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Technology features as triggers for sensemaking

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TECHNOLOGY FEATURES AS TRIGGERS FOR SENSEMAKING

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Technology implementation is complex and often unpredictable. Although previous research describes mechanisms related to the social construction of technology and technology use in organizations, researchers have focused little on the inputs to these models. In this article I attempt to fill this void by examining triggers for initial user sensemaking. The prediction of sensemaking should enhance the application of theories, such as adaptive structuration, and inform the management of technology through greater anticipation of user understanding.

> They did not anticipate that the steel ax would lead to more sleep, prostitution, and a breakdown of social relationships and customs. Change agents frequently do not sense or understand the social meaning of the innovations that they introduce (Rogers, 1995: 423, quoting from Sharp, 1952: 69–92).

The preceding quotation illustrates the possible consequences when implementers do not anticipate user sensemaking regarding a change. The implementers of the steel ax did not foresee the consequences of their introduction of a relatively simple technology. These missionaries believed that the aborigines would use steel axes as they had their stone ones (Rogers, 1995), and they did not anticipate that this new technology would evoke sensemaking and, ultimately, new understandings of the technology. Today, given the complex systems within which new technologies are implemented, it is even more difficult for implementers of modern technologies (e.g., flexible manufacturing systems, customizable voice and electronic mail systems, biotechnology) to anticipate users' sensemaking and its effects (e.g., Weick, 1990).

Modern examples of instances in which user responses to technology are unanticipated and/or extreme are plentiful and vivid. For instance, the responses of the European Union and Greenpeace to Roundup Ready® soybeans[1] resulted in the recall of some 500 tons of Toblerone chocolates containing lecithin derived from the genetically engineered beans (Associated Press, 1997). Members of Greenpeace were concerned about unanticipated effects of genetically engineered soybeans in the food chain, as well as about the possible evolution of superweeds that are immune to standard eradication processes (Greenpeace, 1996). Traditional magnetic resonance imaging (MRI),[2] which requires a patient to stay in a 30-inch-diameter tube for close to an hour, provides another example. Many patients have found this procedure to be impossible, or at least uncomfortable, to tolerate (Majeski, 1995). As a result, open-sided MRIs (using a table, rather than a tube) have become increasingly popular. Proponents of traditional MRIs say that claustrophobia related to the size of the tube is "not a big deal," even though as early as 1995 they began fielding an increasing number of concerns from patients (Majeski, 1995). Similarly, Intel was slow to react to user concerns when an error on its Pentium chip was made public. Apparently, the company perception was that an error that would occur, on average, only once every 27,000 years was not something a logical consumer would worry about (MacMillan & McGrath, 1996). Intel's perception contrasted sharply with that of the users of its technology. From approximately October to December 1994, Intel was the target of worldwide attention as it struggled to come to grips with users' percep-

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[1] Roundup Ready® soybeans are a product of genetic engineering. The herbicide Roundup® can be sprayed directly on the growing soybean plants; weeds are killed, but the specially engineered soybeans are unharmed.

[2] MRI is a form of radiology using radio waves and magnetic energy to produce diagnostic, multisectional anatomical images.

tions of the error (Uzumeri & Snyder, 1996). Intel stock fell 8 points in the 7 trading days after the flaw became known (Kessler, 1995). In each of these cases, user and implementer perceptions of a technology were dramatically different. Each scenario also illustrates the possible cost of such disparate perceptions.

Prior research in which scholars have examined the dynamics and outcomes of differing user and implementer perceptions (Griffith & Northcraft, 1993; Lind & Zmud, 1991; Orlikowski & Gash, 1994; Robey, Farrow, & Franz, 1989) has benefited from other work related to the social construction of technology (e.g., Barley, 1986) and adaptive structuration theory (DeSanctis & Poole, 1994). Social construction and adaptive structuration theory both address the dynamics that lead people to express and enact their realities (e.g., Weick, 1979). That is, there is a cycle of individual-level sensemaking to mutual/social sensemaking to understanding, followed by actions, and then a new cycle beginning with individual-level sensemaking.

Technology has been the focus of critical research in the literature of both social construction (e.g., CT scanners and organizational structuration; Barley, 1986) and adaptive structuration theory (use of group support systems; DeSanctis & Poole, 1994). However, little research seems to focus on the *initial* development of user sensemaking, either specifically related to technology or more generally. Initial sensemaking is a critical input to later-stage models. Starbuck and Milliken (1988), for example, note the importance of this first step but do not provide a detailed model of the process. Similarly, Fiske and Taylor (1991) outline a process of how stimuli become represented in the mind—but linking this process to specific features of technology was not their intention.

As illustrated by the above three examples of unanticipated user reactions to new technologies, the benefits of users and implementers having convergent understandings of technology, and the costs when user and implementer understandings differ, can be great (e.g., Lind & Zmud, 1991; Orlikowski & Gash, 1994; Robey et al., 1989). My goal here is to supply some of the missing links between those understandings. How do users initially make sense of a technology? What role do the features of a technology play in this process? This goal is consistent with Orlikowski and Gash's (1994) call for research focusing on how and when technological understandings change. We do not seem to have theory of how users initially comprehend the capabilities of a technology.

