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Explanation and Understanding in Information Systems

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ABSTRACT

Scientific research is intended to provide explanation of phenomena and to increase our understanding of the world. However, common usage does not make a distinction between explanation and understanding. Examination of the Philosophy of Science literature provides discussion of the explanation-understanding relationship that is valuable for IS research. Scientific explanation is traditionally viewed as subsuming individual cases under broad general laws or as identifying causal mechanisms that produce specific outcomes. Recent discussion suggests the opportunity for unification of these two competing views. In contrast to explanation, understanding is connected to the thoughts, motivations and intentionality of the objects under study and to unification of scientific theory. Therefore *explanations* are arguments answering causal "why" questions under broad general laws and *understanding* results from answering "why" questions regarding intentional behavior or from unification of theories. Different explanation types, such as covering-law, statistical relevance, pragmatic and functional, underlie and support different aspects of understanding. This research describes the tension and opportunity for enhancing knowledge of phenomena by exploiting the explanation-understanding relationship. The framework presented is used to examine explanation and understanding in research streams focused on Adaptive Structuration Theory and Media Richness Theory. The study proposes that research can either provide explanation, increase understanding, or both. Understanding in Information Systems research can be increased by inclusion of multiple explanation types and multiple aspects of understanding to add to an *ideal explanatory text*. Proactive use of the explanation-understanding relationship can aid researchers in recognizing the scope of current research and choosing appropriate research approaches for future work.

Keywords
Philosophy of Science, Explanation, Understanding, Information Systems Research

INTRODUCTION

"Among philosophers of science and philosophical scientists…there seems to be a fair degree of consensus about the ability of science to furnish explanations, and therefore contribute to our understanding of the world" (Salmon, 1998, p. 76). Yet within this consensus there remains significant discussion as to what constitutes an *explanation* and how explanation differs from, or contributes to, our *understanding.*

Two traditions have dominated discussion of scientific explanation in the past 40 years. Hemple and Oppenheim (1948) proposed that explanation consists in subsumption of what is to be explained (the explanandum) under one or more general laws of nature. This reductionist tradition had intuitive appeal, particularly in the physical sciences, but is more difficult to support in the information systems domain where general laws are less likely to be identified. The second major tradition views explanation as a determination of the cause(s) that produce a specific outcome (Humphreys, 1989). This conception formed a cornerstone of positivist ontological tradition (von Wright, 1971) and has produced significant discussion and disagreement about the nature of causality and whether all explanation must be causal in nature. The differences in these two traditions have been explicated in the form of global and local explanatory accounts (Friedman, 1974), and "top down" and "bottom up" (Kitcher, 1985). Explanation either "looks to the most general explanatory schemes we can find and works downward to characterize such items as laws and causal relations" (Salmon, 1998, p. 72) or from "relatively superficial causal mechanisms or particular facts… to ever more general types of mechanisms.. to the most ubiquitous mechanisms that operate in the universe" (Salmon, 1998, p. 72). Recent discussion has attempted a rapprochement of these perspectives that considers the causal mechanism(s) of a phenomenon to be a separate and complimentary explanation to the broader general law explaining the phenomenon (Salmon, 1998). Railton (1981) advocates the concept of the ideal explanatory text which is

both global and detailed. Different researchers with varying interests focus on aspects of the ideal text and produce explanatory information at different levels of detail.

The concept of scientific understanding also originates in two different traditions. One tradition regards understanding as applying in situations where human intentionality, motivation or choice is involved (Salmon, 1998; von Wright, 1971). One "understands the aims and purposes of an agent, the meaning of a sign or symbol and the significance of a social institution or religious rite" (von Wright, 1971, p. 6). Hermeneutic and historical analyses are typical examples of domains in which understanding, rather than explanation is considered the goal. In IS an interpretative ontology, which assumes that "people create and associate their own subjective and inter-subjective meaning as they interact with the world" (Orlikowski and Baroudi, 1991, p. 5), can be selected to achieve these ends. The second tradition of understanding is based upon greater intelligibility of phenomenon through unification of scientific theories (Friedman, 1974; Kitcher, 1976). If fewer independent laws or a smaller number of types of law relate to a large class of apparently diverse phenomena, our understanding is increased.

