	A user creates new folders in her email program to change the way that she records some of her messages.	A user configures the email program to pop up notifications of new emails on her screen.	A user sets up an encrypted connection (SSL) to secure email transfers on the Internet.	A user asks a colleague to help her learn how to take a backup of the email program (PS).	A user asks a colleague to explain communication protocols used in her organization.	A user receives a corrupted email from a friend and calls her to ask what the message said.
Enterprise IT[1]	Enterprise wide software	A user asks the IT department to add fields to a form so that he can record additional data.	A user asks the IT department to rearrange fields on a form to make it more intuitive.	A user asks the IT department to add more memory to the server or client machines so that updates run faster.	A user reads an online tutorial to learn the types of forms he will have to interact with (SS).	A user reads a description of his organization's purchasing process to understand how goods are ordered.	A user calls a friend in the warehouse to check if the inventory number is correct.
About reality[2]	Accounting system	A user asks the accounting department to add a new account so that she can record revenue differently.	A user adds shortcuts to the program menu so that she can easily access frequently used functions.	A user asks the IT department to increase her disk space allocation so that she can work with large reports.	A user asks a colleague to show her how to obtain a report from the system (DS, SS).	A user reads the accounting standards to understand how to record revenue appropriately.	A user checks source documents to determine if an entry in the system is an error.
For reality[2]	Decision support system	A user adds a new decision rule to change the way that decisions are made in the system.	A user selects a different output view so that he can see both the decision and the explanation for making it.	A user installs a new graphics card so that he can see sophisticated graphical output from the system.	A user reviews the system's decision rules to work out why it is making certain types of decisions (DS).	A user asks his manager to clarify certain aspects of the business context in which the system is used.	A user asks the IT department to check if a rule in the system is incorrect.
As reality[2]	Video conferencing system	A user adds a new participant to the video call.	A user changes a setting so that she can view all call participants at once rather than just the person speaking.	A user turns up the microphone on the system so that it picks up her voice more clearly.	A user reviews the system's manual to see if there is a way to change the default viewing settings (SS, PS).	A user conducts background research on some of the topics to be discussed in the call.	A user asks a trusted colleague to verify if a person on the call is who she says she is.

Key: [1, 2] Categories of information systems: [1] McAfee 2006, [2] Borgmann 1999.

[3] When learning a system, an individual might focus on deep structure (DS), surface structure (SS), and/or physical structure (PS). Rather than provide separate examples for each one, we provide examples of different ones in different cells and specify the type in parentheses.

We propose these two actions, adaptation and learning, rather than others, because they both stem logically from representation theory. The need for adaptation stems from representation theory's notion that representations are inherently fallible. If representations are fallible, users can overcome this problem by adapting the system so that representational fidelity (and hence effective use) increases. The notion of fallible representations also implies a need for learning because it suggests that understanding the extent to which an information system faithfully reflects a domain can be critical. The need for learning also stems from representation theory's notion that information systems consist of a complex set of structures that serve to represent a domain. To interact well with complex structures invariably requires learning. Thus, learning should enable more effective use. In addition to adaptation and learning both stemming from representation theory, another reason to propose both (rather than just one of them) in our models is that they are mutually reinforcing. For example, adaptation actions are more likely to be effective if an individual has learned what actions to take, and learning can sometimes be necessary for adaptations to be undertaken at all.

Figure 4 shows the relationships we expect between adaptation and learning and the two effective use dimensions (representational fidelity and transparent interaction). The top panel in Figure 4 shows that actions to adapt a system can affect representational fidelity (Link 1). No sign is shown because adaptations could increase or reduce fidelity, depending on whether or not a user is sufficiently educated to undertake them. For example, when a financial analyst changes a formula in a spreadsheet, her changes could improve or harm it, depending on her knowledge of what is being calculated. As more learning is undertaken, adaptation actions should have a more positive effect (Link 2). Another benefit of learning is that it can enable adaptations (Link 3). For example, the financial analyst may be able to change the formula only when she acquires a rudimentary understanding of how Excel formulae work. This effect should only operate at relatively low values of learning, however, because learning more does not imply an increased need to adapt a system; rather, it just enables the user to undertake such actions.



Key: DS: Deep structure, SS: Surface structure, PS: Physical structure, RWD: Real world domain represented by the deep structure, MA: Mapping between the domain and the deep structure.

Figure 4: The Drivers of Effective use

The bottom panel of Figure 4 shows how adaptations and learning affect transparent interaction. As in the top panel, we propose that although a user can influence transparent interaction by taking actions to adapt the system, these adaptations are more likely to be effective if the user has undertaken sufficient learning (Links 1 and 2). For example, if a company's website designer wants to adapt the forms on a site (surface structure) and the web server configuration (physical structure) to help users place orders more quickly, such changes are more likely to be beneficial if the designer has spent time learning how to design forms (surface structure), change server settings (physical structure), and how the system processes purchases (deep structure). Likewise, he or she will need at least some understanding of these issues to be able to make changes in the first place (Link 3).

There are two main differences between the top and bottom panels of Figure 4. First, the bottom panel shows that even without adaptation, learning can improve transparent interaction (Link 4 in Figure 4). Thus, even if a system cannot be modified, users can obtain and interact with the functions and data in their system more effectively if they invest time and effort learning how to do so. In contrast, as the top panel shows, learning alone cannot improve representational fidelity.

The second difference relates to the specific subscripts shown for each action in Figure 4. This is important because several recent studies stress the need for adaptation and learning (Boudreau and Seligman 2005; Barki et al. 2007); thus our contribution lies in identifying specific *types* of these actions, which we show via these subscripts (and our examples in Table 4). For instance, to improve *representational fidelity*, we suggest that adaptations must focus on a system's deep structure rather than on its surface or physical structure, and learning actions must be focused on the deep structure, the domain, or the mapping between them, rather than on the surface or physical structure. This is because the only way to improve representational fidelity is to improve the mapping between the deep structure and the domain. In contrast, for *transparent interaction*, adaptation and learning actions must be focused on the structures of the system, because the only way to improve transparent interaction is to improve access to the deep structure through the surface and physical structures.