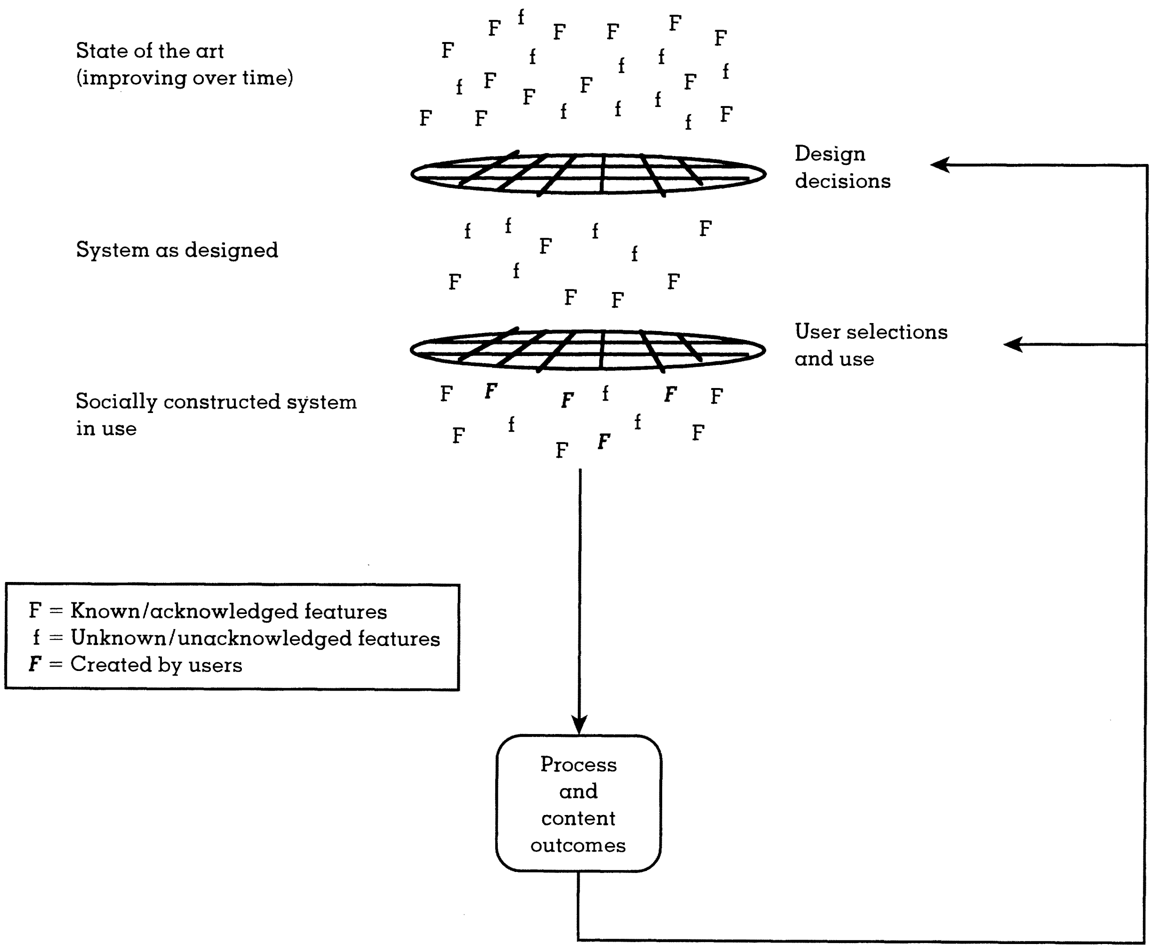
The features-based theory of sensemaking triggers (FBST) I present here attempts to fill this gap. Features of technology (or "technology features" for ease of presentation) are the building blocks or components of a technology (e.g., Griffith & Northcraft, 1994; Nass & Mason, 1990). In this article I link dimensions of technology features with extant research on sensemaking triggers and place the triggering process in context with later-stage models of technology understanding and use (e.g., adaptive structuration theory).

Any technology can be characterized by its features, which result from choices during the design process (e.g., "We will use laser measuring tools to test the dimensional quality of our truck body production. There will be five different statistical reports available to summarize the laser measurements.") and decisions about use (e.g., "I will only use the X-Bar chart statistical report because it is the only one I believe I understand"). Figure 1 provides an illustration of the relationships between designer and user perceptions and technology features. Design and use decisions serve to both filter features out of the system (as depicted by the screens in Figure 1) and to make new features available over time (Garud & Rappa, 1994).

Linking technology features to the process of sensemaking and understanding is central to my argument. This connection is made at the point where user sensemaking is triggered. I have attempted to make this presentation of the FBST comprehensive. The next section provides term definitions, boundaries, and links between the developing theory and extant work. I define technology, relevant agents (users versus implementers), and timing to provide a context for the new concepts. The body of the presentation includes the constructs and dynamics of the FBST. Finally, I tie individual sensemaking to the adaptive structuration and social construction processes that lead to technology understanding.

I anticipate that the long-term result of this model will be an increased ability to predict the form and process of understanding about technology. Organizations where implementers are able to determine which features users mentally

FIGURE 1
Conceptual Model of Technology and Technology Features



bring to the social construction process should ultimately be able to improve technology design, implementation, use, and redesign. Without such knowledge, technology implementation (indeed, any organizational change) proceeds on limited information, and organizations, thus, can less proactively manage the implementation process. The FBST provides a model for anticipating users' understanding of the technology and should therefore provide a background for organizations to change the technology design so that needed features are recognized as a matter of course; to change the implementation based on a need to emphasize certain features; or to take early advantage of features recognized by users, but perhaps overlooked by implementers and designers. Overall, the FBST should increase our ability to anticipate the particular inputs to broader processes of sensemaking. I describe this connection in greater detail below.

FOUNDATION AND BOUNDARIES

Building on the work of Barley (1990) and Rogers (1995), I define technology in broad terms—an approach that allows me to take advantage of research in several areas. "Technology" here includes specific tools, machines, and/or techniques for instrumental action. This definition also allows for the acknowledgment that a technology may have two components: (1) a hardware component, consisting of material or physical objects, and/or (2) a software component, made up of information (Rogers, 1995). Clearly, the proportion of these components varies greatly across technologies; I discuss the impact of these differences below.

The FBST is relevant during the knowledge stage of technology introduction—a stage that begins when a technology user is exposed to the technology's existence and gains some knowledge of its meaning and use (Rogers, 1995). (Later stages of Rogers' model include persuasion, decision/adoption, implementation, and confirmation.) The knowledge focus maintains the model's relevance for technologies both inside and outside organizations. It also allows for an examination of technology change.

Most technologies go through adaptation (customization, addition of new features, and so on) over their life cycles (Leonard-Barton, 1988; Orlikowski, Yates, Okamura, & Fujimoto, 1995; Rogers, 1995). Whereas Rogers argues that such adaptations generally occur during the implementation stage (where the innovation is put into actual use), others suggest that adaptation occurs in cycles (e.g., Leonard-Barton, 1988; Orlikowski et al., 1995). As a result, I conceptualize such changes here as returning to the knowledge stage for the change's own initial exposure to users. Thus, the FBST is tied to initial introductions of either completely new technologies or their adaptations.

The FBST focuses on users of a technology, although other stakeholders are also important. Isabella's survey of the change literature suggests that managers are key to cognitive shifts related to organizational change (1990). Other researchers have noted the role played by managers as "sensegivers" (e.g., Gioia & Chittipeddi, 1991). As noted below, the FBST acknowledges the differences—and importance—of both user and implementer cognitive models. Yet, a technology is ultimately employed by users who may or may not have dramatic reactions to it. Individual user understanding (or sensemaking), as well as its relationship to implementer understanding, has been shown to be critical to the success of a technology (DeSanctis & Poole, 1994; Griffith, 1996; Orlikowski, 1992; Rogers, 1995). Over time, and in different situations, users may become implementers, managers, or designers, and vice versa. Yet, given its focus on the knowledge stage, the FBST concentrates on people who are, at least for the moment, acting as users. This individual-level approach is also a useful companion to Swanson and Ramiller's recent institutional-level assessment of "organizing vision" for new information systems (1997).