This study examines the details of the explanation-understanding relationship and proposes that scientific knowledge of information systems results from the combination of multiple, parallel explanation types and includes interpretive understanding of human intentionality and motives. Covering-law, statistical-relevance, pragmatic and functional explanation all contribute to greater scientific knowledge of phenomena. This study then uses this conceptual framework to analyze different aspects of the Adaptive Structuration Theory and Media richness Theory research streams as examples of the explanation-understanding relationship. This research proposes that application of the explanation-understanding relationship can aid researchers in recognizing the scope and limitations of current research and in subsequent choices of research approaches for future work.

PHILOSOPHICAL BACKGROUND

Two Traditions in Scientific Explanation

The search for scientific knowledge can be traced back to ancient times. Early Greek philosophers recognized a fundamental distinction between descriptive knowledge *that* something occurred and explanatory knowledge *why* something occurred. From this division arises a long history of discussions on what constitutes a valid explanation. Two broad traditions of explanation have can be identified in recent discussion (von Wright, 1971; Salmon, 1989b). One flows from the seminal work of Hemple and Oppenheim (1948) with the formulation of the deductive and inductive covering-law models of scientific explanation. In these models the phenomenon is expected, given a set of explanatory facts which contain at least one general law. This strong emphasis on prediction and reproducibility of phenomena is a cornerstone of the positivist ontology of scientific inquiry. This approach is considered to be problematic when applied to the study of information systems due to the difficulty in identifying covering-laws and the diversity of human behavior under similar environments (Fay, 1996).

A fundamentally different tradition of scientific explanation developed in response to criticisms of covering-law concept of explanation. This tradition involves achieving knowledge of how things work, and of identifying the causes underlying a phenomenon. This approach can be characterized as causal-mechanical explanation (Salmon, 1998). In this tradition "explanation in the social sciences and much of the natural sciences results from identifying causes" (Kinkaid, 1996 p. 98). For the purpose of this study it is assumed that "all explanations of singular events or states of affairs are causal explanations" (Ruben, 1990 p. 35). Causal-mechanical based explanation is fundamentally different from covering-law explanation because we cannot logically deduce an outcome from a description of a cause or logically deduce the cause from the nature of the outcome. Since these explanations are not logically deduced they cannot be determined *a priori* and therefore are produced through experimentation and observation. It must be noted that significant debate surrounds causation in human behavior. For instance, human behavior can be predicted if the societal or organizational rules or norms are understood. Rules may govern behavior but they do not cause behavior (Searle, 2001; Salmon, 1989a). These types of arguments raise questions about the primacy of causation as the foundation for explanation.

Recent study of scientific explanation has attempted rapprochement between these traditions. Explanatory unification proposes that the two accounts of explanation are not incompatible. Diverse phenomena are often caused by the same underlying mechanisms and "to the extent that we find extremely pervasive basic mechanisms, we are also revealing the unifying principles of nature" (Salmon, 1998 p. 90). A physical example is the behavior of a helium balloon inside the cabin of an accelerating passenger aircraft. The movement of the balloon forward in the cabin can be explained in either of two

ways: the causal-mechanical explanation relies on interaction of the cabin walls, air molecules and differential air pressure on the balloon as the plane accelerates. The movement can also be explained correctly by reference to an overarching generalization of the universe in which acceleration is equivalent to a gravitational field. The balloon's movement is explained in relation to what direction is 'upward' in relation to the acceleration, which acts as gravity. Neither of these explanations is superior to the other and determination of which explanation to supply is often a pragmatic choice. The concept of the ideal explanatory text (Railton, 1981) provides another approach to removing the dichotomy between the traditions. Although an ideal text would contain detailed description of the causal mechanisms involved and theoretical derivations of all covering or statistical laws involved (Railton, 1981, p 247), it is recognized that the goal of the individual researcher is to produce parts of such an ideal text. Combining multiple parts increases understanding of the phenomena.