3.4 Summary and Boundary Conditions

The two models we proposed help to fill the gap in the literature that we noted at the outset, by suggesting what effective use involves (its dimensions) and what drives it (its antecedents). To develop the models, we followed Ostrom's (2005) approach in first proposing a high-level framework, then applying it to a particular context, and finally deriving the models. This approach enabled us to link the major decisions we made in developing the theory, from the choice of the overall framework to the specific elements of our models, to representation theory. It thereby enabled us to propose an answer to our guiding research question by showing what this theory of information systems (representation theory) implies for what effective use involves and what drives it.

The answer we provided to our research question is incomplete, however, without a consideration of the boundary conditions of the theory, i.e., factors that moderate its applicability in different contexts (Whetten 1989). Strictly speaking, context includes an infinite variety of factors (Johns 2006). Although a full analysis of contextual factors lies outside the scope of our work, we provide an initial analysis by examining the four elements of context that are most closely associated with system use: user, system, task, and time (Burton-Jones and Gallivan 2007 p. 671). Specifically, we examine how characteristics of each of these elements could moderate the links of our high-level framework in Figure 1. We concentrate particularly on links 1, 2, and 4 in Figure 1 because they can be particularly sensitive to contextual factors (Carver and Scheier 1998). The details of our analysis are shown in Table 5. The analysis suggests that users are more likely to take actions to improve effective use and performance—and, that these actions are more likely to be successful—when

- users are more knowledgeable, experienced, motivated, and supported;
- systems and tasks are simple, flexible, familiar, and independent of other systems/tasks;
- users can quickly take actions and rapidly see the consequences.

In contexts with fewer of these attributes, individuals are less likely to take actions, and the actions they do undertake are less likely to achieve their objectives.

Overall, our analysis of the contextual factors in Table 5 has two implications. The first is the guidance it offers for researchers who wish to test our models. For example, if researchers test our models in contexts where users get immediate feedback on performance, and in contexts where feedback is delayed, we would expect users to reach high levels of effective use and performance quicker in the former context than the latter. A second implication is that it helps to highlight the importance of actions that users can take to improve effective use. This is because not only can users' learning actions and adaptation actions have immediate benefits for effective use, as our models in Figure 4 illustrate, but these actions can also change the user context (e.g., making users more knowledgeable) and change the system context (e.g., making the system more or less complex), which can affect the entire process of improving effective use and performance, as Table 5 illustrates. This latter implication ties in well with the overall theme of our high-level framework—that improving effective use is an ongoing, error-prone, and somewhat unpredictable process—because it suggests that in addition to their direct effects, adaptation and learning could have distal effects that occur through changing the context of use, and these effects may be difficult to predict or appreciate ex ante.

Table 5: Accounting for Context

Link in Figure 1	Effects of Contextual Elements on the Links in Figure 1			
	User	**System**	**Task**	**Time**
1	Actions to improve effective use and performance are more likely to have positive effects when individuals are <u>motivated</u> to perform well, and are <u>knowledgeable</u> and <u>experienced</u> with the system and task (Sonnentag 2002).	When systems are more <u>interdependent</u>, actions to improve use of any one system should have less benefit because actions must be coordinated across systems (Bailey et al. 2009).	When tasks are more <u>interdependent</u>, actions to improve the performance of any one task (or use of a system in that task) should have less benefit because actions must be coordinated across tasks (Crowston 1997).	When actions to improve use and performance <u>take longer</u> to have consequences, individuals (and observers such as researchers) must wait longer for the consequences to materialize.
2	When individuals have more <u>knowledge</u> about their task and system and when they are more <u>motivated</u> to perform well, they are more likely to perceive their levels of effective use and performance accurately (Klein et al. 1997).	When systems are <u>newer</u> and more <u>complex</u>, it should be more difficult for users to judge their level of effective use because it is more difficult to determine a baseline for comparison, that is, to judge how effectively they could be used (Klein et al. 1997).	When tasks are <u>newer</u> and more <u>complex</u> (Wood 1986), it should be more difficult for users to judge their level of performance because it is more difficult to determine a baseline for comparison, that is, to judge how effectively the tasks could be performed (Klein et al. 1997).	When individuals obtain more <u>frequent</u> and <u>regular</u> feedback on their levels of performance and effective use, their perceptions of their levels on these factors should be more accurate because frequency and regularity help people perceive phenomena in the presence of noise (Klein et al. 1997).
4	When individuals are more <u>motivated</u> to perform well, and when they are more able to take actions, because of internal resources such as <u>knowledge</u> or external resources such as social or organizational <u>support</u>, they are more likely to take actions (Deci and Ryan 1985; Azjen 1991).	When systems are more <u>interdependent</u>, users are less likely to take actions to improve use because doing so will take more effort, specifically coordinated effort (Bailey et al. 2009). Systems also have <u>symbolic expressions</u> and <u>functional affordances</u> that guide and enable certain ways of using the systems (Markus and Silver 2008). These will influence the range of actions that users are likely to undertake to improve system use.	When tasks are more <u>programmed</u> (with steps specified in advance) (Ouchi 1979), <u>imposed</u> on individuals (Hackman 1969), and <u>complex</u> (Wood 1986), individuals are less likely to take actions to improve effective use or performance because such actions are more constrained.	When it takes <u>less time</u> for individuals to perceive the consequences of their actions to improve effective use or performance, they are more likely to undertake those actions because faster feedback can help people learn (Kulik and Kulik 1988) and can increase people's motivation (Erez 1977; Myerson and Green 1995).

Key: Underlined terms reflect phenomena in the user, system, task, or temporal contexts that are likely to influence the links in Figure 1.

4. Discussion

In this section, we discuss how our work extends past research and provide guidance for researchers who wish to test and extend our theory.

4.1 A New Perspective

A legitimate query at this point would be to ask whether or not our perspective really differs from prior theories in IS research. Our work primarily contributes to prior literature by explaining both the dimensions of effective use and its drivers. We are not aware of any theory that has contributed in this way before. Several theories have addressed related topics, however, so it is important that we explain how our theory relates to that work. We provide such an explanation in Table 6, indicating the specific ways in which our theory builds on and extends prior work.

