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Functional Explanation in Information Systems

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ABSTRACT

The ontological and epistemological concepts underlying Information Systems research have evolved over time. Historically research in positivist and quantitative paradigms explain phenomena by identifying mechanical-causal factors or by logically deducing outcomes from general laws. As interpretive and qualitative approaches have become accepted, new types of explanatory knowledge have been based on interactions, processes and human intentions. Since IS artifacts are purposeful inventions intended to create new realities, the inclusion of knowledge claims derived from alternative explanations of phenomenon may provide new insights. Functional explanation provides a means of comprehending phenomena such as intentional actions, adaptive behavior, and environmental or cultural selection that are not subject to purely causal-mechanical explanations. A functional orientation provides another level of explanation beyond the current focus of explanation, by examining what function(s) human behaviors and information systems play, rather than what structure and composition underlie a phenomenon. Functional explanation frames questions about how people use IS artifacts, adapt, and find multiple paths to attain functional goals. Implications for the evaluation of research outcomes and for future research are discussed.

Keywords:

Science, Ontology, Explanation, Functional, Information Systems Research

INTRODUCTION

"Scientific method is laden with philosophical methods and philosophical insights." (Sklar, 2000)

The fundamental concepts that Information Systems (IS) researchers accept as constituting science have evolved over time. One of the requirements for progress in any scientific field is the development of a paradigm or *disciplinary matrix* composed of a coherent body of literature and terminology, a set of methods and evaluative criteria, identified problems, models and exemplars (Kuhn, 1962; Kuhn, 1977). Deeply held models define a field's ontology and its epistemology and determine the criteria for explanatory knowledge that provides scientific understanding (Kuhn, 1977). The pragmatic nature of Information Systems science has increased acceptance of an expanded disciplinary matrix that includes multiple ontological perspectives, epistemologies, criteria for explanatory knowledge, and products of research. It has been argued that this diversity may cause fragmentation of the field (Benbasat and Weber, 1996; Robey, 1996) and that the types of research products are less than scientific. The current research argues that instead of causing fragmentation, greater comprehension of IS phenomena is gained by a using multiple types of explanation in addition to multiple ontologies and methods.

This research essay examines how the Philosophy of Science has informed the IS field about the nature of the world (ontology), how knowledge is obtained (epistemology), and what the distinction is between descriptive and explanatory knowledge. Understanding the nature of scientific knowledge and how phenomena are explained is instrumental to understanding what research outcomes actually mean (Salmon, 1989; Hunt, 1991). Over-emphasis on normative systems of explanation can limit potentially interesting lines of inquiry, and some philosophers have argued that a mature discipline is one that sweeps in variables, theories, epistemologies, and forms of explanation from many disciplines to achieve progress in understanding phenomena (Churchman, 1971). From this perspective, when agreement is reached on explanation of a phenomenon, counter-hypotheses are sought that "rock the boat, upset the apple-cart and encourage revolution and dissent...This is the only pathway to reality: whenever we are confident that we have grasped reality, then begins the new adventure to reveal our illusion..." (Churchman, 1971 p. 199). Feyerabend (1963) argues that a set of alternative theories describing the same phenomena provides a better critique of ideas than does a collection of empirical facts. I extend this argument to suggest that a trans-disciplinary field such as Information Systems encompasses many aspects and levels of phenomena and that explanatory pluralism is necessary to increase knowledge.

EVOLUTION OF THE ONTOLOGY-EXPLANATION RELATIONSHIP IN INFORMATION SYSTEMS

Philosophical positions regarding the nature of science and the role of explanation by Karl Popper (1963), Carl Hempel (1962), Thomas Kuhn (1962), and Imre Lakatos (1973) have influenced the language and approach of scientific research. Researchers in IS have adopted many of the concepts from these traditions and have created a diverse set of ideas about what constitutes good theory (Straub, Limayem and Karahanna-Evaristro, 1995; Sutton and Staw, 1995; Gregor, 2002), the existence and relevance of paradigms (Goles and Hirschheim, 2000; Deetz, 1996), the need to account for causality (Lee, Barua and Whinston, 1997; Markus and Robey, 1988) and the positivist-interpretive dichotomy (Fitzgerald and Howcroft, 1998; Orlikowski and Baroudi, 1991; Lee, 1991; Lee, 1989).