Types of Explanation

Within the two explanatory traditions different types of scientific explanation have been proposed. These explanation types (Table 1) have formal descriptions and requirements of the relationships they entail that differ from people's everyday conception of explanation. Major explanation types include covering-law (Hemple and Oppenheim, 1948), statistical-relevance (Salmon 1989b), pragmatic (van Fraassen, 1980), and functional (Wright 1976).

Explanation Type	Definition
Covering-law Explanation	An explanation of either the Deductive-Nomological or Inductive-Statistical type can be "described as an argument to the effect that the event to be explained was to be expected by virtue of certain explanatory facts" (Salmon, 1989b, p.9). The explanatory facts must contain at least one universal or statistical law.
Statistical-Relevance Explanation	"An explanation of a particular fact is an assemblage of facts statistically relevant to the fact-to-be-explained regardless of the degree of probability that results" (Salmon, 1989b p.67).
Pragmatic Explanation	An explanation that is a context-dependent answer to a "why-question" (van Fraassen, 1980). Different explanations of the same instance will result from different questions.
Functional Explanation	"Explanations that are framed in terms of ends or goals" (Salmon, 1989b, p.26). A given social practice [factor] has a certain effect *A*. When it has that effect, there is some mechanism that ensures *A* continues to exist. When the practice stops having that effect, that mechanism stops working.

Table 1. Definitions of Explanation Types

Covering-law explanation is based upon the Deductive-Nomological (D-N) and Inductive-Statistical (I-S) models of explanation presented by Hemple (1962). Covering-law models present the necessary, logical relationship between the event to be explained (explanandum) and a set of explanatory facts that must include at least one general law (explanans). Causal covering-law explanation is distinguished from the co-occurrence of events by asserting that whenever *X* occurs under condition C, *Y* **must** occur. Support for any theoretical covering-law results from continued confirmatory evidence supplied under manipulated conditions intended to suppress or bring about the effect in question. Although covering-law models have provided the fountainhead for discussion of explanation they have been challenged as containing a number of inadequacies, resulting in development of other explanation types.

Statistical-relevance (S-R) explanation considers multiple causal factors, regardless of the degree of probability they have to produce explanatory power (Salmon, 1989a). S-R explanations were developed to account for situations in which wide and variable sets of factors operate differently under different conditions or in different combinations. Identification of causal relationships and necessary and sufficient conditions (Fay, 1996) in social science explanation is difficult and controversial due to the multiplicity and diversity of causes and the incompleteness of our knowledge of causal relationships. Therefore S-R explanation uses statistical hypothesis testing to develop probabilistic models that can include a large number of causal factors. This overcomes the objection to covering-law models of explanation in which the phenomenon to be explained must have a high probability of occurrence (Kitcher, 1989).

Pragmatic explanation is the fourth type of explanation (van Fraassen, 1980). A pragmatic explanation is an answer to a "why-question" that involves not just the relationship between theory and fact, but also the context (Salmon, 1989b), the concept of contrast classes and relevance relations. A question "Why outcome A?" becomes "Why outcome A rather than B, C…?" The appropriateness of a pragmatic explanation is dependent on the intention of the questioner and the relevance of the answer to the questioner's context. In van Fraassen's (1980) example of the shadow of the tower. the architect's explanation would result in a blueprint description, whereas the builder's explanation might rely on the construction materials and stability of the tower. But the relevance relation of the answer to a specific contrast question, "Why is the height h rather than h*?" indicates that the length of the shadow cast by the tower was important to the owner. The relevant explanation depends on who is asking the question and is specific to that particular question (Kitcher, 1989). A pragmatic explanation may create several new questions involving other contrast classes, each of which may have a different explanation.