In addition to these specific ways in which our research extends prior work, a more general difference is that our study represents the first concerted effort to ask what effective use would involve from the perspective of a theory of information systems. Different theories of information systems will have different implications for what effective use involves. It would be interesting to examine what effective use might involve from the perspective of other views of information systems such as socio-technical systems (Bostrom and Heinen 1977), digital options (Sambamurthy et al. 2003), or ensembles (Orlikowski and Iacono 2001). Rather than considering these to be competing views, we see them as opportunities to further explore the nature of effective use and what drives it.

Finally, it is important to restate that our theory is set at a general level. The only studies that we could find of effective use to date have examined specific systems, specifically, collaboration systems (Pavlou et al. 2008), ERP systems (Boudreau and Seligman 2005), and telemedicine systems (LeRouge et al. 2007). We recognize that people use specific systems, not systems in general (Ramiller and Pentland 2009), so there is substantial merit in taking this route. Ultimately, we view theories of specific systems and systems in general to be complementary, however, because no theory can be at once simple, accurate, and generalizable (Weick 1979).

Table 6: How our Theory Builds on and Extends Past Research

Existing theory or model	How our work bears similarity to that theory or model	How our work differs from or extends that theory or model
Technology acceptance model (TAM) (Davis 1989)	Our definition of effective use bears similarity to the definition of "perceived usefulness" and our definition of transparent interaction bears similarity to the definition of "perceived ease of use."	Although our constructs bear some similarity to TAM constructs, there are several differences (e.g., our constructs reflect actual states rather than perceived states). More importantly, TAM explains IT acceptance whereas our theory explains what people need to do to use systems more effectively and increase their performance.
IS success model (DeLone and McLean 1992)	Our definition of representational fidelity bears similarity to the definition of "information quality." Also, our theory helps explain a link between use and performance, which is also offered by the IS success model.	Representational fidelity is not the same as information quality. For example, one difference is that information quality is a property of a system whereas our concept of representational fidelity is a property of use. More generally, the IS success model has never provided a clear link between use and performance, a point that its authors highlighted and called for research to address (DeLone and McLean 2003 p. 16).
Task-technology-fit (TTF) theory (Goodhue and Thompson 1995)	TTF theory has a similar aim to our work, explaining how IT leads to different performance outcomes. In addition, although we do not incorporate the notion of fit in our theory explicitly, it is included implicitly in the fact that our notion of representational fidelity accounts for the pragmatic requirements of the task rather than being purely limited to a semantic view.	TTF theory assumes that the outcome from using a system is more a function of the system than we assumed in our work. Specifically, TTF theory argues that at any given level of use, a system with higher TTF will lead to greater performance (Goodhue and Thompson 1995 p. 218). Although TTF theory poses a link between use and performance, it does not speak to whether this link is positive or what it would take to make it more positive. Our theory extends TTF theory by offering such an explanation, focusing on what actions users can take to improve use regardless of the *a priori* fit of the system.
Adaptive structuration theory (AST) (DeSanctis and Poole 1994)	AST has a similar aim to our theory, explaining variation in the impacts of IT. In addition, like our theory, AST suggests that many of the impacts of IT stem from how IT is used rather than from the IT itself (DeSanctis and Poole 1994 p. 122).	According to AST, improved performance is more likely to occur when individuals use systems in a way that is consistent with the designers' original intention for the system (so-called 'faithful appropriation'). Our theory suggests, in contrast, that effective use is more a matter of obtaining unfettered access to the representations needed for a task, irrespective of how faithfully the user interacts with the system.
Use-related activity (Barki et al. 2007)	Like our work, Barki's et al (2007) model of use-related activity highlights the importance of adaptation and learning in improving performance.	Our theory differs in two ways. First, we view the 'use' construct more narrowly. In the use-related activity model, actions to improve use (e.g., sending change requests to an IT department) are considered part of use-related activity. In contrast, our theory separates actions taken to improve use from assessments of use itself. Second, the use-related activity model proposes that interacting with IT will result in positive outcomes. In contrast, our theory proposes that use has to be *effective* to result in positive outcomes.

4.2 Testing the Theory

Testing the theory would require several issues to be considered. A first step would be to devise measures for the theory's key constructs. It should be possible to adapt existing measures for adaptation and learning (Barki et al. 2007; Sun and Zhang 2008). New measures would need to be constructed for representational fidelity. A starting point would be the literature on information quality (DeLone and McLean 1992) and the view that fidelity is a function of clarity, completeness, correctness, and meaningfulness (Wand and Wang 1996). For transparent interaction, researchers could start with measures for ease of use (Davis 1989) and tailor them to clarify the distinction between the different system structures. However, more work will be required to determine the best way of measuring all the constructs in the theory. One important point is that because teleological theories assume that people can set goals and respond to feedback consciously *or* unconsciously, researchers would not be able to rely solely on self-report questionnaires (Ortiz de Guinea and Markus 2009 p. 441). Rather, a combination of methods will be needed. Although developing and validating a full set of self-report and objective measures lies outside the scope of this work, we provide an initial set of measures in Appendix 2 to help initiate such a program of research.

Researchers would also need to consider the samples in which to test the theory. Because the theory is general, one approach would be to test it across a broad range of systems and tasks, much like the approach in Barki et al. (2007). However, to conduct a strong test of the theory, it would be useful to test it in contexts where intuition would argue against it. For instance, given the weight that the theory gives to faithful representations, intuition might suggest that it is less likely to be supported in contexts where reality is equivocal (Daft and Weick 1984), contentious, or inconvenient. Past research has shown that when reality is inconvenient, users may try to increase performance by falsifying records (Van Maanen and Pentland 1994; Cunha 2006), precisely the opposite of what our theory assumes. In one company Zuboff (1988 p. 354) studied, falsification was condoned over three organizational levels because each level benefited. It would be useful to test our theory in such contexts and determine whether the support (or lack of support) for the theory changes depending on the length of data collection. For example, in the company Zuboff studied, developers were trying to regain control by designing systems to catch falsifications (Zuboff 1988 p. 355). Thus, while our theory might be falsified in the short term in contexts where reality is equivocal, contentious, or inconvenient, it would be interesting to test whether it is supported over the longer term.

