

## RELIABILITY, MINDFULNESS, AND INFORMATION SYSTEMS<sup>1</sup>

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### Abstract

*In a world where information technology is both important and imperfect, organizations and individuals are faced with the ongoing challenge of determining how to use complex, fragile systems in dynamic contexts to achieve reliable outcomes. While reliability is a central concern of information systems practitioners at many levels, there has been limited consideration in information systems scholarship of how firms and individuals create, manage, and use technology to attain reliability. We propose that examining how individuals and organizations use information systems to reliably perform work will increase both the richness and relevance of IS research. Drawing from studies of individual and organizational cognition, we examine the concept of mindfulness as a theoretical foundation for explaining efforts to achieve individual and organizational reliability in the face of complex*

*technologies and surprising environments. We then consider a variety of implications of mindfulness theories of reliability in the form of alternative interpretations of existing knowledge and new directions for inquiry in the areas of IS operations, design, and management.*

**Keywords:** Mindfulness, reliability, IS operations, IS management, IS design, resilience

### Introduction

Software crashes. Hardware breaks. Networks become congested. Viruses and worms bring down systems. Data gets corrupted. Users, for better or worse, use information technologies in ways designers never imagined. Processes evolve. Communication flows and coordination links are restructured. Plans and strategies change, or they remain unchanged long after the world has moved on. Even when functioning well, information systems evolve in response to new problems and environmental changes (Truex et al. 1999). Information systems are fundamentally complex; system features and their outcomes are often more emergent than planned (Orlikowski 1996). Despite this complexity, individuals, organizations, and societies increasingly depend on information systems to reliably provide core services and capabilities.

The paradox of relying on complex systems composed of unreliable components for reliable outcomes is rarely acknowledged in theoretical discussions of IS operations, design, and management. IS research tends to assume a best-case scenario regarding reliability of information systems, focusing on techniques for achieving reliable performance by building technically reliable information systems from structured combinations of components. While increasing technical reliability is desirable, this focus fails to account for

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the reality that many important systems are not (and perhaps cannot be) inherently reliable. Largely unaddressed are questions about how individuals and organizations achieve reliable performance when working with unreliable systems. This may be one reason why the IS literature often has an ethereal flavor, seeming to be both correct and yet irrelevant to practitioners who must make things work with real technologies, users, and organizations (Benbasat and Zmud 1999).

Rather than assuming that individual and organizational reliability are beyond the scope of IS research, the role of information systems in undermining or realizing reliable performance should be a central concern (Stewart 2003). We seek to highlight how organizations achieve reliability when working with fundamentally complex, fragile, and often unreliable information systems. Central to our approach is the premise that individual and organizational reliability arises from both what work is done and how it is performed. The preplanned routines that are the focus of most IS design efforts are necessary, but insufficient, elements of reliable performance. It is also necessary for systems and processes to promote individual and collective *mindfulness*—way of working characterized by a focus on the present, attention to operational detail, willingness to consider alternative perspectives, and an interest in investigating and understanding failures (Langer 1989; Weick and Sutcliffe 2001; Weick et al. 1999). While these principles have been touched upon in the IS literature, individual and collective mindfulness theories provide a succinct and compelling lens for viewing key aspects of reliability. Our goal is to highlight how applying individual and collective mindfulness concepts in studies of IS design, management, and use can contribute to the realization of reliable work and performance outcomes in organizations.

## IS Research and Reliability

Organizational reliability has been defined as the “capacity to produce collective outcomes of a certain minimum quality repeatedly” (Hannan and Freeman 1984, p. 153). Reliable performance is not merely the attainment of a desired outcome level, but also the ability to control variance in outcomes (Deming 1982). Achieving reliable business performance is a focus of many popular management programs (e.g., Six Sigma, ISO 9000), which incorporate an underlying rationale of cost control and customer satisfaction through elimination of unwanted variance in attributes of products and services.

As businesses depend increasingly on information systems, it becomes important that they be designed, used, and managed