Functional explanation, the final explanation type, provides legitimate explanations by identifying the end state or goals and determining the conditions which led to that end state (Salmon, 1989b). First-person descriptions of behavior frequently contain this type of account: for example, "Why did I ride my bike? To get to work." Notice that getting to work does not necessitate riding the bike nor is it a sufficient condition for the behavior since the rider might also have wanted to enjoy a nice morning outside (Manicas, 1997). The future goal explains the event, based upon belief that the event will fulfill the goal. Wright (1976) predicates functional explanations on the consequences of a feature. A feature's presence is explained by the relationship that when it was present in the past, it had certain results or consequences.

Traditions in Scientific Understanding

A sharp distinction between understanding and explanation is not made in ordinary usage of the terms. All scientific explanations, whether pragmatic, functional or some other kind are said to increase our understanding of a phenomenon. But this increase in scientific understanding through the production of scientific explanation does indicate that understanding is a direct result of the explanatory effort. In addition, understanding has a psychological component or "re-creation in the mind of the scholar of the mental atmosphere, the thoughts and feeling and motivations of his study" (von Wright, 1971, p. 6).

Focus of Understanding	Subject of Understanding
Empathy	Sharing of feelings and emotion, which provides psychological satisfaction.
Shared Meaning	Determining the meaning of concepts, symbols, behaviors and other forms of expression. Frequently the focus of anthropology and interpretative studies in the social sciences.
Human Purpose	Inquiry into the reason, intention or purpose underlying human behaviors, institutions and customs. Often requires distinguishing the explicit aims from the latent or emergent function.
Natural Phenomena	Identification of causal mechanisms and/or of general laws governing natural phenomena.

Table 2. Types of Human Understanding

Salmon (1998) describes the distinction in the first tradition between four major types of understanding (Table 2). First there is understanding based upon empathy or the sharing of feeling or emotions. This is a psychological rather than semantic category (von Wright, 1971) but the theological or metaphysical character it has eliminates it from the current discussion. A second type of understanding relates to the meanings of types of human expression in many contexts. These expressions include language, symbols, institutions, behaviors and meanings and are frequently the focus of interpretative studies in information systems research. A third type of understanding is based upon an appeal to purpose or the intention of the human behavior (for a review of intentionality see von Wright, 1971). A person's trip to the store to purchase aspirin in based upon the person's belief that aspirin is an effective medication for headache and that the store will be a good place to purchase it. It is the constellation of beliefs and desires in the context of the end goal that provides understanding rather than the actual acquisition of the aspirin. The final type of understanding results from production of scientific explanation of natural phenomenon in the empirical sciences. This type of understanding is considered to be the result of empirical studies from a positivist ontological stance.

A second tradition in understanding is based upon phenomena becoming more comprehensible or intelligible as "science increases our understanding of the world by reducing the total number of independent phenomena that we have to accept as ultimate or given" (Friedman, 1974 p. 15). This concept of *explanatory unification* is expanded by Kitcher (1989) and modified to consider unification of the number of independent laws that must be considered. This synthesis of a wide variety of phenomena under a unified scientific world-picture is argued to present a more comprehensible, that is, understandable knowledge of the world (Salmon, 1998). Understanding the phenomena "is not simply a matter of reducing the fundamental incomprehensibilities but of seeing connections, common patterns, in what initially appeared to be different situations" (Kitcher, 1989 p. 432). Newton's unification of Kepler's laws of planetary motion, Galileo's laws of free fall, the pendulum and projectiles and the molecular behavior of gases increased our understanding of the universe. The Newtonian synthesis is an example of how the tradition of explanatory unification successfully addressed a wide array of phenomena and led to understanding of other observations during the eighteenth and nineteenth centuries (Salmon, 1998).