Data collection periods, therefore, are another issue to consider. Research over different lengths of time would be particularly valuable. Past research shows that when individuals have multiple goals, they tend to focus more on the higher-level goal (the end) and focus on the lower-level goal (the means) only when unexpected problems occur (Vallacher and Wegner 1987). Moreover, individuals generally attend to short-term ends rather than long-term performance ends (Baumeister and Heatherton 1996). Together, these findings suggest that people will rarely focus on optimizing system use for long-term performance; they are much more likely to concentrate on their immediate performance goals and they may take many actions to achieve these goals—only some of which might involve improving their use of a system. Finally, when they do attempt to improve their use of a system, they are likely to take the simplest approach possible (Todd and Benbasat 1999). Thus, work-arounds, kludges, and shadow systems are likely to be the norm (Koopman and Hoffman 2003), with users implementing more time-intensive, long-term solutions only when short-term fixes are ineffective and they have the time and resources to devise a better solution. Collecting data over different timeframes, therefore, would enable researchers to see the different learning and adaptation actions that users take over time and how they relate to short-term vis-à-vis long-term performance.

4.3 Extending the Theory

Our work could be extended in several ways. One would be to extend the way that we considered representations. Although information systems offer one form of representation, there are many other representations that individuals may use, such paper records, physical artifacts, and human memory (Hutchins 1995; Chandler 2002). A valuable way to extend our theory, therefore, would be to examine how users choose among different forms of representation, use them in concert, and improve their use of multiple representational media over time.

Another approach would be to extend our high-level framework. We adopted the typical view, which uses a negative (discrepancy-reducing) feedback loop (Carver and Scheier 1998). Liang and Xue (2009) showed how positive (discrepancy-enlarging) feedback loops can explain users' behavior when they are threatened by a system and try to avoid it. A combined view that allows for both types of loops would be useful. It would enable researchers to study instances in which performance is a function of the effective use of one system (or some parts of it) and the resistance of another system (or other parts of it). The current version of our framework does not enable us to explain how resistance behaviors could occur or how they could help. Positive feedback loops can also be used to study instances when virtuous circles arise in improving effective use (e.g., the more that performance increases, the more actions a user takes to further increase performance).

A third approach would be to reconsider our assumptions about the nature of representations. Consistent with representation theory, we have argued that if a system fails to represent a domain faithfully, users will benefit from adapting the system so that it more faithfully reflects the domain. A different approach would be to change the *domain* so that it more faithfully reflects the system. Both types of adaptation would improve representational fidelity, but they would do so in different ways. Allowing for both possibilities would strengthen our theory and provide a link between this work and the literature on how organizations and systems coevolve (Lassila and Brancheau 1999).

A fourth approach would be to focus on other elements of our overall framework. For instance, while we focused on the link between 'actions' and 'consequences,' it would be valuable to consider the links to and from 'perceptions' to 'actions.' Zuboff's studies provide many examples of the perceptions and associated cognitions, attitudes, and emotions that users have when working with representational media and how these can drive behavior. Describing the perceptions of workers in a paper mill, she remarked:

> "It is as if one's job had vanished into a two-dimensional space of abstractions, where digital symbols replaced concrete reality. Workers reiterated a spontaneous emotional response countless times—defined by feelings of loss of control, of vulnerability, and of frustration" (Zuboff 1988 p. 63).

We believe that for many users—not just these workers—ineffective system use will be associated with feelings of lost control, vulnerability, and frustration. Increases in effective use should help mitigate each of these problems. For example, we expect that

- *representational fidelity will engender feelings of trust.* Trust refers to a willingness to be vulnerable to another entity (Rousseau et al. 1998). When representational fidelity increases, users are likely to trust their systems more because they will have more positive expectations of the consequences of relying on those representations, for example, when using them to make decisions (Nicolaou and McKnight 2006).
- *transparent interaction will engender feelings of control and competence.* Feelings of control and competence refer to feelings that a person can take actions and those actions will yield intended results (Ryan and Deci 2000). Such feelings are precisely what help users avoid frustration (Bessiere et al. 2006). When transparent interaction increases, feelings of control and competence should rise because users will feel less obstructed by a system's surface and physical structures and more able to interact with the deep structure.
- *effective use will engender feelings of satisfaction with the system.* People are satisfied with a system when their overall attitude towards it is favorable (Wixom and Todd 2005). When users' are using a system more effectively, their satisfaction is likely to grow, partly because of the resulting increase in performance and partly because effective use generates the positive feelings of trust, control, and competence.

An important way to extend our research would be to test these predictions and determine the ways in which these or other feelings sustain existing ways of working or trigger users to engage in actions that increase or decrease effective use. In such studies, researchers would have to remain aware that perceptions can have multiple effects, both beneficial and costly. For example, when users trust a system, they are more likely to invest in actions to improve their use of it—a beneficial outcome. At the same time, such users are likely to become less vigilant for limitations associated with their systems and rely on them when they should not do so—a costly outcome (Butler and Gray 2006 p. 220). More theory is needed to determine what level of trust the most effective users would exhibit and how this might change as users gain more experience with a system.

5. Conclusion

Information systems are designed to help people and organizations achieve goals, but these goals cannot be achieved except through effective use. Although it is vitally important for individuals and their organizations to understand the degree to which systems are used effectively—and how to raise this level of effectiveness—information systems researchers have little theory to turn to in seeking to understand these issues. We demonstrated one way of addressing the problem, drawing on the representation theory of information systems to develop a theory that explains how effective use and performance evolve, as well as detailed models that explain the nature of effective use and its drivers. We believe that our theory offers a distinctly different perspective on effective use and a stimulating platform for research on how systems are, and need to be, used, to attain desired outcomes. Such research can help individuals and organizations reap the true reward of investing in information systems.

Appendix 1: Further Details on Representation Theory and our Extensions

Representation theory has existed for some time (Wand and Weber 1988), but it has mainly been used to study conceptual modeling (Weber 1997), never effective use. Only a few studies have applied the theory to other topics, specifically, data quality (Wand and Wang 1996), fit (Davern 1996), maintenance (Heales 2002), and alignment (Rosemann et al. 2004; Sia and Soh 2007). To apply it to the topic of effective use, we had to expand what is generally considered within its scope.