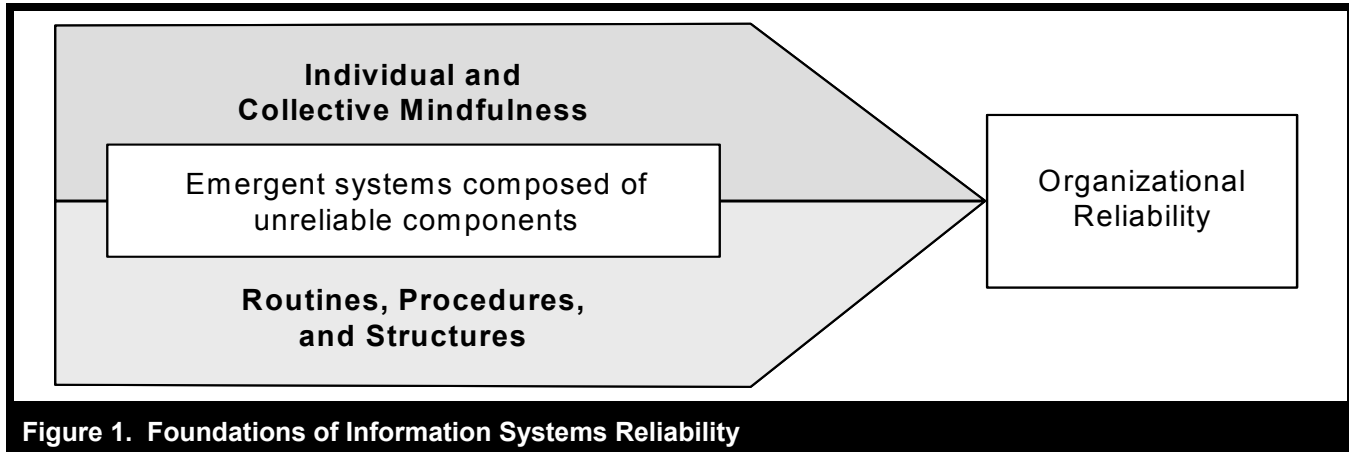
to contribute to reliable aggregate performance—in spite of imperfect technology (Sipior and Ward 1998), uncontrollable user behaviors (Orlikowski 1996), and dynamic environments (Mendelson and Pillai 1998). Although the role of information systems in achieving organizational reliability has not been a major theme in prior IS research,<sup>2</sup> scholars have recognized that technical reliability is a factor in successful systems and have discussed techniques for enhancing the reliability of information systems and services. Models of information system quality, success, and IS service quality (e.g., DeLone and McLean 1992, 2003; Jiang et al. 2002) have assessed system reliability by measuring users’ perceptions of system dependability—often with a single survey item—and have demonstrated its association with outcomes such as user satisfaction or use behavior. Conceptually, these studies characterize system reliability as a desirable “good,” the nature, source, and consequences of which are typically unspecified. Consistent with this approach, Broadbent and Weill (1999) include reliability as a feature of an effective IT infrastructure, while leaving its antecedents unexamined.

In other work, IS scholars have examined the nature of information system reliability problems. A first perspective treats a lack of IS reliability as an agency problem. Software errors (Austin 2001), data quality problems (Ba et al. 2001), and system failures (Abdel-Hamid 1999) happen because IS personnel focus on objectives other than reliability. From this perspective, the solution is to realign incentive structures, encouraging individuals to focus on creating reliable systems (Ravichandran and Rai 1999). However, these studies have little to say about what individuals or organizations actually do differently to achieve this reliability.

Other work focuses on the application of structured routines to reduce uncertainty and increase system quality (De and Hsu 1986; Hardgrave et al. 2003). For stable environments and technologies, structured designs and routine-driven approaches can significantly improve system reliability (Kydd 1989). However, in the face of dynamic environments and evolving systems, managers and developers often must adapt or abandon structured approaches, thereby reducing (or eliminating) their reliability-related benefits. Some authors advocate the use of more responsive development methods, such as short-cycle development processes and shorter-term

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<sup>2</sup>We found only 32 articles that dealt directly or indirectly with issues of reliability when we manually examined articles published in *MIS Quarterly*, *Information Systems Research*, and *Journal of Management Information Systems* for the period 1999 through 2003 and searched the titles, abstracts, and keywords of articles in these journals back to journal inception (or 1980, in the case of *MIS Quarterly*), using the terms reliability, consistency, unreliable, failure, inconsistency, resilience, error, trustworthy, untrustworthy, continuity, flexibility, and adaptiveness.



**Figure 1. Foundations of Information Systems Reliability**

goals (e.g., Truex et al. 1999; van der Zee and de Jong 1999). These approaches rely on faster problem detection and mid-course adjustment of development trajectories to reduce technological flaws and improve alignment of system and organizational goals. Other scholars emphasize procedures for gathering and using information during development. They suggest that reliable execution of IS development activities is enhanced by intentionally seeking out conflicting information (Salaway 1987), considering a wider range of ideas (Peffer et al. 2003), and using risk-management techniques that shape and direct managers' attention (Lyytinen et al. 1998).

While existing work contributes to our understanding of information system reliability, it leaves largely unexamined questions of how system reliability translates into reliable organizational performance. Although some have argued that perfectly reliable information systems may actually hinder an organization's ability to perform reliably in dynamic environments (Hedberg and Jonson 1978), it is likely that reliable systems will typically improve individuals' and organizations' ability to perform work reliably. However, analytic modeling and anecdotal evidence suggests that it is not feasible to expect development methods and operational procedures to result in flawless information systems (Olson 2003; Westland 2000). Therefore, important questions remain about how systems should be designed and used if individuals and organizations are to achieve reliable performance in spite of technological imperfections.

Beyond technical flaws, research highlighting the complex interplay of practices, processes, and structures surrounding information systems suggests that even technically reliable systems may not result in consistent organizational outcomes. Information technologies are interpreted differently by various parties (Bloomfield and Coombs 1992; Gopal and

Prasad 2000), and applied differently across contexts. Their appearance triggers change within organizations (Griffith 1999) which factors into the ongoing emergence of individuals' work practices and organizations' structures (Orlikowski and Barley 2001). This research underscores the interplay of technology, potentially idiosyncratic behaviors, and context (Orlikowski 1996), suggesting that even when based on the best technology, information systems can introduce significant complexity and variation. Thus, the challenge remains for IS researchers to provide theories and models that help organizations and individuals design, manage, and use information systems to achieve reliable work from complex, fragile systems composed of unreliable components.

## Achieving Reliable Performance

Studies of human systems reveal two strategies for achieving reliable performance: routine-based reliability and mindfulness-based reliability (Figure 1).