Thus, FBST is a model about users' initial technology sensemaking. FBST ends where adaptive structuration theory (DeSanctis & Poole, 1994) and other models of the reciprocal process of social, organizational, and technical construction (e.g., Barley, 1986; Orlikowski, 1992; Weick, 1995) begin. For example, whereas the FBST addresses how users initially make sense of the capabilities of a new technology, adaptive structuration theory uses this initial user sensemaking as an input for understanding how technology is used and adapted within an organization. (I focus on adaptive structuration theory given its clarity and growing empirical attention; see, for example, Chin, Gopal, & Salisbury, 1997).

The key to adaptive structuration theory is that the role of advanced technologies is acknowledged to consist of two parts: (1) the structures that are provided by the technology and (2) the emergent structures resulting from human perception and use of the technology in the organizational context (e.g., DeSanctis & Poole, 1994). Adaptive structuration theory speaks to the processes by which human interaction, technology, and social structures combine to create a technology-in-use. FBST speaks to the processes by which a technology's structures (features) are first made sense of. Only then can these technology structures be combined with human interaction and social structures.

FEATURES

DeSanctis and Poole (1994) separate the structure of a technology into features and "spirit" (the general intent for use underlying the features, as in "spirit of the law"). However, for FBST, the analysis must be more fine grained to explain how users come to initially understand a technology. The main focus in FBST is on the first step in the understanding process: the triggering of user sensemaking about the features of a technology. I use certain dimensions of technology features to connect a technology with sensemaking triggers. As noted above, features are the building blocks or component parts of a technology. For example, an assembly line may be mechanical or magnetic and it runs at some pace; a personal digital assistant can take input from a keyboard and/or a stylus; and a telephone can be digital or analog and have audio and/or visual capabilities.

This more fine-grained, features-based approach is consistent with other recent research. Rather than speaking of technology as a whole (e.g., Woodward, 1965), many researchers have begun to focus on more specific technologies—for example, advanced manufacturing technology (Dean, Yoon, & Susman, 1992), business computing/office automation (Attewell, 1992), or group support systems (Poole, Holmes, Watson, & DeSanctis, 1993). However, even at this more specific level of analysis, there is still a great deal of variability within broad technology descriptors.

I anticipate that a features-based approach will provide a valuable unit of analysis. Griffith and Northcraft (1994) discuss the issue of "features" versus the more global concept of "technology" in the context of communication media. They explain communication media as "socially constructed convenient fictions for describing and discussing particular constellations of features" (1994: 283). Expanding this analysis strategy to include technology in general simply requires that technology be seen as a "socially constructed convenient fiction." Any technology is actually a combination (constellation) of features: distinct parts, aspects, and qualities. Features that are noticed by users then can be socially constructed into an organizational system—for example, as described by adaptive structuration theory.

The marketing literature also deals with the concept of features. Authors often model consumer behavior as a choice from among a set of products with varying attributes (Wedel, Vriens, Bijmolt, Krijnen, & Leeflang, 1998)—or features[3]—to use the terminology of the current research. MacMillan and McGrath (1996) note the importance of being able to discern which features consumers will find salient, and the disastrous results if consumer perceptions are misjudged.

The concept of a feature, however, remains somewhat elusive. It is possible to examine some technology features at increasingly smaller (or larger) units of analysis (e.g., DeSanctis & Poole, 1994). For example, the personal digital assistant may take input from a stylus, the stylus may be plastic or metal, the plastic may be hard or soft, ad infinitum. Likewise, a personal computer may be a small node on an internal intranet and/or an even smaller node on the Internet. The cognition literature describes these as differences between component and holistic properties (Garner, 1978). The following section provides a descriptive process for focusing this examination of features.

Multidimensional theory drawing from marketing, innovation,[4] and technology management provides relevant insights for understanding how technology features trigger sensemaking—and thus, to a degree, which features to attend to. In the following discussion I develop two feature dimensions from these three areas of theory. Features can be placed along the continuum of each dimension, and their placement is linked to the sensemaking triggers below.

Consumer behavior research focused on cognition suggests the first technology feature dimension: *concrete* versus *abstract*. Concrete features can be directly and specifically described, whereas abstract features must be described more indirectly and/or generally (e.g., Johnson et al., 1992). Extended from the marketing use of the terms, the continuum from concrete to abstract refers to the degree of verifiable "fact" inherent in the feature. Even ostensibly concrete features may have different degrees of verifiability—that is, some features may be easily observed,[5] whereas others may be verifiable only with special knowledge or tools. The more difficult it is to

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[3] In the marketing and cognition literature, authors also use the term *features*, although in a more limited way. The distinction there is that products (or stimuli) can have attributes of two types: either dichotomous features (a car has antilock brakes or it does not) or more inherently continuous dimensions (such as the level of safety provided by a given car; e.g., Garner, 1978; Johnson, Lehmann, Fornell, & Horne, 1992). Here, I use "features" more generally, consistent with prior technology research (DeSanctis & Poole, 1994; Griffith & Northcraft, 1994).

[4] Although the innovation literature does provide insight into dimensions of features, it is important to note that dimensions of features are not the same as the five attributes often used to describe innovations as a whole (i.e., relative advantage, compatibility, complexity, trialability, and observability; Rogers, 1995). As noted, these attributes are useful for understanding innovations as a whole and across the full life cycle, whereas FBST is a features unit of analysis and focuses on the knowledge stage of technology implementation.

[5] Observability here refers to the observability of the *feature*—not of its benefits (as in Rogers' use of the term to describe the observability of an *innovation*).

verify a feature, the closer the feature should be placed to the abstract end of the continuum. For example, although the genetically engineered feature of Roundup Ready® soybeans can be verified with sophisticated technology, that feature may be relatively abstract for most users (who lack the technology to distinguish between Roundup Ready® beans and others). The environmental safety feature of these beans is even more abstract. Likewise, the 30-inch-diameter tube of a traditional MRI is clearly concrete, whereas noises made by a functioning MRI are more abstract.

There is no strong theory suggesting a typology of features, but the extant literature appears to converge on a second type of feature that can be applied to the description of a technology. Marketing, innovation, and technology literature all raise issues related to a core versus *tangential* dimension. This dimension can be linked to the criticality of a particular feature to the identity and/or goal of the technology. Tangential technology features are not the main defining features of a technology, and their use may be optional. Core technology features, if removed or changed, change the overall nature of the technology.