Figure A1 illustrates the difference between the scope of how we apply representation theory and the scope nearly all other researchers have used. The figure shows the system that an IS represents, the IS itself, and the use of the IS. The figure also distinguishes two parts of the represented system: a real-world domain (such as an inventory warehouse) and a perception of it (how someone perceives the warehouse). Because researchers traditionally used representation theory to study conceptual modeling alone, the focus was solely on creating a faithful representation of how users perceived a domain—the inner dashed box in Figure A1. Excluded were the distinction between reality and peoples' perceptions of it, the surface and physical structures that support the deep structure, and how and why systems are used. Researchers recognized their importance, but excluded them in the interest of concentrating on conceptual modeling (Wand and Weber 1995 pp. 204-207). In contrast, we need to consider all the issues in Figure A1—the outer dashed box—because all are necessary to understand the nature and drivers of effective use.

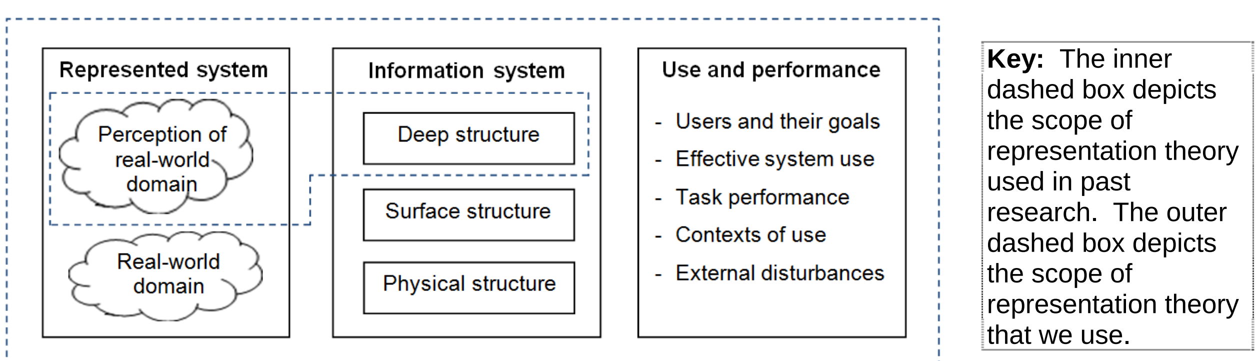


Figure A1: Broadening the Scope of Representation Theory

Appendix 2: Measurement Strategies

A full description of measurement strategies would require its own paper. However, to provide a starting point, we briefly describe how each construct in our theory can be measured in Table A1 and provide example measurement items for several of these constructs in Table A2.

Table A1: Assessment of the Theory's Key Constructs

Construct/ Dimension	Definition	Assessment	Studied providing measures
Effectiveness	A dimension of performance referring to the extent to which a user's has achieved the goals of the task for which the system was used.	Can be measured by using or adapting existing self-report measures or using independent ratings.	(Burton-Jones and Straub 2006)
Efficiency	A dimension of performance referring to the extent of goal achievement for a given level of input (such as effort or time).	Can be measured by using or adapting existing self-report measures or using independent ratings.	(Gattiker and Goodhue 2005)
Representational fidelity	During use, the extent to which a user is obtaining representations from the system that faithfully reflect the domain represented by the system.	No existing assessment. The specification of this construct can start with the four aspects of data quality derived from representation theory: *completeness*, *meaningfulness*, *clarity*, and *correctness* (Wang and Wand 1996), and the notion that representational fidelity is a pragmatic concept, not merely a semantic one. **See Table A2 for tentative and illustrative measures.**	
Transparent interaction	During use, the extent to which a user is accessing the system's deep structure unimpeded by the system's surface and physical structures.	No existing assessment. Construct's specification can start with measures of ease of use (Davis 1989) and include the idea that content accessibility is impeded due to the *interface* as well as to the *physical/material* structures. **See Table A2 for tentative and illustrative measures.**	
Adaptation	Users' actions to improve the representations in a system (deep structure) or the way they access them (through surface and physical structures).	Can be measured by adapting existing measures of technology adaptation that focus on adapting a system's data or functions (to adapt deep structure), or its interface or hardware (to adapt surface/physical structure).	(Barki et al. 2007; Sun and Zhang 2008)
Learning	Users' actions to learn (a) the domain the system represents, (b) the system itself, or (c) the mapping between the domain and the system.	Can be measured by adapting existing measures of learning so that they can capture the extent to which users engage in the three activities of learning the *domain*, the *system*, and the *mapping* between the two.	(Barki et al. 2007)

Table A2: Illustrative Measures for New Constructs

<table>
<tr><td colspan="2">Representational Fidelity</td></tr>
<tr><td>Self reported assessment (agreement scale)</td><td>Independent assessment</td></tr>
<tr><td>o <u>General assessment</u> – Examples scale for measuring the completeness, clarity, correctness, and meaningfulness of a representation:

When using the system, I find the content it provides me is sufficiently *
▪ … complete
▪ … clear
▪ … correct
▪ … meaningful

o <u>Context-specific assessment</u> – Examples of measuring the “completeness” aspect in three different system contexts:

[When using system X…]
▪ Reporting system: … the reports I obtain present a sufficiently complete picture of the domain they describe
▪ Video-conferencing system: … the video presentation I obtain provides a sufficiently complete picture of the communication context
▪ Excel application: … the data I see provides all that I need to understand the domain being represented

* <u>Note</u>: The term “sufficiently” is used in our measures of representational fidelity because this construct is assessed based on a consideration of users’ needs (as discussed in §3.3.1).</td><td>o <u>By a person</u> (context-specific assessment)

Expert observers can rate the extent to which any given user (e.g., user x, y, etc) is obtaining complete, clear, correct, and meaningful information from the system. For example, the following items could be used to measure the completeness dimension:

▪ Reporting system: Item rated by a manager:
▪ the reports that user x has obtained from the system provide a sufficiently complete picture of the domain it reports on

▪ Video-conferencing system: Item rated by the conference moderator:
▪ the video presentation that user x obtained from the system provides a sufficiently complete picture of the communication context

▪ Excel spreadsheet: Item rated by a manager:
o the data that the user has obtained from the system provides all that he/she needs to understand the domain being represented

o <u>By computer logs</u> (context-specific assessment)