Management and IS research has typically focused on one of these strategies at a time, ignoring their interdependence and synergistic impacts. We review each approach below, and identify their individual and cumulative benefits in achieving reliability in the face of dynamic complexity.

### *Routine-Based Reliability*

A routine is a "relatively complex pattern of behavior... functioning as a recognizable unit in a relatively automatic fashion" (Winter 1986, p. 165). An activity is routinized when a certain stimulus produces a fixed response that

involves a predefined pattern of choice from an established set of options without searching for new possibilities (March and Simon 1958). Routine-based reliability posits that reliable performance can be achieved efficiently by creating repeatable packages of decision rules and associated actions. For individuals, this involves learning steps to be taken, often to the point where executing the routine becomes automatic (Langer and Piper 1987; Langer and Weinman 1981). Organizationally, routine-based reliability involves the creation and execution of standard operating and decision-making procedures, which may be unique to the organization or widely accepted across an industry (Spender 1989). One goal of identifying and institutionalizing “best practices” is to reduce variation in outcomes. At both the individual and organizational levels, routines are powerful tools for efficiently increasing outcome reliability.

Routine-based reliability is commonly advocated in the IS literature. Processes are often automated by embedding them in computer systems in order to increase both reliability and efficiency (Zuboff 1988). Software is a codification of human knowledge (Conceição et al. 1998), and information systems users are implicitly expected to defer to the technology, allowing the embedded routines and standards to determine what should be done next. The idea that standardizing processes, automating routines, and embedding procedures in information systems is the optimal strategy for reducing errors and improving reliability is so well accepted that it is stated as fact in many systems analysis and design texts (e.g., Dennis and Wixom 2003) and practitioner publications (e.g., Vaughan 1996).

Routine-based approaches to reliability are fundamentally Taylorist (Morgan 1986). They posit that individual and organizational reliability is best achieved by front-loading human cognition. Procedures and processes are designed in advance, usually by managers or analysts, and applied in the moment by operators. Information systems are created and training programs are prepared to lead users step-by-step through the proper routine. Procedures, routines, training, and systems are designed to decrease the need for creative human involvement in the moment, in an effort to reduce errors, unwanted variation, and waste.

While routines are important tools for creating reliable performance, they are not without limitations. Routine-based approaches depend on a match between situation and response. Ideally, each stimulus triggers an appropriate routine. However, there is evidence that both individual and organizational perceptions are shaped by the routines and systems that are in place (Langer 1989). Routines, plans, and

systems predispose us to see situations in particular ways. Individuals and organizations are significantly less likely to detect stimuli for which they are unprepared (Clarke 1993). When faced with variation and complexity, such misperceptions reduce individual and organization reliability. The assumption that perception triggers appropriate responses ignores the possibility that pre-learned responses can themselves color perception.

Moreover, routines achieve their purpose primarily when they are reproduced faithfully and appropriately. It remains unclear what happens when routines and systems are themselves emergent and composed of imperfect, evolving components. Does process automation result in more reliable outcomes when handling exceptions is a central part of the process (Kraut et al. 1999)? How does formal training and control interact with the processes by which work and system use practices emerge (Galletta et al. 1995)? Routine-based reliability implicitly assumes that systems and routines are themselves rationally constructed, stable, repeatable, and reliable. If this is untrue, as suggested by recent studies of organizational rules, processes, and systems (Feldman and Pentland 2003; March et al. 2000; Orlikowski 2000; Repenning and Sterman 2002), rather than solving the reliability problem, routines may aggravate it by adding greater complexity and more unreliable components.

### ***Mindfulness-Based Reliability***

While routine-based approaches focus on reducing or eliminating situated human cognition as the cause of errors, mindfulness-based approaches focus on promoting highly situated human cognition as the solution to individual and organizational reliability problems (Weick and Sutcliffe 2001). A mindful response “to a particular situation is not an attempt to make the best choice from among available options but to create options” (Langer 1997, p. 114). Mindfulness-based approaches hold that individuals’ and organizations’ ability to achieve reliable performance in changing environments depends on how they think: how they gather information, how they perceive the world around them, and whether they are able to change their perspective to reflect the situation at hand (Langer 1989). From this perspective, routines are a double-edged sword. They are helpful when they provide options, but detrimental when they hinder detection of changes in the task or environment. Whether describing individuals or organizations, mindfulness-based approaches posit that—more than just consistency of action—properly situated cognition is ultimately the basis for reliable performance.

## Individual Mindfulness

At an individual level, mindfulness focuses on the ability to continuously create and use new categories in perception and interpretation of the world (Langer 1997, p. 4). In contrast, mindless behavior involves routine use of preexisting categorization schemes. Mindlessness is a state of reduced attention resulting from premature commitment to beliefs that may not accurately reflect the phenomena at hand (e.g., Chanowitz and Langer 1980). It tends to lead to “mechanically employing cognitively and emotionally rigid, rule-based behaviors” (Fiol and O’Connor 2003, p. 58).