IS research can be further informed by the philosophy of science in determining the criteria for evaluating explanatory knowledge. The criteria of what constitutes an explanation are rooted in the beliefs about the nature of the world and the means of discovering knowledge that underlies all research. Philosophers recognize the distinction between descriptive knowledge *that* something occurred and explanatory knowledge *why* it occurred (Salmon, 1989). Early definitions of scientific explanation, beginning with Aristotle, included multiple facets, including teleological, formal, material, and efficient aspects of causation (Ruben, 1990). Much of science today focuses on the latter two aspects, but more importantly, Hempel and Oppenheim (1948) shifted the modern debate over the nature of scientific explanation to the position of explanations as deductive arguments based on formal logic (Salmon, 1989). This became a fundamental basis for the logical positivist approach to social science and engendered debate regarding explanatory knowledge in both the physical and social sciences. Although the tenants of the positivist ontology have been described differently (Salmon, 1989; Hunt, 1991; Lee, 1999), all descriptions support a covering-law model where explanatory knowledge relies on the presence of general laws. Covering-law explanation distinguishes the co-occurrence of events by asserting that whenever *X* occurs under condition *C*, *Y* must occur. Support for any covering-law results from continued confirmatory evidence supplied under controlled conditions, intended to suppress or bring about the effect in question.

The positivist ontology used in IS research often excludes human intentionality or functional analysis and focuses on prediction and intervention. This may be due, in part, to the rejection of cognition, motivation, and learning by psychology in the mid 20th century (Koch, 1999). Yet IS researchers are often interested in the beliefs and values of people, in their intentional actions and their chosen patterns of use. The validity of explanations referring to "mental" factors has been questioned and these factors are thought to be reducible within a materialist program (Salmon, 1989). Dissent with this view is based upon the complexity of human action (Hayek, 1996), the distinction between the subject matter of social science and the natural sciences (Fay, 1996), and the meaning of the behavior as viewed by the subject performing it (Fay and Moon, 1996). Social science in IS seeks to account not only for what happened and how it came about, but also the importance, meaning, and "why" the subject performed a specific action (Fay and Moon, 1996). Human behavior is highly adaptive and influenced by pragmatic considerations -- what works functionally will be repeated. The distinction between objective, subjective, and inter-subjective research enables the differing aspects of the human world to be more completely understood (McDonald, 2002; Mingers, 2001). This attachment of meaning to the world by the subjects has been termed the interpretative ontology (Orlikowski and Baroudi, 1991; Lee, 1999). Researchers may know that a statement was made and what the statement means, but they do not know why the statement was made. From an interpretive perspective, researchers have an incomplete explanation of the statement.

Research in Information Systems draws upon both the natural and social science and encompasses a plurality of research paradigms (Mingers, 2001). Researchers have agreed that the phenomena surrounding IS have multiple aspects or levels upon which research can focus. Simon (1969) described the IS artifact as the "interface" between the "inner" environment composed of the composition and organization of the IS artifact and "outer" environment in which the artifact functions. Orlikowski and Iacono (2001) suggest that theorizing about the IS artifact should occur at in "five broad meta-categories, each representing a common set of assumptions about and treatments of information technology..." (p 123). These meta-categories represent aspects of phenomena, including material components and relationships, purpose and intention in a wide variety of communities, and emergence and evolution of technosocial processes over time. From a different perspective, Mingers (2001) identifies the material, social and personal worlds as important aspects to be addressed via multi-method research. To address the different tasks and problems faced during the process of research, he argues for "critical pluralism" to extend scientific understanding through mixing of methods and triangulation. Within his description of research as a process he asks, "What is happening? Why is it happening? How could the situation or explanation be different?" (p 246).

Each of these perspectives divides research into different levels, which concern different aspects of the phenomenon. Research at these different levels will result in a plurality of explanation types. Each suggests that IS research requires both representational approaches studying variables and linkages and the interpretation and understanding of human perceptions, social structures, information processing, and adaptation. Research of these different aspects of the human-information

technology system will result in explanations that are relevant to either the mechanisms which produce the phenomenon, the general laws governing the phenomenon, the material composition and interactions of the artifact(s) involved, or the formation of structure or the function of the artifact in relation to the external world.

DESCRIPTIVE VS. EXPLANATORY KNOWLEDGE

Descriptive knowledge can be characterized by the presentation of “objective” or “factual” accounts of the phenomena with no theoretical grounding or interpretation (Orlikowski and Baroudi, 1991). Taxonomies, observations of an event and descriptions of the impact of an information technology on an organization are examples of descriptions. Frameworks for research and models, which represent some particular aspect of the world, are also descriptive rather than explanatory.