The Explanation-Understanding Relationship

Identification of causal-mechanical processes and of general or probabilistic laws are both valid approaches to developing explanations. Different types of explanation can be produced from any ontological or epistemological perspective (for a review see Hovorka, Germomprez and Larsen, working paper) and can increase different types of understanding. By recognizing that different explanation types lead to different types of understanding we are able to remove the tension between understanding of meanings, purpose or intentions and understanding of natural phenomena from positivist science. For example, pragmatic explanation that a potential adopter chooses to use one information system instead of a different system, based on a perception of usefulness, yields an understanding of that individual's purpose or intention. At the same time the statistical-relevance explanation of the directionality and degree of influence of other variables increases our knowledge of the mechanisms of the phenomena.

The concept of the *ideal explanatory text* (Railton, 1981) provides a means of removing the dichotomy between traditions in explanation and understanding. An ideal text would contain detailed description, at all levels of analysis, of the causal mechanisms involved, the theoretical derivations of all covering-laws and understanding of human goals and intentions. Combining multiple parts increases scientific knowledge of the phenomena. Therefore the ideal explanatory text can be used to evaluate research by determining whether the researcher has added explanation or understanding of the phenomenon.

Examination of two research streams will provide examples of how the explanation-understanding relationship can influence research. By developing these examples, this research shows how the concepts of explanation, understanding and an ideal explanatory text can be used to design, critique and improve research.

Example 1: Adaptive Structuration Theory

Research on Adaptive Structuration Theory (AST) provides an example of how the explanation-understanding framework could produce a research stream. Initially Desanctis and Poole (1994) proposed that during the organization change process there is a duality of structures: those that are inherent to the technology, and those that emerge due to human interaction with the technology. The authors emphasize the recursive relationship between the technological structures and the social process of appropriation of the technology driven by individual purpose and intention. The research question, which was focused on organizational change and individual or group purpose, was contained in constructs (Groups Internal System; Social Interaction; New Social Structures), which recognized that "people actively select how technology structures are used…groups actively select structures from among a large set of potentials" (Desanctis and Poole, 1994, p. 129). The authors proposed that determination of the aspects of appropriation would require interpretation to distinguish between faithful and unfaithful appropriation. This inquiry regarding a contrast class would produce a pragmatic explanation. The emergence of unplanned organizational structures resulting from structuration is strongly associated with functional explanation of the appropriated technologies. Although the authors did not explicitly recognize these explanation types, our increased understanding of emergent organizational structures results from pragmatic and functional explanations involving the constructs.

Chin, Gopal and Salisbury (1997) add to the ideal explanatory text by developing a causal-mechanical measure of the faithfulness of appropriation construct and provide statistical-relevance explanation of how the construct causes change in other variables (perceived ease of use, satisfaction, perceived usefulness). While emphasizing that user groups intentionally

select specific structures in the technology, the study increases our understanding of the dramatic differences between groups by showing that causal relationships influence the outcome variables.

These studies contribute explanatory information and increase our understanding of organizational change. But questions regarding the nature of the human-technology interactions and the intentions underlying human selection of technology structures are left unaddressed. These are aspects critical to understanding the phenomena but appear to be non-causal and not governed by generalized laws.

Example 2: Media Richness Theory

Examination of the research stream surrounding Media Richness Theory (MRT) provides a retrospective look at how the explanation-understanding framework could be used to identify research opportunities. The original MRT framework prescribed law-like relationships between media channels and uncertain tasks (Daft and Lengel 1984). The theory proposed that media have inherent, structural characteristics that define the ability to reduce uncertainty in communication. This explanation relied on a law-like generalization and did not account for the causal mechanisms of the media channel- task relationship. It also did not account for human intention or shared meaning within the communication.

Later research identified the role that social norms, shared meaning and organizational context played in defining media richness (Schmitz and Fulk, 1991; Markus, 1994; Lee, 1994). An apparently simple information request was actually rich with information and subtle meaning in which single instances of media richness were explained through contextually dependent environments. These studies relied on the understanding of shared meaning and the purpose of the communication. The theory was also explored experimentally (Dennis and Kinney, 1998) and through a survey-based field study (El-Shinnawy and Markus, 1992). In these studies, statistical-relevance explanation was used to describe media richness and identified probabilistic causal mechanisms for the relationships proposed.