For individuals, mindfulness involves (1) openness to novelty, (2) alertness to distinction, (3) sensitivity to different contexts, (4) awareness of multiple perspectives, and (5) orientation in the present (Sternberg 2000 quoting from Langer 1997). Sternberg (2000) describes these constituent parts of a mindful cognitive style as being based on certain abilities. Openness to novelty is the ability to reason about new kinds of stimuli. Alertness to distinction involves an ability to compare, contrast, and make judgments about how things are the same or different. This is particularly important when individuals must define the nature of a problem they are facing; greater alertness to distinction reduces the chances that one will misdefine, or misdiagnose, a problem. Sensitivity to context is an awareness of the characteristics of whatever particular situation an individual faces, which is a precursor to being able to notice when situational characteristics change. People who are aware of multiple perspectives can engage in dialectical thinking—that is, to see things from different or opposing points of view. Finally, individuals who are oriented to the present devote more of their attention to their immediate situation (as opposed to contemplating future possibilities or recalling past events). Together, these may go beyond a set of capabilities or cognitive styles. Instead, mindfulness may be “considered a disposition because it has to do with how disposed people are to process information in an alert, flexible way” (Perkins et al. 1993, p. 75).

While there are certainly dispositional aspects to mindfulness, mindful cognition and behavior are also context-dependent and can be promoted or inhibited in a variety of ways. The composition of the immediate social context, a person’s background, ability, and relationships with others, and the nature of available information all contribute in subtle ways to the likelihood of mindful thinking. Some theorized antecedents of individual mindfulness, such as thinking critically about how things can be and are done (i.e., adopting a process orientation; Langer 1989, p. 34) or being an outsider in a group or organization (Langer 1989, p. 160), are consistent with techniques that are central to information systems design,

development, and management. Other approaches to enhancing mindfulness, such as presentation of information as conditional, models as nondeterministic, and data as highly contextualized (Langer et al. 1989), or avoiding a strong goal or outcome focus (Langer 1989, p. 34) present greater challenges for IS professionals. In the extreme, mindfulness theory suggests that some staples of information systems design, such as the transfer of routines between contexts, the use of highly specific instructions, and the assumption that information gathering necessarily leads to greater certainty, can hinder mindfulness with significant detrimental consequences.

Individuals who are mindfully engaged in a task are both motivated and able to explore a wider variety of perspectives. They can also make more relevant and precise distinctions about phenomena in their environments, enabling them to adapt to shifts in those environments (Fiol and O’Connor 2003, p. 59). Individuals who mindfully process information are more likely to be willing and able to apply it in new ways and in alternative contexts (Chanowitz and Langer 1980; Langer 1989). Because such individuals are more likely to consider different perspectives (Langer et al. 1975), they are apt to create innovative solutions to problems and alter their actions to take advantage of changing environments (Langer 1989, pp. 199-201).

In contrast, individuals who focus on one perspective and a single way of doing things are likely to encounter a variety of problems. Mindless acceptance of information or data gives rise to a perception of certainty that can create premature commitment to a solution (Langer and Piper 1987). Mindless learning of a routine in an effort to increase short-term efficiency often comes at the expense of adaptability. This can lead to overlearning, a condition in which individuals lose the ability to critically evaluate, explain, and adapt their behavior (Langer 1989, p. 20-21; Langer and Weinman 1981). Mindless adoption of a role or routine can also undermine an individual’s perception of self-confidence and competence in dynamic contexts (Langer and Benevento 1978). This suggests that efforts to promote IS use through the development of routine or habit (Limayem et al. 2003) should be undertaken with an awareness that this type of behavior may have unexpected detrimental consequences.

## Collective Mindfulness

Collective mindfulness is to individual mindfulness as organizational learning is to individual learning: a theoretical elaboration of cognitive concepts at the level of an organizational entity. Drawing on studies of high-reliability organi-

zations and the individual mindfulness literature, researchers have recently begun to develop the idea of mindfulness at macro-levels of analysis, such as business unit, work group, and organizations. Collective mindfulness<sup>3</sup> is

a combination of ongoing scrutiny of existing expectations, continuous refinement and differentiation of expectations based on newer experiences, willingness and capability to invent new expectations that make sense of unprecedented events, a more nuanced appreciation of context and ways to deal with it, and identification of new dimensions of context that improve foresight and current functioning (Weick and Sutcliffe 2001, p. 42).

Like individual mindfulness, organizational mindfulness focuses on an organization's ability to perceive cues, interpret them, and respond appropriately. Extreme examples of collectively mindful organizations include hospitals that provide life-and-death services under tight resource constraints (Kohn et al. 1999) and aircraft carriers that must coordinate fuel, personnel, and explosives in complex, hostile environments (Weick and Roberts 1993). However, performance in organizations as mundane as community swimming pools (Knight 2004) and restaurants (Rose 2004) also relies on the ability to remain collectively mindful.