MacMillan and McGrath (1996) provide a somewhat similar concept to that of core. They use the term *basic* (1996: 62) to describe a feature that consumers expect and take for granted in a product. Their use of "basic" is somewhat more general than the concept of core versus tangential in that basic features can still be tangential, although they are perhaps more likely to be core. Core features are basic, although the reverse may not be true. For example, it is basic that a laptop computer have a keyboard, even though other input methods are possible without changing the function of the computer (e.g., handwriting or voice recognition). Keyboards may be basic, but they are also tangential. In contrast, the ability to connect to a specific telephone number is both a basic and a core feature of modern telephones.

More directly related to the concept of core versus tangential technology features is the idea of *discontinuous* versus *continuous* innovation. Discontinuous innovations are those that do not exist in current technology and cannot be created through the extension of current technology (e.g., Veryzer, 1998). The relationship between core versus tangential and discontinuous versus continuous is that changes to core features are the defining events of discontinuous innovation. Changes or adaptations to tangential features are only extensions or modifications of an innovation and, thus, are continuous. Here, I use core versus tangential rather than discontinuous versus continuous because the latter dimension is more appropriate for technologies as a whole than for specific technology features. It is conceptually difficult to discuss continuous innovations that might have discontinuous technology features (as would be the case for a discontinuous innovation related to a tangential feature). In addition, evaluation of whether a technology is continuous or discontinuous relies on knowledge of prior technologies and is therefore outside the bounds of the FBST, which is directly focused on the introduction of a specific technology to a particular user. Evaluation of whether a feature is core or tangential requires only knowledge of the function of the technology under consideration and is a more parsimonious concept.

In summary, some features are core to the definition of a technology, whereas others are more tangential (e.g., Griffith & Northcraft, 1994). For example, Culnan and Markus (1987) provide a list of key attributes (i.e., features) for a variety of electronic media. For voice mail these features include message forwarding, distribution lists, message storage and retrieval, and message editing. However, voice mail may have additional features as well. That provided by Pacific Bell, for example, includes pager notification services and the ability to transfer an incoming call to a human attendant. Thus, like much technology, voice mail has several core technology features, as well as others that are more tangential. Although features have been described in the literature using other terms, such as basic and discontinuous/continuous, the concept of core versus tangential is more appropriate for a focus on the initial presentation of a technology, its features, and the features' subsequent effects.

Analysis of core versus tangential technology features also provides an opportunity to find the appropriate level of analysis for the features themselves. As noted above, identifying technology features from within the complexity of a technological whole may be difficult. Features themselves can have features, and so on. In their study of a group support system, DeSanctis and Poole (1994) anchor their analysis to the social structures relevant to the technology. That choice has clear merit given the social nature of a group support system. A more generally applicable approach may be to anchor the level of analysis to that most appropriate for the core features.

Figure 2 illustrates the role of technology features in triggering sensemaking and the subsequent links to adaptive structuration and understanding. First, the features-based perspective (rather than a holistic analysis of technology) focuses our attention on how, once a technology is presented, types of technology features differentially trigger user sensemaking—the first step in understanding a technology. Second, features that trigger sensemaking at the individual level then serve as inputs to adaptive structuration, which combines the outcomes of multiple individuals' sensemaking in a social construction process.

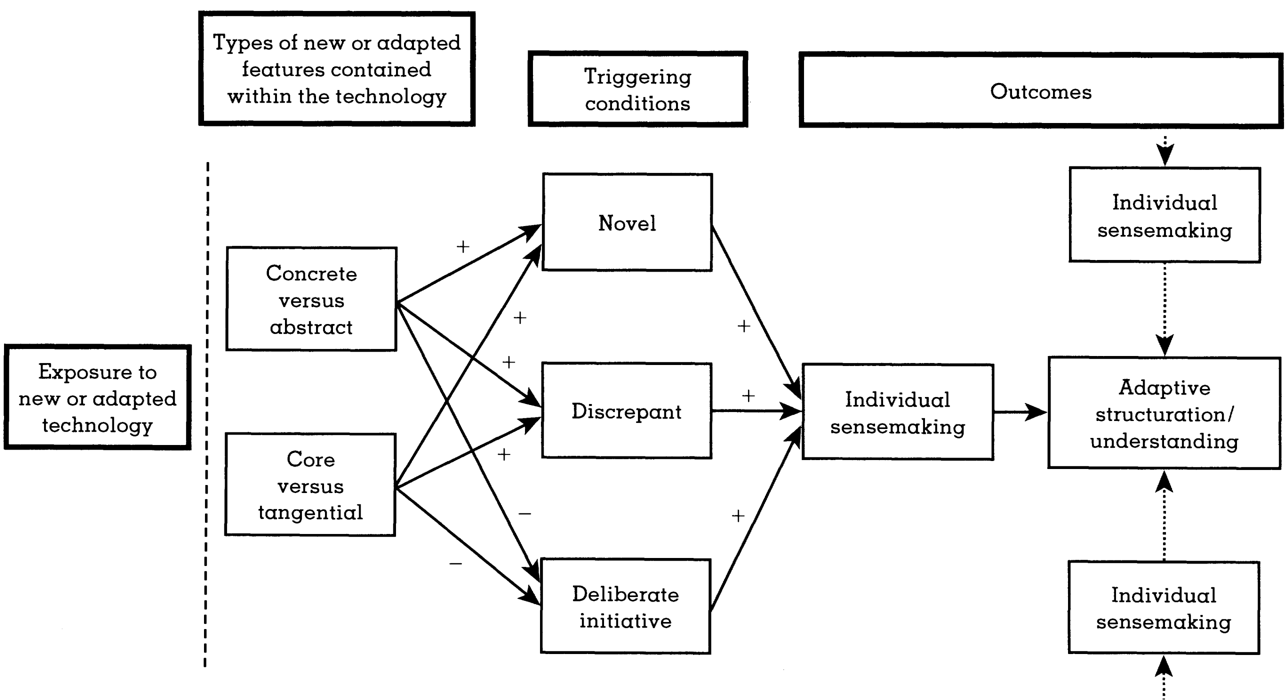
The next sections provide a general background on sensemaking, a discussion of the importance of triggering sensemaking, and a description of and propositions regarding features' roles in triggering sensemaking. These sections flesh out the FBST. The prior discussion has provided a foundation by examining critical dimensions of technology features—dimensions that were derived from a broad spectrum of research. In the next section I illuminate the dynamic connections that translate the features of technology into the basis of user understanding.