▪ Programs could be written to calculate the extent to which content obtained by users is clear, complete, meaningful, and correct. For example, in a reporting system, a program could compare the SQL queries sent by users to the system to obtain reports with the queries needed to obtain reports that are as clear, complete, correct, and meaningful as required in that context.</td></tr>
<tr><td colspan="2">Transparent Interaction</td></tr>
<tr><td>Self reported assessment (agreement scale)</td><td>Independent assessment</td></tr>
<tr><td>o <u>General assessment</u> – Example scale for measuring the extent to which a user has unimpeded access to the content they need:

When using the system, I find that
▪ … I have seamless access to the content that I need (Overall Item)
▪ …I have difficulty obtaining the content I need because of the system’s interface (Negatively</td><td>o <u>By a person</u>

An external evaluator can observe the individual using the system and report on difficulties or errors in the completion of specific tasks, due to the surface or physical structure. For example:
▪ For surface structure: Wrong path followed to access a document, difficulty in navigating a web</td></tr>
</table>

worded item focusing on surface structure) ▪ …I have difficulty obtaining the content I need due to physical characteristics of the device(s) I use *(Negatively worded item focusing on physical structure)* o Context-specific assessment - Examples of items measuring difficulty of accessing deep structure due to the surface structure: [When using system X…] ▪ Reporting system: … I have difficulty obtaining everything I need because of the system's interface ▪ Video-conferencing system: … I have difficulty seeing what I need to see because of the system's interface ▪ Excel application: … I have difficulty obtaining the data I need because of the system's interface	page or menu structure ▪ For physical structure: Difficulties in reading content because of monitor size or difficulties in providing content due to an inability to use input devices, e.g., a mouse, or small keys. o By computer logs (will need to be system-task specific) ▪ Programs can be written to determine the extent to which users make errors in navigating or interacting with a system. Simple measures could include input errors or time to complete task. More complex measures could include ratings of the extent to which a user's navigation path to a webpage or system feature approaches the quickest path that can be taken to that page or feature (see, e.g., Hilbert and Redmiles 2000)

References

Ahearne, M., Jones, E., Rapp, A., and Mathieu, J. "High Touch Through High Tech: The Impact of Salesperson Technology Usage on Sales Performance via Mediating Mechanisms," *Management Science* (54:4) 2008, pp 671-685.

Austin, J.T., and Vancouver, J.B. "Goal Constructs in Psychology: Structure, Process, and Content," *Psychological Bulletin* (120:3) 1996, pp 338-375.

Azjen, I. "The Theory of Planned Behavior," *Organizational Behavior and Human Decision Processes* (50:X) 1991, pp 179-211.

Bailey, D.E., Leonardi, P.M., and Chong, J. "Minding the Gaps: Understanding Technology Interdependence and Coordination in Knowledge Work," *Organization Science* (in press) 2010.

Barki, H., Titah, R., and Boffo, C. "Information System Use-Related Activity: An Expanded Conceptualization of Information System Use," *Information Systems Research* (18:2) 2007, pp 173-192.

Beal, D.J., Cohen, R.R., Burke, M.J., and McLendon, C.L. "Cohesion and Performance in Groups: A Meta-Analytic Clarification of Construct Relations," *Journal of Applied Psychology* (88:6) 2003, pp 989-1004.

Bessiere, K., Newhagen, J.E., Robinson, J.P., and Schneiderman, B. "A Model for Computer Frustration: The Role of Instrumental and Dispositional Factors on Incident, Session, and Post-Session Frustration and Mood," *Computers in Human Behavior* (22) 2006, pp 941-961.

Bodker, S. "Understanding Representation in Design," *Human-Computer Interaction* (13) 1998, pp 107-125.

Bostrom, R.P., and Heinen, J.S. "MIS Problems and Failures: A Socio-Technical Perspective. Part 1: The Causes," *MIS Quarterly* (1:3), 1977, pp 17-32.

Boudreau, M.-C., and Robey, D. "Enacting Integrated Information Technology: A Human Agency Perspective," *Organization Science* (16:1), 2005, pp 3-18.

Boudreau, M.-C., and Seligman, L. "Quality of Use of a Complex Technology: A Learning-Based Model," *Journal of Organizational and End User Computing* (17:4) 2005, pp 1-22.

Burton-Jones, A., and Gallivan, M.J. "Towards a Deeper Understanding of System Usage in Organizations: A Multilevel Perspective," *MIS Quarterly* (31:4) 2007, pp 657-679.

Burton-Jones, A., and Straub, D. "Reconceptualizing System Usage," *Information Systems Research* (17:1), 2006, pp 38-60.

Butler, B.S., and Gray, P.H. "Reliability, Mindfulness, and Information Systems," *MIS Quarterly* (30:2) 2006, pp 211-224.

Campbell, J.P. "Modeling the Performance Prediction Problem in Industrial and Organizational Psychology," in: *Handbook of Industrial and Organizational Psychology (2nd Ed),* M.D. Dunnette and L.M. Hough (eds.), Consulting Psychologists' Press, Palo Alto, CA, 1990, pp. 687-732.

Carver, C.S., and Scheier, M.F. *On the Self-Regulation of Behavior* Cambridge University Press, Cambridge, UK, 1998.

Chandler, D. *Semiotics: The Basics* Routledge, Abingdon, Great Britain, 2002.

Chin, W.W., Gopal, A., and Salisbury, W.D. "Advancing the Theory of Adaptive Structuration: The Development of a Scale to Measure Faithfulness of Appropriation," *Information Systems Research* (8:4), 1997, pp 342-367.

Crowston, K. "A Coordination Theory Approach to Organizational Process Design," *Organization Science* (8:2), 1997, pp 157-175.

Davern, M.J. "When Good Fit is Bad: The Dynamics of Perceived Fit," *Proceedings of the 17th International Conference on Information Systems*, Cleveland, Ohio, 1996, pp. 112-121.

Davis, F. "Perceived Usefulness, Perceived Ease of Use, and End User Acceptance of Information Technology," *MIS Quarterly* (13:3), 1989, pp 318-339.