Theorists specifically interested in organizational reliability have highlighted (1) preoccupation with failure, (2) reluctance to simplify, (3) attention to operations, (4) focus on resilience, and (5) the migration of decisions to expertise as key aspects of organizational mindfulness (Weick and Sutcliffe 2001; Weick et al. 1999). A preoccupation with failure focuses the organization on converting errors and failures into grounds for improvement, often by treating all failures and near-failures as indicators of the health of the overall system. For example, aircraft carrier personnel are encouraged to report even small problems, and significant organizational effort is expended to review both failures and near misses (Weick and Sutcliffe 2001). Focusing on errors and failures helps avoid the overconfidence, complacency, and inattention that can result when employees believe success has become commonplace and routine. Reluctance to simplify refers to a collective desire to continually see problems from different perspectives. This increases the organization's chances of noticing and reacting appropriately to small anomalies and errors and reduces the likelihood of larger, disastrous failures. Sensitivity to

operations implies that some individuals in an organization have developed an integrated overall picture of operations in the moment. For example, studies of nuclear weapons suggest that many problems arise not from a single failure, but when small deviations in different operational areas combine to create conditions that were never imagined in the plans and designs (Sagan 1993). In these cases, considering general policies and plans (i.e., what should be done) can mask potential problems, while attending to the true nature of the firm's operations (i.e., what is actually done) improves the likelihood that small errors can be detected before they interact to produce large failures. A commitment to resilience refers to a tendency to cope with dangers and problems as they arise—through error detection and error containment—and exists in contrast to a commitment to anticipation, which focuses on planning. Weick et al. (1999) describe the fifth and final component of collective mindfulness as the migration of decisions to expertise resulting from the under-specification of structures. This departure from hierarchical decision structures permits problems to migrate to the experts most capable of solving them. Collective mindfulness is associated with cultures and structures that promote open discussion of errors and mistakes (Weick and Roberts 1993) and cross-job training and awareness (Hutchins 1995). It increases organizations' ability to achieve reliable performance in dynamic, unstable environments (Weick et al. 1999).

Collective mindfulness is not simply the result of having individually mindful personnel. In general, mindfulness involves the ability to detect important aspects of the context and take timely, appropriate action. However, more so than with individuals, in organizations the processes of perception are often separate from the processes of action. Front-line employees are often most knowledgeable about the true state of the organization's systems and capabilities. For example, sales people who interact regularly with customers are often most aware of shifting needs and demand. Yet, these individuals rarely are capable of fundamentally changing the direction or priorities of the organization. Collective mindfulness requires organizations to couple the ability to quickly detect issues, problems, or opportunities with the power to make organizationally significant decisions. This may be accomplished by moving decision-making authority (Weick and Roberts 1993; Weick et al. 1999), taking steps to increase top management's ability to perceive the important signals, or creating an organizational environment that enables the smooth interaction of perception and action (Grove 1996). Regardless, achieving organizational mindfulness ultimately relates as much to the distribution of decision-making rights (i.e., power) as it does to the capabilities of any particular individual.

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<sup>3</sup>Although the following discussion refers primarily to organizations, collective mindfulness can be a characteristic of any organizational unit or group.

The concept of mindfulness offers a theoretical basis for resolving the IS reliability dilemma. It provides a possible basis for answering questions about how individuals and organizations can hope to efficiently create information systems, processes, and practices out of complex, fragile, uncertain components in order to achieve reliable results. How can organizational reliability be achieved in complex environments by adding additional unreliable components? If information systems and work practices are really the result of emergent social processes involving negotiation of multiple interests, why do formal systems development methodologies based on structured design principles have any beneficial effect? Mindfulness theories suggest the answer to these questions lies in characteristics of the perspectives and work practices that the systems and methodologies promote. Whether intentional or not, methods, models, and systems that encourage individuals and organizations to engage their work mindfully are likely to result in more reliable outcomes.

## Implications for Information Systems Research and Practice

The assertion that reliable performance depends on both routines and mindful behavior is of considerable importance to many areas of IS research. In this section, we identify several reliability-related issues within IS operations, management, and design, and consider how individual and collective mindfulness can be applied to both reinterpret existing knowledge and provide a foundation for future studies that engage this increasingly important problem.

### Information Systems Operations

One managerial implication of collective mindfulness theory is that reliable performance arises not from abstract plans or strategies but rather from an ongoing focus on operations (Weick and Sutcliffe 2001). If organizations are to achieve reliable outcomes from real systems, it is paramount that they have ways of organizing and managing IS operations. Yet, aspects of IS operations are rarely considered in the IS literature. When they are considered, the approaches taken are largely atheoretical. Over the past three decades, far more attention has been given to development of IS strategic plans (Hartono et al. 2003) than to understanding the challenges of IS operations. Individual and collective mindfulness provides a foundation that both justifies and grounds research in IS operations.

### Structuring Information Systems Operations to Handle Normal Accidents

How can (and should) the IS function be structured to provide reliable systems and services? While some research focuses on users' evaluation of the IS function (e.g., Pitt et al. 1995), there is little work, either normative or empirical, related to the work practices, structures, or personnel arrangements that make reliable IS operations possible. Given the extensive body of research about system development teams, it is surprising that no comparable body of work examines how firms organize (or how they should organize) the operational aspects of the IS function. For example, some organizations create specialized units tasked with rapidly addressing system failures—that is, to improve the reliability of fundamentally unreliable technologies. These groups are already prevalent in industries such as banking and utilities that have cultural and regulatory emphases on reliability, and they are increasingly common in other industries. Anecdotal evidence suggests that response teams can differ widely in terms of effectiveness, cost, and their ability to learn over time. Some firms staff response groups with experienced IS professionals able to repair failed systems themselves, while others assign this role to teams of relative novices who focus on marshaling the resources and knowledge necessary to address failures as they arise. Other organizations take a different approach to managing the “normal accidents” (Perrow 1984) that occur when working with complex information systems. Instead of creating specialized units, they handle system failures through *ad hoc* mobilization of IS personnel. Between specialized response teams and pure *ad hoc* crisis resolution are a range of structures and practices for managing day-to-day fire-fighting, failures, and catastrophes that arise when working with complex information systems in dynamic organizational settings. Organizational mindfulness theory implies that, far from being incidental, it is these structures, roles, and practices that underlie a firm's ability to make effective use of information technologies. However, the existence of specialized crisis response groups presents an interesting theoretical puzzle: if they are indeed viable mechanisms for assuring a high level of reliability in IS operations, how do they fit into mindfulness theory, which argues that reliable collective outcomes are only possible when a mindful approach permeates an organization? Additional research is needed to better understand how these aspects of IS operations are, and should be, managed to effectively balance the potentially competing needs for efficiency and reliability.

