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Abstract
Developing explanations of observed phenomenon is one of the major functions of research in Information Systems (IS). But what is an explanation? What types of explanation can IS research provide and what do they mean? The objectives of this research are to develop a shared language, to increase understanding of the meaning of research results and to stimulate discussion of explanation in Information Systems research. Four years of articles published in two top-ranked IS journals over a period of ten years were sampled based on four explanation types defined in modern philosophy: covering-law, statistical-relevance, pragmatic and functional. Explanation types, sub classifications ontologies and research methods were classified and the relationships between these characteristics were examined. Results reveal opportunities for studying Information Systems beyond a single explanation, towards the use of a rich set of explanation types to fully describe phenomena.

Keywords: Explanation, ontology, methodology, information systems research.

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Introduction

"A fundamental aim of science is to provide explanations of natural phenomenon" (Salmon 1989b, p.4). If the field of Information Systems (IS) is considered a science, it can be inferred that investigation into observations of IS phenomena is intended to result in an explanation. Some researchers point out the differences between the natural sciences and the technological or "sciences of the artificial." (Simon 1969; Bunge 1979). Simon (1969) suggests that the explanation of artificial environments, like information systems, is built on the combination of prescribed explanation types from both natural (physiological) and artificial (computer science) reference disciplines. He states that "the relation between physiological and information-processing explanations will become just like the relations between quantum-mechanical and physiological explanations in biology (or the relation between solid-state physics and programming explanations in computer science)" and that the two explanations "constitute two linked levels" through which information systems are explained (Simon 1969, p. 97). Bunge states that "determination is often multiple and probabilistic rather than simple and linear" (Bunge 1979, p. 270) and that some sciences focus on structure and behavior and others focus on composition and mechanism. We argue that this prescription of explanation types for specific scientific disciplines limits our understanding of phenomena. Instead, we argue that the interdisciplinary field of Information Systems, built from both natural and artificial scientific disciplines, relies on the mixing of explanation types from reference disciples through which research phenomena are understood and research agendas are shaped.

This leads to the research question, "what types of explanation can IS research provide and what do they mean?" The value of examining the types of explanation is not obvious as we all have an intuitive understanding of "explanation." For example, everyone has a common understanding of what it means to explain a game – we describe the rules. We explain that the driveway is wet because it rained. A nursery rhyme explains, "the kingdom was lost and all for the want of a horseshoe nail" (Owen 1989). We explain the length of the shadow by the height of the tower that casts it (Van Fraassen 1980). We explain that the behavioral intention to use an IT artifact lies, in part, in its perceived usefulness (Davis 1989). These examples represent different types of explanation, illustrate what explanation can provide, and show a need to clarify what an explanation means in a research context.

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 both a field's ontology and its epistemology (Kuhn 1977), and determine the criteria for explanatory knowledge that provides scientific understanding (Salmon 1989b). There has been no direct discussion in the IS literature regarding the interpretation or meaning of research results – i.e. what type of explanation is the research providing about the relationships between entities in the world? There is a need to examine how IS purports to explain phenomena so a shared language and understanding can be developed to evaluate research findings and strengthen paradigms.

To address these challenges we first examine how the Philosophy of Science has informed the IS field about the nature of the world (ontology), and how knowledge is obtained (epistemology). The relationship between the ontology and epistemology of IS is fundamental to understanding the debate regarding the nature of scientific explanation (Salmon 1989b; Hunt

1991). We identify the different types of explanation discussed in the literature and recognize that each type was introduced as the universal definition of explanation in science, not as typology of a coexisting set of categories. Therefore this paper focuses attention on the differences between research explanations rather than a means of reducing these concepts to categories (Deetz 1996).

Second, we survey the field of Information Systems and describe the types of explanation used. Examination of the explanatory relationships entailed in research results benefits the IS field in the same manner that critiques of ontologies, methods, techniques, and tools have been valuable. Understanding of explanation in IS research may guide judgments about inconsistencies in the literature and expose opportunities for triangulation. Alternative explanations resulting from different theories or research approaches provide a means of critiquing accepted theory above and beyond analysis of how well a theory reflects the facts. We argue that from this perspective a "plurality of theories allows for a much sharper criticism of accepted ideas than does the comparison with the domain of facts which are supposed to sit there independently of theoretical considerations" (Feyerabend 1963, p. 923).

In the examination of the use of explanation in the IS field, we explore how explanation in IS literature has changed during the past decade. In other research domains, a mature "system of inquiry" is one that "sweeps in" variables, theories, epistemologies, and explanation types from many disciplines to achieve progress in understanding phenomena (Churchman 1971). In this system, 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 and put us back again in the black forest" (Churchman 1971, p. 199). A change in emphasis and broadening of what explanation types are provided by research may indicate increasing maturity in the field and could reveal potential areas for future research. Finally we argue that research can benefit from this analysis by enabling researchers to identify and produce rich, multi-perspective explanations in the study of research phenomena (Mingers 2001), contributing to broader scientific understanding.

Ontology Explanation Relationship

Philosophical positions regarding the nature of science and the role of explanation by Karl Popper (1963), Carl Hemple (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 et al. 1995; Sutton and Staw 1995; Gregor 2002), the existence and relevance of paradigms (Deetz 1996; Goles and Hirschheim 2000), the need to account for causality (Markus and Robey 1988; Lee et al. 1997) and discussion of the positivist-interpretivist dichotomy (Lee 1989; Lee 1991; Orlikowski and Baroudi 1991; Fitzgerald and Howcroft 1998).