SENSEMAKING

Earlier, I noted that differences in understanding between users and implementers have been shown to play a role in the success of a technology. Research from a cognitive perspective that addresses the congruence of understanding between participants is growing in both the general organizational literature (e.g., Fiol, 1994; Meindl, Stubbart, & Porac, 1994) and in work focused specifically on technological implementation (DeSanctis & Poole, 1994; Griffith & Northcraft, 1996; Klein & Sorra, 1996; Orlikowski, 1992). Overall, user understanding appears to play a key and complex role in technology success.

Weick (1990) states that new technologies are simultaneously the source of stochastic, continuous, and abstract events. He also notes that technologies require ongoing structuring and sensemaking if they are to be managed. This is

FIGURE 2
Features, Triggers, and Understanding



consistent with Leonard-Barton's (1988) assertion that technologies and organizations adapt to each other in cycles. The downside is that continuous change can be inefficient (Orlikowski, 1992), and opportunities must exist for designers to understand users' sensemaking (March, 1971; Tyre & Orlikowski, 1994). Tyre and Orlikowski (1994) found that these "windows" of sensemaking are rare unless an unusual event or discovery provides a trigger that connects technology features and sensemaking.

Researchers have given triggers for sensemaking less research emphasis than sensemaking itself (Louis & Sutton, 1991), although some have noted the distinctive importance of the trigger. For example, Starbuck and Milliken, in a much-quoted passage, declare that "noticing may be at least as important as sensemaking. . . . If events are noticed, people make sense of them; and if events are not noticed, they are not available for sensemaking" (1988: 60). Weick, in discussing the extraction of cues (i.e., the triggers that cause cues to be noticed), states that even small or subtle features can have large sensemaking effects (1995: 52).

Louis and Sutton (1991) provide the most explicit discussion of triggers in the sensemaking process. In their review of wide-ranging literature, including psychology (e.g., James, 1890), sociology (e.g., Mills, 1940), organizations (e.g., March & Simon, 1958), and cognition (e.g., Kiesler & Sproull, 1982), these authors identify three circumstances that trigger the change from the unconscious *use* of schema to conscious attention to the *development* of schema. They describe a transition "from habits of mind" to "active thinking" (1991), specifying three trigger conditions:

1. The situation is novel.
2. There is a discrepancy between what is expected, given the schemas in use, and what is observed.
3. There is deliberate initiative: one is asked to think.

These triggers function at a very early stage in information processing. Fiske and Taylor (1991) describe, in detail, information processing for social encoding: the process whereby stimuli become represented in the mind. Consumer psychologists have discussed information processing related to products (Kardes, 1994). Social cognition and consumer psychology views are consistent with Fiske and Taylor's summary:

> Most theorists agree that we perform some kind of unconscious *preattentive analysis* of environmental stimuli, combining features into the objects and events we notice consciously. Once noticed, a stimulus may come in to conscious *focal attention*, to be identified and categorized. As *comprehension* occurs, the stimulus is given semantic meaning. Finally, *elaborative* reasoning links the particular stimulus to other knowledge, allowing for complex inferences (1991: 246).

Sensemaking triggers constitute the process of noticing. These triggers are based on the results of preattentive analysis. When sensemaking is triggered, the user may develop perceptions of salience and/or vividness (Kardes, 1994) and then focus his or her attention on the stimuli.

Introductions of technology often provide these triggering conditions. For instance, unfamiliar or previously unknown situations (e.g., the first use of video conferencing) produce *novelty*. Using schemas that are inappropriate for the current situation (e.g., using sampling-focused statistical methods when a new inspection technology checks 100 percent of the product) produces *discrepancy*. And a request to notice differences or to think about something in a new way (e.g., software installations that require options to be selected before the installation will continue) provides *deliberate initiative* to begin sensemaking.

Other researchers have provided alternative descriptions of triggers for sensemaking—for example, "shocks" and "occasions for sensemaking" (Weick, 1995), "thresholds" (Huber & Daft, 1987), and "gaps" between the way things are and the way one wants them to be (Smith, 1988). However, Louis and Sutton's (1991) treatment is the most clearly articulated to date and provides the focus here.

Louis and Sutton (1991) suggest that level of novelty, likelihood of failure of extant schema, and/or deliberate initiative are functions of the situation (i.e., the technological change) and the individual (i.e., how much experience and/or training the individual possesses). Thus, organizations can influence the sensemaking surrounding the implementation of a technology by managing both user background and technology features.

LINKING FEATURES AND SENSEMAKING

One way of understanding these relationships is to focus on how sensemaking may be triggered by different features. As mentioned earlier, technology features vary on at least two dimensions: (1) concrete versus abstract and (2) core versus tangential. Figure 2 illustrates propositions relating different types of features to different outcomes regarding novelty, discrepancy, and deliberate initiative. I discuss these relationships between features and sensemaking triggers below. Louis and Sutton note that the trigger is not tripped just because a situation is novel or discrepant, or because it prompts deliberate initiative; the situation must actually be experienced as novel, discrepant, or as requesting or requiring deliberate initiative (1991). In the following propositions I examine how and why this cognitive dynamic begins.

The model, as I have noted, focuses on technologies in the knowledge stage. That is, the ability of features to trigger sensemaking is considered at the stage where users are first exposed to a particular version of a technology, which may be new or an adaptation. The change may be the result of management, designer, or user action. Particular technology features may or may not trip multiple sensemaking triggers. (It is also possible that features are not entirely independent—that is, one feature may cause another to be more or less likely to trigger sensemaking; however, this complex discussion is left for future research. I refer interested readers to Kardes [1994].) Finally, the action of a feature triggering sensemaking is similar to that of a stimulus coming "into conscious focal attention" (Fiske & Taylor, 1991: 246). That is, when features cause one to experience novelty or discrepancy and/or to provoke deliberate initiative, they are noticed. Technology features that trigger sensemaking serve as a foundation for the process of how users come to understand the technology as a whole.

Concrete versus Abstract

One can determine whether a technology feature is concrete or abstract based on the amount of verifiable fact that can be ascribed to the feature. ("Ascribed," I should note, acknowledges that even "verifiable fact" is a social construction.) That said, some features are more concrete than others. This distinction is similar to Weick's idea that modern technologies include "a technology in the head and a technology on the floor" (1990: 17). Concrete technology features may be literally on the floor. Abstract technology features are more likely to exist in the head. In addition, Rogers, although his work is concerned with innovations as a whole rather than features, suggests that the degree to which an innovation's results are observable will positively affect the innovation's diffusion. He goes on to note that innovations in which the software/information is dominant over the hardware (i.e., innovations that are less concrete) will take longer to diffuse, since software/information is harder to observe (1987).