In contrast, explanatory knowledge is commonly thought of as providing the mechanisms of how a phenomenon occurred. Hempel's (1948) Deductive-Nomological (D-N) and Inductive-Statistical (I-S) models have had a large influence on modern conceptions of science (Salmon, 1989). These covering-law models present the logical relationship between the event to be explained (*explanandum*) and the premise which includes at least one general law (*explanans*). The event to be explained is expected given the initial conditions and the general law. The suitability of both these models for providing a basis for explanation has been challenged based on counterexamples noting the asymmetry of explanation¹ and the arbitrariness of statistical occurrence². Although these two models have provided the fountainhead for discussion of explanation, the absence of universal laws in IS makes application of covering-law models difficult as the basis for explanation.

Hempel's conceptualization of explanation has largely been supplanted by statistical-relevance explanation (Salmon, Jeffrey and Greeno, 1971). Criticism of covering law models led to emphasis on causal relationships in which one condition, X causes the occurrence of condition Y. But many IS phenomenon are influenced by a wide and diverse set of factors that operate differently under different conditions or in different combinations. The role and identification of causal relationships and of necessary and sufficient conditions (Fay, 1996) in explanation is controversial due in part to the multiplicity and diversity of causes and the incompleteness of our knowledge of causal relationships. The influence of a large number of casual factors leads to the use of statistical hypothesis testing and probabilistic explanations. Salmon's statistical relevance explanation allows for multiple factors of low probability to have explanatory power (Salmon, 1989). Statistical techniques are used to indicate the amount of variance in an outcome measure which a set of factors accounts for, and whether or not an hypothesis is significant at a pre-determined level (Polanyi, 1958).

FUNCTIONAL EXPLANATION

In contrast to Hempel's and Salmon's conception of explanatory knowledge, functional explanations do not focus on antecedents or causes of phenomena. Instead, functional analysis accounts for cases where legitimate explanations are provided by the end state or goals of a phenomenon (Salmon, 1989) and shifts the focus from a reductionist perspective, to a systems or holistic perspective. Aspects of phenomena such as adaptive behavior, the range of functional uses of artifacts and environmental or cultural selective pressure do not evoke notions of causal mechanisms. Instead these types of questions necessitate a different set of criteria for knowledge claims that fit within the diverse characterizations of functional explanation.

Functional explanation in social science has been heatedly debated and is defined in diverse ways (Hunt, 1991; Malinowski, 1944; Elster, 1996; Kinkaid, 1994; Hempel, 1996). Nagel (1961) differentiated six meanings of the term function, four of which are of interest in this study: 1) function as dependence between variables (e.g. x is a function of y), 2) function as an indispensable role (e.g. biological or cultural processes that are necessary for continued existence of the organism or society), 3) function as the utility of a thing (e.g. the function of the information system was to support decision making), and 4) function as the contribution that an object makes toward maintenance of an existing condition in a given system. (e.g. how an organizational norm contributes to continued existence of organizational culture). To this list I would add 5) purposive or goal-oriented (teleological) behaviors that are performed because of the consequences which have followed them in the past. For all extents and purposes, this is the definition of operant behaviorism (O'Donohue, 2001; Ringen, 1976) which has fallen out of favor in light of the cognitive revolution. Although the latter three definitions are the focus of this research, the others

¹ E.g., A falling barometer allows inference that there has been a drop in air pressure but the drop cannot be explained by referring to the barometer.

² E.g., in an experiment with two outcomes, X and Y with $p < .05$ and $p > .05$ respectively, enough trials will produce some instances of Y. Therefore we can explain X but not Y.

were introduced to point out that most writings on functional analysis lack specificity, and all lack consensus. It is important to determine how the terms are used in evaluating any functionally-based research.

In this research I do not attempt to reconcile or draw conclusions regarding these debates, but instead adopt a modest definition that functional explanation consists of identification of a relationship between ends or goals and the preceding conditions such that the effect ensures that the phenomenon of interest continues to exist. First person descriptions of behavior are frequently couched in these terms: e.g. "Why did I ride my bike to the store? To get to aspirin." The consequences of the future goal explain the event, based upon belief that the event will fulfill the goal. The explanation is correct even if the store has no aspirin. From a variable study perspective, the desire causes the action. But from a functional perspective, we can observe that riding the bike also fulfills the goals of getting exercise, being outdoors and relaxing. Functional explanation seeks to identify the classes of functions that "go together" and fill a niche in the users goals and leads to insights into what people are actually doing. This kind of knowledge claim emphasizes explaining purposeful behavior, the variety of outcomes, and the reinforcing consequences of human behaviors. Whereas causal-mechanical explanations stress necessary or sufficient conditions (e.g. the dependant variable depends on the existence of variable A *and* variable B), functional explanation stresses the range of possible influences and multiple paths that achieve functional goals (e.g. the functional goal can be fulfilled with action A *or* action B).