Ngwenyama and Lee (1997) applied a pragmatic explanation perspective that directly contrasted different approaches to the work of Markus (1994) from a critical-theory perspective. They explained how social influences guide the choices individuals make, and described individuals as contextually constructed actors on their social environment. This pragmatic explanation resulted in unification of the explanatory and understanding aspects of media richness theory that accounts for shared meanings and human purpose in addition to inherent media characteristics and broad law-like relationships.

In retrospect it is apparent that different types of explanation and understanding were used to increase scientific knowledge of the diverse phenomena surrounding media richness theory. But research remains to be done regarding how people develop shared meaning, why they are influenced by social norms and whether probabilistic relationships have causes. Proactive use of the explanation-understanding relationship can aid researchers in recognizing the scope of current research and then choosing research approaches that will move towards a unified understanding of a phenomenon.

DISCUSSION

The explanation-understanding framework (Figure 1) is not a deterministic, one-to-one relationship. Instead, multiple types of explanation can lead to different aspects of understanding. The relationships shown in Figure 1 represent a fusion of concepts from the literature and the relationships seen in the examples developed above, rather than a set of logically determined connections. It is likely that other explanation-understanding relationships can be found. Explanation types are coexistent, and no one explanation supersedes another as each type adds to the ideal explanatory text of the phenomenon. This leads to a reduction in the number of theories required to explain an array of phenomena since mutually supporting explanations can be produced within the same theory. This further increases the comprehensibility, and understanding, of the phenomenon.

Scientific understanding results, in part, from inquiry into the meanings of human artifacts, intentions and motives in addition to causal mechanisms underlying human behavior and the components of information systems. This understanding may be based on types of explanation different from those normally provided by the natural sciences. But it is precisely the variety of explanation that increases our understanding by providing synthesis of diverse phenomena under a more limited set of causes or laws. Information systems research will also benefit by recognition that increased understanding results from obtaining a broad general world-picture in addition to causal-mechanical explanations.

By examining the characteristics of explanation and understanding and the relationship between them, researchers in information systems will be better equipped to gauge the scope and limitations of research and to determine the most fruitful direction for future research. Although it is possible to dismiss the differences and the relationships as a mere verbal quibble, the information systems field will benefit from recognizing and applying the specific characteristics of explanation and understanding in research. Each term has attributes related to specific aspects of the information system that will increase our knowledge of such systems.