### Technical Support and Just-In-Time Mindfulness

Technical support is another aspect of IS operations that individual and organizational mindfulness theories suggest is

crucial. When IS users and procedures are assumed to be reliable, technical support is seen as a cost arising from inadequate user training or poor design. However, when systems, users, and processes are seen as fragile, technical support becomes an important part of how organizations achieve reliable outcomes from unreliable systems, processes, and practices. Faced with the need to balance efficient application of routines under “normal” circumstances, and mindful attention to abnormalities and alternative possibilities, individuals must find a way to quickly transition between these states. Work pressures favor routinized efficiency, which makes it difficult for individuals to act in a mindful fashion (Langer 1989). Interaction with technical support personnel helps users momentarily transition to mindful consideration of their situation. This shifts users’ focus from the goal to the process, increases the salience of technical details and specific actions, and forces them to consciously attend to the current state of the system (as opposed to the expected state). Much of the benefit of this type of technical support may arise simply from interacting with someone who is knowledgeable about the system, focused upon the immediate problem, and unaware of the individual’s work goals and expectations for the system. More than simple knowledge transfer, some technical support interactions may be micro-environments that promote the rapid and temporary adoption of individually mindful thinking. This function of technical support is unlikely to be well supported by “self-help” solutions, such as manuals or knowledge-bases, designed primarily to convey technical information.

From an organizational perspective, characterizing technical support in terms of mindfulness raises questions about how this aspect of IS operations should be managed. Mindful groups and organizations are characterized by the movement of problems and decisions to individuals with appropriate expertise and knowledge (Weick and Roberts 1993). This suggests that the escalation strategies, whether formal or informal (Pentland 1992), by which problems are shifted from users to technical support personnel are important not just for the efficient operation of the IS function but for the reliable operation of the IT-enabled organization as a whole.

The importance of focusing upon failure—and the general unwillingness of most organizations to do so under normal operating conditions—is another aspect of mindfulness theory that points to the technical support function as an important part of an organization’s ability to achieve reliable performance. This raises questions about how technical support should be managed and how the link between technical support personnel and the rest of the organization should be handled. For example, if awareness of near-misses and learning from failure is an important aspect in ongoing

reliable operations, what are the consequences of relying on external service providers for technical support? Could it be that organizations, in pursuit of cost reduction, are losing a core aspect of their ability to function reliably over the long term? At both an individual and organizational level, mindfulness theories suggest that in spite of its mundane nature, technical support may be a crucial aspect of an IT-enabled organization’s ability to function reliably while using critical, yet fragile technologies, systems, and procedures.

### **Business Continuity: Mindfully Managing the Unexpected**

Another aspect of IS operations that is of increasing interest to managers concerned about reliability, and yet essentially absent from IS literature, is business continuity and disaster recovery. In spite of a series of high-profile disasters that directly affected many organizations and business systems (e.g., the World Trade Center bombings of 1993 and 2001, and the widespread power failures in the northeast United States and Canada in 2003), firms still vary widely in their approaches to preparing for, and adapting in response to, such unexpected events. Despite the crucial role that information systems play in organizations and the high costs associated with information systems failures (NIST 2002), IS research provides little guidance for managers who must evaluate investments in this area, craft policies, train personnel, and adjust organizational structures to enhance business continuity. In this realm, firms are faced with the problem of managing the unexpected—of ensuring that signs of failure are detected quickly and handled early, before they become costly disasters (Weick and Sutcliffe 2001).

Business continuity professionals recently have sought to articulate how and why organizations should take special steps to prepare for unexpected events (Barnes 2001; Doughty 2001). While some techniques developed by this practitioner community derive from mainstream IS management methods, many business continuity practices differ significantly in both intent and form. Standard planning assumptions (that likely future scenarios can be probabilistically anticipated and that individuals can understand, or at least imagine, their potential impact) often do not apply when considering large-scale breakdowns of organizational processes and systems (Clarke 1993). Standard approaches to program evaluation and financial justification also often fail to capture the importance of business continuity and security efforts, leading to systematic under-investment in these activities (Doughty 2001). Thus, while continuity planning often involves the development of plans and specification of routines, business continuity personnel are aware that the purpose of plans and

routines is to create a context and culture in which individuals and organizational units are better able to practice resilience and reliability in the face of unexpected events (Hiles and Barnes 1999). Because such cultures embody aspects of mindfulness, including a focus on operations, a commitment to resilience, and a willingness to openly consider past failure, mindfulness theory may be important in descriptive and normative research of these increasingly important capabilities. For example, collective mindfulness theory's emphasis on operational practice mirrors the common business continuity management recommendations that firms seeking reliability must move beyond general, high-level planning (e.g., Segars and Grover 1999) and regularly engage in operationally focused simulations of specific failures and disasters (Barnes 2001). Generally, the juxtaposition of routine-based and mindfulness theories of organizational reliability suggests that while standard planning techniques and disaster handling routines may increase an organization's ability to perform reliably, the impact of these techniques is affected by the degree to which they either enhance (mediation) or are enhanced by (moderation) collective mindfulness.