Information Systems artifacts are purposeful inventions intended to create new realities (Simon, 1969; Orlikowski and Iacono, 2001). Systems are intended to fulfill certain functions, and as Hevner (2004) notes, systems are designed with respect to "...the functional capabilities, information contents, and human interfaces..." (p 76) and can be evaluated in terms of functionality. But as humans adapt and form new goals, information systems may fulfill new and unintended functions. Functional explanation is one approach to comprehending of these types of phenomena. The goal-orientation of IS, allows research to legitimately change the question from, "Is it valid and true?" to, "What would happen if...?". Whitehead (1967) proclaimed that *what something is* cannot be differentiated from *what it does*. Since humans are constantly anticipating changes and reacting to feedback from their environment. They make adjustments to those changes to fulfill their needs or goals. Actions that produce negative feedback are avoided while positive feedback reinforces behaviors. Asking questions from this view is not about identifying causes but requires analysis of what functions the activity fulfills. An increased emphasis on functional explanation in IS would provide insight into what set of functions go together, such that information systems fill a niche and continue to be used. From this perspective we ask, "when people use a system, what are they doing?" rather than try to predict whether the system is adopted in an unspecified manner or what the impact of its use is on a specific performance outcome. This allows researchers to frame questions regarding how functions change as people selectively adapt to the system, as their information needs change, and as they structure their environment and the IS artifact.

Our ability to understand information system adoption provides a good example of this difference. In the Technology Acceptance Model (for review see Venkateshet.al., 2003), behavioral intention to adopt an information technology is predicted with the constructs perceived ease of use and perceived usefulness. The perceived usefulness construct is extremely general so that, although the model is predictive, it leaves broad gaps in our understanding as to what the artifact is *useful for*. Was a particular system adopted because a critical mass of friends also used it, or because it increased social standing? Is it useful for the same things during learning and after it has been used for a period of time? Are its usefulness and its functions the same, independent of culture and background? A different explanation of the adoption process can be gained by examining what function(s) the user attributes to the artifact. In addition, over time, the functional explanation of the use of an information system may change. For example, if email was once used as a tool for corresponding exclusively with managers may now be used as a tool for maintaining social capital. In this case, our functional explanation of email will change, however the measures within the technology acceptance model remain the same.

Functional explanation can also provide insight into the interactions of users and information systems and the ways in which users adapt systems, and adapt to systems. These are emergent phenomena rather than causal-mechanical outcomes. For example, within the organization science literature, three important types of processes that shape organizational forms: variation, selection, and retention (Aldrich, 1999). Variation refers to those processes, rational, non-rational and random, which create variations in form among organizations. Selection works on this variation, with the environment selecting against those organizations that do not fit with their environments. Unfit organizations cease to exist, leaving those organizations that fill the niche in the environment. "The organizational forms of the survivors become set through processes of retention so that the organization will continue to be in fit it its environment and so continues to survive -- until the environment changes significantly when that organizational form will become misfitted and no longer be able to survive" (Donaldson, 1995 p 43). By analogy, the adoption and continued use of information artifacts may be functionally explained in a similar manner. Functional explanation does not deny causation but suggests that there is something to learn by what people actually do with information systems, what functions these actions fulfill, and what changes as users adapt to a

system. The question then becomes, "what functional goals is this information system fulfilling when it is working?", which is a fundamentally different question from, "what causes drive the user's behavior."

DISCUSSION

This research essay is informative in three ways. First, by providing historical context for research approaches and outcomes, IS researchers can better understand what research results mean, in terms of the scope and completeness of descriptive and explanatory outcomes. This knowledge provides additional criteria for assessing research results, and framing new research questions, and can lead to insights about future research. Second, by outlining a functional perspective for developing explanatory knowledge of IS, an alternative to the current emphasis on causal/mechanical and statistical explanation which is provided, which opens lines of inquiry into areas where attribution of causes is problematic. Finally, based on these suggestions, I argue that opportunities exist to pursue functional explanation, which can provide insight into what people actually do with an information system that may increase our comprehension of human-information system interactions. Humans continuously interact with information systems, their environment and their experiences, and alter their behavior to fulfill functional goals. This shifts our research focus from pursuit of antecedents and causes to, "what if...?" types of questions that may benefit both behavioral and design sciences. Since the IS field involves the study of goal-oriented systems, the pursuit of functional oriented research will provide valuable insights.

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