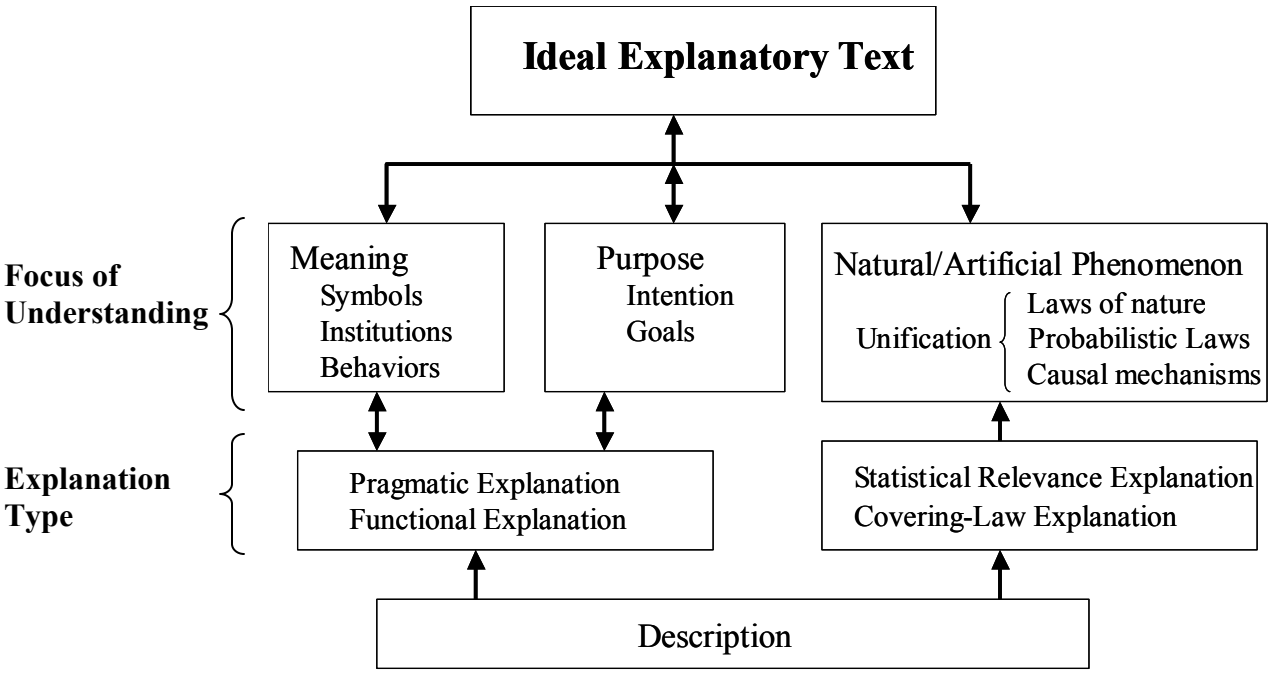

Figure 1. Explanation – Understanding Framework

Different types of explanation provide information regarding different perspectives of a phenomenon and multiple mutually supportive explanations increase scientific understanding. In addition, different explanation types can result from research based on different ontologies and epistemologies. By recognizing which types of explanation have not been provided by specific research, researchers can chose perspectives and methods that will add to overall understanding.

This study make three contributions to the IS research community:

1.) By grounding explanation and understanding in concepts and terminology from the Philosophy of Science, researchers are better able to evaluate, critique and extend research efforts. Research streams that develop multiple types of explanation approach Railton's ideal explanatory text by unifying fine-grained causal mechanisms and more generalized law-like regularities and by incorporating understanding of human intentions, goals and meanings.
2.) By emphasizing the concept of understanding as pertaining to human intentions, goals and meanings, we consolidate different epistemological perspectives into a more complete world-view of phenomena without diminishing the importance of explanation of causal-mechanical regularities observed in information systems. The inclusion of understanding allows interpretive, hermeneutic and critical-theory perspectives to be incorporated into explanatory information systems research and models.
3.) Finally, this study demonstrates that by focusing research on identifying causes and causal chains, we may blind ourselves to identification of interactions and of phenomena for which there are no causes and no explanation. The types of explanation that support the physical sciences (statistical-relevance, covering-law, pragmatic) provide explanatory information for research into the technological aspects of information systems. The types of explanation commonly provided in the social sciences (pragmatic, functional) lead to understanding of the human components of information systems. But the study of information systems is, at least in part, about the interaction and interface

between the two. These interactions are not causal for they do not contain temporal order or cite mechanisms for the regularities they produce. It is at the interface between the technological and human aspects of the system that many interesting research questions reside. The explanation-understanding relationship proposed in this study is crucial in its capacity to add explanatory information to an ideal explanatory text of the phenomenon. But at the same time, it is important to recognize that there may be no laws, causes or accepted explanation of some phenomena in human behavior and that studying these phenomena is critical to unified understanding in IS.

Recognizing the different types of explanation and understanding will aid researchers in synthesizing current and previous research and in exposing gaps in the scientific knowledge of phenomena. This framework provides researchers new avenues to advance scientific knowledge and to shape the evaluative criteria, identified problems, models, and exemplars in IS research. The academic and practitioner communities will benefit by recognizing the scope of research explanations and from identifying what aspects of explanation and understanding are deficient in current scientific knowledge of IS phenomenon. By examining explanation types and associated terminology and showing the relationship between scientific explanation and scientific understanding, researchers are better equipped to recognize opportunities for research as well as to determine how their own research can increase scientific understanding and add to the ideal explanatory text of each information systems phenomenon.

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