Davis, R., Shrobe, H., and Szlovits, P. "What is a Knowledge Representation?," *AI Magazine* (Spring) 1993, pp 17-33.
Deci, E.L., and Ryan, R.M. *Intrinsic Motivation and Self-Determination in Human Behavior* Plenum, New York, 1985.
DeLone, W.H., and McLean, E.R. "Information Systems Success: The Quest for the Dependent Variable," *Information Systems Research* (3:1), March 1992, pp 60-95.
DeLone, W.H., and McLean, E.R. "The DeLone and McLean Model of Information Systems Success: A Ten-Year Review," *Journal of Management Information Systems* (19:4), Spring 2003, pp 9-30.
Dennis, A.R., Wixom, B.H., and Vandenberg, R.J. "Understanding Fit and Appropriation Effects in Group Support Systems via Meta-Analysis," *MIS Quarterly* (25:2), June 2001, pp 167-193.
DeSanctis, G., and Poole, M.S. "Capturing the Complexity in Advanced Technology Use: Adaptive Structuration Theory," *Organization Science* (5:2), May 1994, pp 121-147.
Devaraj, S., and Kohli, R. "Performance Impacts of Information Technology: Is Actual Usage the Missing Link?," *Management Science* (49:3) 2003, pp 273-289.
Erez, M. "Feedback: A Necessary Condition for the Goal Setting--Performance Relationship," *Journal of Applied Psychology* (62:5) 1977, pp 624-627.
Eysenck, M.W. *Attention and Arousal: Cognition and Performance* Springer-Verlag, Berlin, 1982.
Fishbach, A., and Ferguson, M.F. "The Goal Construct in Social Psychology," in: *Social Psychology: Handbook of Basic Principles,* A.W. Kruglanski and T.E. Higgins (eds.), Guilford, NY, 2007, pp. 490-515.
Gasser, L. "The Integration of Computing and Routine Work," *ACM Transactions on Office Information Systems* (4:3), July 1986, pp 205-225.
Gattiker, T.F., and Goodhue, D.L. "What Happens After ERP Implementation: Understanding the Impact of Interdependence and Differentiation on Plant-Level Outcomes," *MIS Quarterly* (29:3), 2005, pp 559-585.
Goodhue, D.L., and Thompson, R.L. "Task-Technology Fit and Individual Performance," *MIS Quarterly* (19:2), 1995, pp 213-236.
Haas, M.R., and Hansen, M.T. "When Using Knowledge Can Hurt Performance: The Value of Organizational Capabilities in a Management Consulting Company," *Strategic Management Journal* (26) 2005, pp 1-24.
Hackman, J.R. "Toward Understanding the Role of Tasks in Behavioral Research," *Acta Psychologica* (31) 1969, pp 97-128.
Heales, J. "A Model of Factors Affecting an Information System's Change in State," *Journal of Software Maintenance* (14:6) 2002, pp 409-427.
Hilbert, D.M., and Redmiles, D.F. "Extracting Usability Information from User Interface Events," *ACM Computing Surveys* (32:4), December 2000, pp 384-421.
Hutchins, E. *Cognition in the Wild* MIT Press, Bradford, 1995.
Hutchins, E.L., Hollan, J.D., and Norman, D.A. "Direct Manipulation Interfaces," in: *User Centered System Design: New Perspectives on Human-Computer Interaction,* D.A. Norman and S. Draper (eds.), LEA, Hillsdale, NJ, 1986, pp. 87-124.
Jain, V., and Kanungo, S. "Beyond Perceptions and Usage: Impact of Nature of Information Systems Use on Information System–Enabled Productivity," *International Journal of Human-Computer Interaction* (19:1) 2005, pp 113-136.
Johns, G. "The Essential Impact of Context on Organizational Behavior," *Academy of Management Review* (31:2) 2006, pp 386-408.
Kent, W. *Data and Reality* 1st Books Library (originally published by North Holland, 1978), 2000.
Klein, B.D., Goodhue, D.L., and Davis, G.B. "Can Humans Detect Errors in Data? Impact of Base Rates, Incentives, and Goals," *MIS Quarterly* (21:2), 1997, pp 169-194.
Kulik, J.A., and Kulik, C.-L.C. "Timing of Feedback and Verbal Learning," *Review of Educational*