### **Information Systems Management**

While IS operations focuses on running systems in such a way that firms can achieve reliable outcomes, and IS design is concerned with creating systems that promote mindful use and work, IS management is focused on blending the available technologies, resources, and people so that a firm's IS investments reliably provide value. Whether at the level of a particular development project or for the IS function as a whole, the goal is not just to provide momentary business value, but to do so consistently over time by reliably providing the capabilities that the firm needs to survive and grow (Weill and Broadbent 2000).

### **Mindfulness and Management of Information Systems Development**

Across a variety of technologies, industries, and organizations, it is noted that a large proportion of systems development projects fail to provide any workable system (Abe et al. 1979; Standish Group 1995; van Genuchten 1991). Drawing implicitly on routine-based approaches to reliability, researchers have proposed a variety of control structures, methodologies, and planning schemes to address this problem (Lyytinen et al. 1998; Peffers et al. 2003; Ravichandran and Rai 1999; Segars and Grover 1999). Formal controls, reviews, and governance structures have been proposed as a

way of ensuring that new systems will meet users' and organizations' needs (De and Hsu 1986). Structured analysis of problem areas, with extensive documentation of requirements, is expected to increase system quality (Dennis and Wixom 2003). However, in spite of the range of formal techniques available, managers of development projects continue to supplement them with *ad hoc*, informal activities (Kirsch 1997; Kirsch et al. 2002). Likewise, while many software development methodologies are available, organizations often fail to use them in the way their advocates propose would be necessary to achieve reliable project outcomes. Technologies that embed structured methodologies have not achieved widespread acceptance (Fichman and Kemerer 1993), and when used at all they are often significantly modified (Orlikowski 1993). Similarly, relatively few firms achieve the level of structure and rigor that is advocated by software engineering experts as a basis for producing technically robust systems (King 2003).

While it may be that most developers and firms are simply blind to the advantages of formal development and project management methodologies, mindfulness theories suggest another possibility. Experienced developers and managers may implicitly recognize the value, and difficulty, of maintaining a mindful approach when performing complex tasks in dynamic environments. This recognition would lead them to avoid the use of techniques that hinder or discourage mindful behaviors and perspectives in favor of those that promote them. Recent work with project managers suggests that techniques which help managers notice emerging problems and rapidly mobilize necessary personnel to resolve them are key to managing project risk (Lyytinen et al. 1998). Thus, it is not the anticipation of generalized risks that leads to reliable outcomes, but rather managerial and team mindfulness with its attention to operational details (so that issues will be detected quickly) and flexible structure (so that issues will quickly find their way to the those who have the expertise needed to resolve them) (Weick and Roberts 1993; Weick and Sutcliffe 2001).

Recent interest in agile development methods (Cusumano et al. 2003) also reflects a desire for techniques that promote mindfulness. While formal analysis and design methods have many significant benefits, at their core they rely on cognitive commitment and assumptions of stable requirements, abstract characterizations of work settings, and design/use dualism (Kakola and Koota 1999). Any methodology that works on this basis runs the risk of promoting premature cognitive commitment on the individual level (e.g., Chanowitz and Langer 1980) and failure to consider emerging issues at the organizational level due to an over-reliance on abstraction (Weick and Sutcliffe 2001). In contrast, the principles under-

lying agile development techniques such as eXtreme programming (e.g., Beck 2000) may be desirable because they promote mindfulness. Discarding formal requirements and specifications entirely in favor of intimate user involvement and ultra-fast cycling of operational systems focuses developers on the details of what is needed and what exists, rather than the abstractions of what is expected or promised. Pair programming, where two individuals work together on a single workstation, forces developers to consider problems from multiple perspectives. Open access to code, in which developers are allowed to make changes wherever necessary, allows for easy migration of problems, expertise, and solutions. Each of these techniques serves to increase individual or collective mindfulness. While the exact nature of the tradeoffs between formal and agile development methodologies remains unclear, mindfulness theory provides an avenue for explaining how the latter can contribute to the production of reliable information systems, and, perhaps, why developers' departures from structured methodologies may actually benefit their projects.

## **IS Design**

Mindfulness theories also have a variety of implications for the practice of designing information systems. First, designing reliable systems is more than a software engineering problem. If users contribute to, or undermine, a system's reliability, then designing reliable systems requires the development of technologies that promote mindful user behavior. Second, information systems embed and affect work practices. As a result, they can change an organization's ability to develop and maintain mindful approaches to its work and environment. Whether at the individual, unit, or organizational level, mindfulness theory raises questions about the principles and consequences of how systems are designed.