More precisely, new or adapted concrete features are more likely to be noticed as new than are new or adapted abstract features. Orlikowski and Gash provide a field example of this: the implementation of LotusNotes in a large management consulting firm, where a senior technologist commented, "I first saw it [Notes] as an e-mail product. I didn't see the grand scope of the product" (1994: 186). Although both e-mail and the more "grand" information-processing capabilities of Notes were new in this setting, employees noticed the concrete e-mail feature before the more abstract "scope" feature—the grand scope of the technology as a "competitive advantage" or a way to invoke cultural change.

The theoretical underpinnings of this proposition rely on verification. New or adapted concrete features can be observed, perhaps even directly compared with older features. As a result, novelty can be directly recognized. Abstract features can also be compared, but verification related to some fact is more difficult. In summary, I propose:

> *Proposition 1a: New/adapted concrete features are more likely to be experienced as novel than new/adapted abstract features.*

The concrete versus abstract dimension also speaks to the second trigger for sensemaking: whether a new or adapted feature will create a discrepancy for extant schemas. Concrete features can grind to a halt when an inappropriate schema is applied. Because unanticipated effects of abstract features may be easier to explain away, they are not as likely to be experienced as discrepancies.

Consider, for example, the implementation of a laser-based measuring system at several automobile assembly plants. I participated in a 3-year study of this transition, in which the old technology for measuring the shape of a part required taking the part off the assembly line, placing it in a measuring jig, and using mechanical tools to take the measurements. Two or three parts could be measured per shift. These measurements were then compared to a hard copy of the expected measurements. The new technology, however, involved using lasers to measure the part while it traveled down the assembly line.

The users noticed the concrete feature of measuring without removing parts from the assembly line immediately, and they adjusted schemas accordingly; no one ever tried to measure a part with the new technology by removing it from the line. However, only after using the new technology for several months did the users realize that their random sampling–based statistical tests were inappropriate, given a database from 100 percent measurement. That is, the more abstract feature—need for population versus sampling statistical techniques—took much longer to trigger a realization that old schemas were inappropriate.

This can be explained by noting that there is generally less observable variance in a concrete feature and its outcomes than in an abstract feature, whose form and outcomes are more open to interpretation. When variance occurs between anticipated and observed outcomes in a concrete feature, users are more likely to recognize the variance as a discrepancy. Similarly, changes in reward contingencies are noticed more quickly when reinforcement schedules are verifiable (e.g., for every third behavior, a reward is given) than when reinforcement schedules vary around some mean (e.g., on average, for every third behavior, a reward is given). Further evidence is provided by the extinction of contingent behavior patterns after the removal of a reward. Extinction happens when discrepant schema are acknowledged and behavior is adjusted accordingly. When a reward system is eliminated, extinction occurs more quickly for concrete, fixed schedules than for more abstract, variable ones (Goltz, 1992). Thus:

Proposition 1b: New/adapted concrete features are more likely to be recognized as discrepant than new/adapted abstract features.

The relationship between concrete and abstract features and deliberate initiative is more complex. A deliberate sensemaking initiative may be a user's response to an internal or external request for conscious attention (Louis & Sutton, 1991). It may be that once concrete features are put in use, they are assumed to be stable, whereas abstract features may appear to be more open to negotiation and, thus, create opportunities for deliberate sensemaking initiatives. Weick (1990) notes that users often consider technologies to be self-evident artifacts. If abstract features contain fewer concrete artifacts and more software/information, then abstract features may take longer to become self-evident in an organizational setting.

Computer (electronic work) monitoring provides an interesting example. The ability to track work is one of computer monitoring's concrete features, whereas the legality of computer monitoring (e.g., Committee on Education and Labor, 1991) is a more abstract feature. Which feature is more likely to be discussed at a management meeting? Once management has made the decision to use computer monitoring, it seems unlikely that the relatively concrete tracking feature will have to be discussed. However, management may discuss the more abstract legal issues before every appraisal.

Still, the relationship between concreteness and deliberate initiative is complex. The above discussion focuses on the probability that a feature will evoke a situation where sensemaking is deliberately initiated. These arguments suggest that abstract features are more negotiable and, thus, more likely to create situations where sensemaking may be initiated. However, even though concrete features are less likely to create situations where sensemaking may be initiated, if such an initiative *is* raised, this initiative is more likely to be noticed than the initiative in response to an abstract feature. This final twist in the prediction is based on the arguments for Proposition 1b. A deliberate initiative raised by a concrete feature would be more likely to be noticed as discrepant from the standard technology environment.

Proposition 1c: Conscious deliberation is more likely to be triggered by new/adapted abstract features than by new/adapted concrete features.

Proposition 1d: If conscious deliberation is triggered by both abstract and concrete features, then the trigger in response to the concrete feature will dominate that of the abstract feature.

Generally speaking, concrete technology features are more likely to trigger sensemaking than are abstract features. The next step is to consider the role of core versus tangential features in this triggering process.

Core versus Tangential Features

Whether a feature is core or tangential depends on how critical the feature is to the overall identity of the technology. Examples of core features include the ability to send messages in e-mail, the ability to track work in computer monitoring, and the reprogrammability of robots. Examples of tangential features include the reply function in e-mail, whether employees are signaled when computer monitoring begins, and the speed of a particular robot. Core features are the defining features of the technology; if these are new or adapted from prior use, the technology itself is new or changed. Tangential features are largely options related to the use of core features.

In a 1986 article Barley detailed the events following a change in core technology within the field of radiology. He described changes in radiology before the late 1960s as incremental improvements. However, he noted that more recent computer-driven technologies resulted in changes to core features. These innovations included operating principles that were both dramatically different from the older methods and that created completely new systems of diagnostic signs for radiologists to master. Not only did the users of the computed tomography (CT) scanners notice that the technology was new, but the technology was also shown to provide an occasion for structuring within the radiology organization (Barley, 1986).

Proposition 2a: New/adapted core features will be more likely to be experienced as novel than will new/adapted tangential features.

Louis and Sutton (1991) suggest that discrepancies result from a significant difference between expectations and reality. If a core feature is the defining characteristic of a technology, users will notice discrepancies related to a core feature immediately; the technology cannot function with mismatched schemas in place. After a change in core technology within Barley's radiology departments, it became clear that the old diagnostic schemas would not work with the new technology, and the department was faced with the "untenable prospect of scanning patients without the necessary expertise" (1986: 88).