Research (58:1) 1988, pp 79-97.
Lassila, K.S., and Brancheau, J.C. "Adoption and Utilization of Commercial Software Packages: Exploring Utilization Equilibria, Transitions, Triggers, and Tracks," *Journal of Management Information Systems* (16:2), Fall 1999, pp 63-90.
Law, K.S., Wong, C.-S., and Mobley, W.H. "Toward a Taxonomy of Multidimensional Constructs," *Academy of Management Review* (23:4), October 1998, pp 741-755.
LeRouge, C., Hevner, A.R., and Collins, R.W. "It's More than Just Use: An Exploration of Telemedicine Use Quality," *Decision Support Systems* (43) 2007, pp 1287-1304.
Liang, H., and Xue, Y. "Avoidance of Information Technology Threats: A Theoretical Perspective," *MIS Quarterly* (33:1), March 2009, pp 71-90.
March, J. *The Pursuit of Organizational Intelligence* Blackwell Publishers Ltd, Oxford, UK, 1999.
Marcolin, B.L., Compeau, D., Munro, M.C., and Huff, S.L. "Assessing User Competence: Conceptualization and Measurement," *Information Systems Research* (11:1) 2000, pp 37-60.
Markus, M.L., and Silver, M.S. "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 Association for Information Systems* (9:10/11) 2008, pp 609-632.
Myerson, J., and Green, L. "Discounting of Delayed Rewards: Models of Individual Choice," *Journal of the Experimental Analysis of Behavior* (64:3) 1995, pp 263-276.
Nicolaou, A.I., and McKnight, D.H. "Perceived Information Quality in Data Exchanges: Effects on Risk, Trust, and Intention to use," *Information Systems Research* (17:4), Dec 2006, pp 332-351.
Orlikowski, W.J. "Integrated Information Environment or Matrix of Control? The Contradictory Implications of Information Technology," *Accounting, Management and Information Technologies* (1:1) 1991, pp 9-42.
Orlikowski, W.J., and Iacono, C.S. "Desperately Seeking the "IT" in IT Research - A Call to Theorizing the IT Artifact," *Information Systems Research* (12:2), June 2001, pp 121-134.
Ortiz de Guinea, A., and Markus, M.L. "Why Break the Habit of a Lifetime? Rethinking the Roles of intention, Habit, and Emotion in Continuing Information Technology Use," *MIS Quarterly* (33:3), Sept 2009, pp 433-444.
Ostrom, E. *Understanding Institutional Diversity* Princeton University Press, Princeton, NJ, 2005.
Ouchi, W. "A Conceptual Framework for the Design of Organizational Control Mechanisms," *Management Science* (25), Sept 1979, pp 833-848.
Overby, E. "Process Virtualization Theory and the Impact of Information Technology," *Organization Science* (19:2), 2008, pp 277-291.
Pavlou, P., Dimoka, A., and Housel, T.J. "Effective Use of Collaborative IT Tools: Nature, Antecedents, and Consequences," Proceedings of the 41st Hawaii International Conference on System Sciences (HICSS), IEEE, Hawaii, Jan 7-10, 2008.
Pavlou, P., and El-Sawy, O.O. "From IT Leveraging Competence to Competitive Advantage in Turbulent Environments: The Case of New Product Development," *Information Systems Research* (17:3) 2006, pp 198-227.
Payne, J.W., Bettman, J., and Johnson, E.J. *The Adaptive Decision-Maker* Cambridge University Press, New York, 1993.
Ramiller, N.C., and Pentland, B.T. "Management Implications in Information Systems Research: The Untold Story," *Journal of the Association for Information Systems* (10:6), June 2009, pp 474-494.
Robey, D., Schwaig, K.S., and Jin, L. "Intertwining Material and Virtual Work," *Information and Organization* (13) 2003, pp 111-129.
Rosemann, M., Vessey, I., and Weber, R. "Alignment in Enterprise Systems Implementations: The Role of Ontological Distance," *Proceedings of the 25th International Conference on Information Systems*, Washington DC., Dec 12-15, 2004, pp. 11-19.
Rousseau, D.M., Sitkin, S.B., Burt, R.S., and Camerer, C. "Not So Different After All: A Cross-

Discipline View of Trust," *Academy of Management Review* (23) 1998, pp 393-404.
Ruhleder, K. "Rich and Lean Representations of Information for Knowledge Work: The Role of Computing Packages in the Work of Classical Scholars," *ACM Transactions on Information Systems* (12:2) 1994, pp 208-230.
Ryan, R.M., and Deci, E.L. "Self-Determination Theory and the Facilitation of Intrinsic Motivation, Social Development, and Well-Being," *American Psychologist* (55:1), 2000, pp 68-78.
Sambamurthy, V., Bharadwaj, A., and Grover, V. "Shaping Agility through Digitial Options: Reconceptualizing the Role of Information Technology in Contemporary Firms," *MIS Quarterly* (27:2) 2003, pp 237-263.
Seddon, P.B. "A Respecification and Extension of the DeLone and McLean Model of IS Success," *Information Systems Research* (8:3), 1997, pp 240-253.
Sia, S.K., and Soh, C. "An Assessment of Package-Organisation Misalignment: Institutional and Ontological Structures," *European Journal of Information Systems* (16) 2007, pp 568-583.
Sonnentag, S. *Psychological Management of Individual Performance* Wiley, Chichester, 2002.
Subramani, M. "How do Suppliers Benefit from Information Technology Use in Supply Chain Relationships," *MIS Quarterly* (28:1), March 2004, pp 45-74.
Suchman, L. "Representations of Work," *Communications of the ACM* (38:9), 1995, pp 33-35.
Sun, H., and Zhang, P. "Adaptive System Use: An Investigation at the System Feature Level," in: *Proceedings of the International Conference on Information Systems (ICIS)* Dec 14-17, Paris, France, 2008, pp. 1-17.
Todd, P., and Benbasat, I. "Evaluating the Impact of DSS, Cognitive Effort, and Incentives on Strategy Selection," *Information Systems Research* (10:4), December 1999, pp 356-374.
Vallacher, R.R., and Wegner, D.M. "What do People Think They're Doing? Action Identification and Human Behavior," *Psychological Review* (94:1) 1987, pp 3-15.
Venkatesh, V., Morris, M.G., Davis, G.B., and Davis, F.D. "User Acceptance of Information Technology: Toward a Unified View," *MIS Quarterly* (27:3), 2003, pp 425-478.
Walsham, G. "Knowledge Management Systems: Representation and Communication in Context," *Systems, Signs, and Actions* (1:1) 2005, pp 6-18.
Wand, Y., and Wang, R.Y. "Anchoring Data Quality in Ontological Foundations," *Communications of the ACM* (39:11) 1996, pp 86-95.
Wand, Y., and Weber, R. "An Ontological Analysis of Some Fundamental Information Systems Concepts," *Proceedings of the 9th International Conference on Information Systems*, Minneapolis, MN, 1988, pp. 213-225.
Wand, Y., and Weber, R. "An Ontological Model of an Information System," *IEEE Transactions on Software Engineering* (16) 1990, pp 1282-1292.
Wand, Y., and Weber, R. "On the Deep Structure of Information Systems," *Information Systems Journal* (5) 1995, pp 203-223.
Weber, R. "Editor's Comments: Still Desperately Seeking the IT Artifact," *MIS Quarterly* (27:3) 2003, pp iii-xi.
Weick, K.E. *The Social Psychology of Organizing* Addison-Wesley, Reading MA, 1979.
Whetten, D.A. "What Constitutes a Theoretical Contribution?," *Academy of Management Review* (14:4), Oct 1989, pp 490-495.
Wixom, B.H., and Todd, P.A. "A Theoretical Integration of User Satisfaction and Technology Acceptance," *Information Systems Research* (16:1) 2005, pp 85-102.
Wood, R.E. "Task Complexity: Definition of the Construct," *Organizational Behavior and Human Decision Processes* (37:1) 1986, pp 60-82.
Yoo, Y., Boland, R.J., and Lyytinen, K. "From Organization Design to Organization Designing," *Organization Science* (17:2) 2006, pp 215-229.
Zuboff, S. *In the Age of the Smart Machine* Basic Books, USA, 1988.