## **Designing for Mindful Use**

Technical views of system reliability focus on reliability as a characteristic of a technology object resulting from a well-executed design and development process. High-quality, technically reliable software can be achieved when competent IS professionals follow appropriate development methodologies (e.g., Ravichandran and Rai 1999). Yet because of declining marginal returns to software testing (Westland 2000) and limits on programmers' abilities to predict future behavior of inherently complex systems (Donat and Chalk 2003), technical system reliability is unlikely to be fully

achieved. Even when they are able to create software that is relatively high-quality, organizations routinely fall short of ensuring adequate data quality (Olson 2003). Therefore, while it remains important for designers to strive to create systems that are free from hardware, software, and data flaws, technical reliability is not sufficient. A complete characterization of systems design must also consider how systems can be designed to help users achieve reliable outcomes in spite of the failures, glitches, and errors they will encounter.

A focus of the IS design literature is to develop systems that fit with minimal effort into users' work routines. Systems are designed to enhance ease-of-use (e.g., Venkatesh et al. 2003)—that is, to reduce the cognitive effort required to perform a task. Cognitive fit arguments (e.g., Vessey and Galletta 1991) also stress the benefits of providing an interface and capabilities that are consistent with a user's cognitive frame. Expectation confirmation theory (e.g., Bhattacharjee 2001) implies that meeting users' expectations for a system is an important part of encouraging use. Well-designed systems are thought to engender user trust and confidence and enhance usability by providing interfaces and capabilities that are easy to use and conform to users' preferred perspectives and expectations.

When considered from a mindfulness perspective, these same characteristics may have negative implications. While software that is easy to use increases users' efficiency, it also increases their vulnerability to change or failure because it makes task execution more automatic (Langer 1989). Conscious, mindful effort is required to build and evolve the kind of detailed understanding that underlies users' ability to detect failures, diagnose problems, and respond appropriately to changes. Similarly, systems that provide results tailored to one perspective, and avoid revealing alternative perspectives, increase efficiency at the expense of reliability and effectiveness (e.g., Markus et al. 2002) by discouraging mindfulness. Finally, and perhaps most fundamentally, information systems that present information as unequivocal facts, analysis results as unambiguous, or system-provided "advice" as certain, run the risk of hindering individuals' ability to produce reliable outcomes. For example, spreadsheets often contain errors (Galletta et al. 1996), yet individuals routinely accept the results of spreadsheet calculations uncritically. Grammar and spell-checking agents embedded in word processors are subject to similar problems, with novice users accepting flawed recommendations and expert users missing errors that they assumed the agents would catch (Galletta et al. 2005). Users' willingness to uncritically accept software-generated results demonstrates how easy it is for systems to promote routinized, mindless use that can ultimately undermine reliable performance. Providing both explanations and

answers, supporting the consideration of multiple perspectives (Markus et al. 2002), and enabling what-if scenario analysis are thus examples of design features that enhance individual mindfulness.

### Designing to Enhance Collective Mindfulness

Beyond promoting or hindering individuals' mindful use of information systems, how systems are designed can also affect collective mindfulness. Organizations that operate in dynamic and unpredictable environments are particularly vulnerable to systems that promote efficient, routinized behavior by reducing the involvement of humans in day-to-day activities (Weick and Sutcliffe 2001). Information systems designed to automate tasks or aggregate data, such as ERP systems, reduce the labor involved in handling transactions within and between organizations but may undermine organizational mindfulness by masking unexpected variation. Routines that are embedded in software restrict and channel users' choices (Kogut and Zander 1992). Process automation can therefore have the undesirable effect of increasing efficiency while lowering satisfaction and quality of work (Kraut et al. 1999). Further, by aggregating data, such systems encourage an abstract conceptualization of work processes that makes maintaining collective mindfulness more difficult. Finally, and perhaps most counterintuitively, mindfulness theory suggests that in the extreme, reliable performance may actually be enhanced by systems that, as a result of inadequacies and errors, encourage individuals to seek out multiple information sources and critically evaluate the data upon which they rely (Hedberg and Jonson 1978). Mindfulness theories do not imply that automation, routines, or technically reliable systems are undesirable. However, they do remind us that while it may seem costly, situated and active human cognition ultimately underlies an organization's ability to handle the unexpected situations that inevitably arise in modern IT-based business environments.

### Conclusions

Recent commentaries have noted that while information technology has become more complex, componentized, and fragile, and its use has become more situated, diverse, and central, our models of technology have remained largely unchanged (Orlikowski and Iacono 2001). Other commentators suggest that IS scholars have consistently avoided engaging the nature of the technologies that we study (Benbasat and Zmud 2003). Our response is to agree with the premises but challenge the conclusions of these arguments.

Information technologies, and the ways in which they are applied, have become much more "problematic" (Orlikowski and Iacono 2001). Partially because of this, IS scholars have tended away from theorizing about actual technologies. While some respond to this with calls to reengage the technology artifact and reclaim our competitive advantage of understanding information systems, we contend that a profitable direction for IS research is to provide theories and methods that help practitioners apply technologies and manage systems that are, at best, fragile and complex, and, at worst, unknowable and unpredictable, in ways that increase individuals', teams', and organizations' ability to work reliably and efficiently. The examples we provide of real-world conundrums in information systems design, development, and management all demonstrate that mindfulness is a useful lens for illuminating under-researched aspects of phenomena that are central to the management and use of information systems in organizations. Rather than trying to generalize the situated, systematize the problematic, or simplify the complex, IS practitioners need conceptual tools that help them mindfully manage, so that they can support the efforts of others to survive and thrive in complex, dynamic environments.

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