Even if discrepancies between old and required schemas exist, they will be recognized only to the extent that they are encountered. For example, when the drawing feature of Microsoft Word changed from version 5 to version 6, because this feature was tangential to the core of the word processing system, the changed drawing feature was recognized as a discrepancy only by users of that feature of the software. A change from text-based input to voice input would be more likely to be noticed and recognized as a discrepancy because the text-based input feature of extant word processing technologies is more core than their graphics capabilities. To summarize:

Proposition 2b: New/adapted core features are more likely to be experienced as discrepant than new/adapted tangential features.

I noted the role that user choice plays in the user's understanding of features and in the success or outcomes of a technology in the discussion above. User choice is basic also to the next analysis: What is the relationship between core versus tangential features and deliberate initiative for sensemaking?

Core features are inherent in a technology's use. Contemplating deliberate initiative for sensemaking regarding the core of a technology is akin to asking whether the technology should be adopted. In the features-based model the focus is on the knowledge stage of technology introduction. Basic adoption has already taken place. Given that the user has chosen the technology, it is unlikely that there will be deliberate initiative related to core features.

However, the user may select any of the technology's many tangential features as "options" (e.g., Connolly, Jessup, & Valacich, 1990). As options, tangential features (e.g., menu selections or methods to change settings) are put into use by deliberate initiative. At the same time, "default" settings, employed so that no changes are needed to bring the technology into immediate use (Gustafson, 1994), reduce the probability that there will be deliberate initiative related to tangential features. The probability that the user will take deliberate initiative is moderated by the viability of these default settings.

In other words, making use of tangential features implies deliberate initiative, but given the existence of default settings, there is less probability that the user will select from available options. Support for this prediction is based on the ideas of satisficing (e.g., Davis, 1997; Simon, 1957). That is, users (and people in general) are prone to a search strategy that will end on the first viable solution. If the default settings are viable, it is less likely that tangential features will be considered; thus, there will be less opportunity for deliberate initiative. Nevertheless, deliberate sensemaking initiatives are more likely for tangential than for core features, given that the technology has already been adopted. Thus:

> *Proposition 2c: Conscious deliberation is more likely to be triggered by new/adapted tangential features than by new/adapted core features.*

> *Proposition 2d: The viability of default settings moderates the relationship between core and tangential features and deliberate initiative. The likelihood of conscious deliberation is reduced when default settings satisfy basic user needs.*

Proposition Summary

The above propositions suggest that concrete, core technology features are most likely to trigger sensemaking. This trend is clearest and most demonstrable in the case of the novelty and discrepancy triggers. Concrete and core technology features are expected to dominate the set of features that are considered as users initially make sense of technology. The question of deliberate initiative is more complex.

Deliberate initiative may be affected by implementation and/or design, rather than by technology features alone. In other words, deliberate initiative is more complex because it assumes an exogenous event. For a user to be confronted by deliberate initiative, either the technology or some other agent must ask for sensemaking.

The examples of Roundup Ready® soybeans and the Pentium chip are cases in point. Because both the key features in these examples are relatively abstract and somewhat tangential, sensemaking about the features is unexpected. However, in both cases third-party agents created the opportunity for deliberate sensemaking initiatives. In the case of the genetically engineered soybeans, environmental and governmental groups raised consumer consciousness (e.g., Greenpeace, 1996) related to the technology. In the case of the error in the Pentium chip, a research mathematician had to bring the error to an Internet discussion group before the feature was generally noted (Uzumeri & Snyder, 1996). In contrast, the 30-inch tube on a traditional MRI system, although tangential, is concrete, and patients are actively concerned about the choice between traditional and open-sided systems (e.g., Majeski, 1995).

THE NEXT LINK: FROM SENSEMAKING TO ADAPTIVE STRUCTURATION AND UNDERSTANDING

Novelty, discrepancy, and deliberate initiative (Louis & Sutton, 1991) suggest *when* sensemaking will take place. The last step is to consider *what happens* when sense is made of technological features. The Outcomes section of Figure 2 depicts the relationship between individual-level sensemaking, adaptive structuration, and understanding. Clearly, the focus in this article is on how technology features trigger sensemaking. However, although triggers may be the origin of how users come to understand a technology, it is important to keep these processes in perspective with more broad-reaching visions of social construction and adaptive structuration. The contribution of the FBST is to illustrate how technology design, in the form of features, initiates individual-level sensemaking. Individual-level sensemaking then produces an input to models that address the processes of social construction and adaptive structuration—models that acknowledge the importance of enactment and the duality of organizational and technological change (e.g., Orlikowski, 1992).

It may also be the case that an approach similar to that of the FBST could be used to extend such theories as adaptive structuration. Technology features may be able to enhance the understanding of group-level sensemaking and enactment processes. For example, DeSanctis and Poole (1994) note that the role of technology in organizations must be considered as an interplay among technology, social structures, and human interaction. Their discussion of technology as used and adapted by users could perhaps be examined using a lens fashioned from the current individual-level FBST. Although social structure aspects of the adaptive structuration model have received additional attention (Chin et al., 1997), it will be important to further our development of the technological dimensions as well. Applying an FBST approach to group-level sensemaking may be one profitable tactic.

DISCUSSION

FBST provides a unit of analysis for the complex topic of how users initially understand a technology. It may be that difficulties in predicting and managing successful technology implementations arise because key components of the understanding process have been overlooked. Certainly, this model of features, triggers, sensemaking, and understanding is a simplification of the complexities inherent in any technological system. However, people regularly use simplifying heuristics to make sense of their world (Simon, 1957; Tversky & Kahneman, 1974). The unit of analysis used here is an attempt to replicate the cognitive simplification processes adopted by users of new technology.

Marketing, innovation, and technology management all provide foundations for approaching research related to the implementation of technology. The predictions advanced here are the first, I believe, to relate technology features to sensemaking triggers and then to the process of how users come to understand technology. In other cognitive analyses of technology use and understanding, researchers have assumed that people have different understandings of technology and that these differences matter. However, prior analyses do not appear to address how a user's initial sense of a technology comes to into being. The FBST model strives to fill this void.

The actual process by which user and, for example, implementer understandings diverge is at the boundary of this model. The FBST suggests which features will instigate sensemaking in the knowledge stage. Even at this first step there may be user and implementer differences. The FBST is a probabilistic model; concrete, core features are more likely to engender sensemaking, but this is not an absolute. Variation also can occur at each step of the models presented in Figures 1 and 2. The technology design may vary between the time that implementers are first introduced to the technology and the time when users are introduced. Some features may only sometimes bring about sensemaking. Third parties may be more or less involved at different stages in a technology's life cycle. And, finally, social construction processes may vary across groups, settings, and/or time. I leave management and additional modeling of these differences to future research.

My goal in this work is to clarify the process of how users come to understand technology in order to enhance—not replace—extant models. Thomas notes that, although prior researchers have examined the importance of perspectives and values, "we aren't told how they come into being" (1994: 25). For example, Orlikowski and Gash (1994) focus on the importance of understanding technological frames (underlying assumptions, expectations, and knowledge about a technology). Similarly, Griffith and Northcraft (1993) argue that frames offer a new lens for explaining and anticipating technology outcomes. The FBST provides a connection by illustrating the development of understanding. At the other end of the process, Barley (1986) provides an important look at how technology, both from physical and socially constructed perspectives, works in the structuration of organizational roles. The features-based model begins at an earlier stage by considering how the people within those roles make sense of a technology.

Testing the FBST

Testing this model will require a different type of description and analysis than researchers used in many of the aforementioned studies. The longitudinal approaches of some of the earlier works (Barley, 1986; Orlikowski & Gash, 1994) are appropriate, but researchers must also vary the features of the technology. The FBST suggests that the effects of features on sensemaking are mediated by the acknowledgment that a feature is novel, different from what was expected, and/or triggers deliberate initiative for sensemaking. The levels of these triggers are predicted by the features' dimensions (concrete versus abstract, and core versus tangential).

Figure 2 suggests a causal model and would be best tested as such. Future research should include the development of assessment items for the two features dimensions. Users should be questioned regarding the features of the particular technology (the self-report measure will serve to identify the most vivid and salient features) and the assessment items used to measure each of the dimensions. To ensure variance on the features' dimensions, one should use an analysis like that suggested by DeSanctis and Poole (1994)—that is, a review of manuals, discussions with designers and users, and observation of the system itself—to identify less vivid or salient features for assessment.

The development of measures for the novelty, discrepancy, and deliberate initiative triggers also await future research. Louis and Sutton (1991) do not empirically test their theory of triggers, although they do present concepts that could be used to develop measures. Novelty, for example, could be measured by the extent to which the feature "stands out of the ordinary," is "unique," and was "unfamiliar or previously unknown" (based on their description found on p. 60).

Applying the FBST

Assuming the validation of the FBST, the next step is to design technological systems and implementation processes to make use of what is known about triggering and directing user sensemaking. Some analyses may benefit from diverse individual perspectives about a technology; others may suffer in such circumstances. Technology managers and designers could then explicitly consider the need for convergence or diversity in individuals' inputs to adaptive structuration by building from the work of Lind and Zmud (1991) and Fiol (1994).

Where diverse initial individual perspectives are desired (perhaps to increase the range of suggestions, variety, and/or creativity), technology managers and designers could develop technology systems whose core features are concretely different from those of prior systems, that need to be used differently from prior systems, and that explicitly request later sensemaking. Such systems will create more triggers for more users and, thus, more opportunity for sensemaking. Although it is possible that the resultant individual understandings will converge, it is a necessary condition for divergent understanding that sensemaking at least be triggered.

Alternatively, where convergent individual perspectives are desired, the FBST may suggest that technology managers and designers who require convergent inputs to adaptive structuration should focus on systems that are similar (in both appearance and functionality) to extant, well-understood systems. Systems in these cases would be designed to provide few options or tangential features.

In future research focused on the broader processes of social construction and understanding, scholars might also consider whether sensemaking that results in a diverse set of mental models is more likely to promote insights or motivate redesign. Such a scenario, combined with deliberate initiative for redesign (Tyre & Orlikowski, 1994), may push the overall sociotechnical system to evolve. Dutton and Dukerich (1991) present an issues-level focus for strategic sensemaking that parallels the features focus here. They note that it is important to consider which strategic issues gain attention and how they are interpreted. Those issues may become focal points in a way similar to the "garbage can model" (Cohen, March, & Olsen, 1972) of decision making.

Finally, future research is needed to follow up on some of the more intricate issues I raised earlier, but only in passing. The propositions I present here were generated on the basis of technology features (core versus tangential, and so on). However, as Orlikowski (1992) suggests, there are additional areas to be addressed when considering how users come to understand technology: institutional context; power, knowledge, and interest of human actors; and temporal and spatial distance between the design and use of the technology. This latter issue—temporal and spatial distance—is especially interesting and important for the long-term focus of sensemaking and redesign.

CONCLUSION

This article offers a technology features-based theory of sensemaking triggers (FBST) to describe how users initially make sense of a technology. In eight propositions I describe how two dimensions of technology features (concrete versus abstract and core versus tangential) trip Louis and Sutton's (1991) sensemaking triggers (novelty, discrepancy, and deliberate initiative).

The FBST provides a possible basis for improving the design and management of technology in organizations. Orlikowski (1992) and others (e.g., Barley, 1986; DeSanctis & Poole, 1994) suggest that the use of technology in organizations must be understood as a reciprocal interaction among technology, organizational context, users, and the outcomes of users' actions (e.g., redesign of the technology and/or organizational systems and structure). Here, I propose that the FBST provides insight into the initial conditions of these structurational models. Managers and implementers concerned about the consequences of differing user and implementer understandings of technology (such as those illustrated in the introduction) may find direction in the FBST. Certainly, managers may not want to diffuse all conflict between user and implementer perceptions; such conflict may be at the heart of creativity and technological system improvement (e.g., Fiol, 1994; Griffith, 1996). However, technology implementation will be better served if managers, implementers, and users all have a strong grasp on the mechanisms underlying the development of their perceptions.

Thus, the FBST has implications for both theory and practice. The fine-grained approach suggested by the FBST is open to empirical validation. Given such validation, it may be possible to take additional steps in theorizing about both individual- and group-level sensemaking. As noted above, future research needs to address the broad context of technology use in organizations. The outcomes of empirically validating the FBST may provide a foundation for expanding the model to include contextual issues, such as time, user knowledge, and so on.

Additionally, technology designers and implementers may manage sociotechnical systems (e.g., Pasmore & Sherwood, 1978) with greater acumen when they are better informed regarding the process of how users come to make sense of a technology. Providing information about sensemaking processes to the users themselves may inoculate them against the perceptual biases suggested by the FBST. Thus, this model illuminates a critical link in the process of technology sensemaking.

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