IS research can be further informed by the field of philosophy in determining the nature and requirements of an explanation. The criteria of what constitutes an explanation is rooted in the beliefs about the nature of the world and the means of discovering knowledge which underlies all research. Philosophers recognize the distinction between descriptive knowledge that something occurred and explanatory knowledge why it occurred (Salmon 1989).

Citing Aristotle (Physics II, Chapter 3), Ruben writes:

> "Knowledge is the object of our inquiry, and men do not think they know until they have grasped the 'why' of it... In one sense (1) that out of which a thing comes to be and which persists is called 'explanation'...In another sense (2) the form or archetype... and its genera are called 'explanations'. Again (3) the primary source of the change or coming to rest...Again (4) in a sense of end or 'that for the sake of which' a thing is done.... are all ways in which the term 'explanation' is used…. As the word has several senses, it follows that there are several explanations of the same thing." (Ruben, 1990, p. 78)

These early definitions of scientific explanation sought necessary and sufficient conditions, including teleological (purpose; final cause), formal (abstract structure), material (composition), and efficient (responsible agent) aspects of causation. Modern science focuses almost exclusively on the latter two aspects, but more importantly, Hemple and Oppenheim (1948) shifted the debate over the nature of scientific explanation to the position of explanations as deductive arguments (Salmon 1989a). This shift toward a positivist approach has engendered ongoing debate regarding theories and types of explanation in both the physical and social sciences. This work defines a positivist ontology as "studies premised on the existence of prior fixed relationships within the phenomena" (Orlikowski and Baroudi 1991, p. 5).

Although the tenants of the positivist ontology have been described differently (Salmon 1989b; Hunt 1991; Lee 1999), the original descriptions require that explanations rely on the presence of general laws and are referred to as nomological or covering-law models (Salmon 1995b citing Hemple and Oppenheim 1948). Causal covering-law explanation is distinguished by 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. Different types of scientific explanations have gradually evolved to consider factors that are relevant to the event but not sufficient or necessary. Other types of scientific explanations emphasize the subject's interpretation of the event or the context of the investigation.

The positivist ontology used in IS research often excludes human intentionality. This may be due, in part, to the rejection of cognition, motivation, and learning by psychology in the mid 20th century (Koch 1999). Yet Information Systems researchers are often interested in the beliefs and values of people, in their intentional actions and their chosen patterns of use. In the debate regarding the role of explanation in science, the proponents of nomological explanations describe social science in terms of the inevitability of the relationship between causal forces and behavioral outcome (Hemple 1996). The scientific validity of explanations referring to "mental" factors has been questioned and these factors are thought to be reducible within a materialist program (Salmon 1989a). 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 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). The distinction between objective, subjective, and inter-subjective research enables the differing aspects of the human world to be more completely understood (Mingers 2001; McDonald 2002). The goal of many studies is to describe, predict, or intervene in behavioral outcomes and the deeper understanding of why an action was performed requires an intentional account and a need for interpretation. This attachment of meaning to the world by the subjects has been termed the interpretative ontology (Orlikowski and Baroudi 1991; Lee

1999) and is defined as research 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). Researchers may know *that* a statement was made and *what* the statement means, but they do not know *why* the statement was made. In the interpretive ontology, researchers have an incomplete explanation of the statement.

Finally, critical social theory was used to represent a supradisciplinary philosophical perspective (Horkheimer 1972; Kellner 2001). The original purpose of critical social theory was to explain society through historical and contextual references across various scientific disciplines. Critical social theory seeks to explain social structures resulting in domination, articulate human activity striving to transform society (Kellner 2001), and explore the production of the false-consciousness (Agger 1991). A researcher using critical social theory is not concerned with such familiar concepts as usefulness, performance, or productivity, but instead is intent on explaining how influences guide individuals in their actions and describing individuals as socially and contextually constructed actors upon their environment. Data are not intended to prove or disprove theory but are used in understanding the regularities of process rather than cross-sectional differences (Orlikowski and Baroudi 1991, p. 20).

Explanation Types

The philosophy of science presents formal descriptions and requirements of the relationships entailed by explanations that differ from peoples’ everyday understanding. The past two centuries of philosophical discussion have produced a complex set of theories and models of explanation from which five major types can be extracted: descriptive/structural, covering-law, statistical-relevance, pragmatic and functional (Table 1).

Descriptive/structural explanation 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 structural/descriptive explanations.

Covering-law explanation, is based upon Hemple’s (1962) Deductive-Nomological (D-N) and Inductive-Statistical (I-S) models of explanation (Salmon 1989b). Covering-law models present the logical relationship between the explanandum (the event to be explained) and the explanans (the premise, including at least one general law). The suitability of both these models for providing a basis for scientific explanation has been challenged based on counterexamples noting the asymmetry of explanation[1] and the arbitrariness of statistical occurrence[2]. 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.

[1] 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. Rain will explain why a driveway is wet but a wet driveway doesn’t explain why it rained.
[2] In an experiment with two outcomes, X and Y with p<.05 and >.05 respectively, enough trials will produce some instances of Y. Therefore we can explain X but not Y.

Statistical relevance explanation (S-R) allows for multiple factors of low probability to have explanatory power (Salmon 1989a). S-R explanations was developed in response to criticism of covering law models which relied on causal relationships in which one condition, X, causes the occurrence of condition Y. But many IS phenomenon are influenced by a wide and variable 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 extremely controversial. This is due in part to the multiplicity and diversity of causes and the incompleteness of our knowledge of causal relationships. Causal models are also prone to intuitive holes [3] and suffer from coexistence laws[4]. The influence of a large number of casual factors leads to the use of statistical hypothesis testing and probabilistic explanations. 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). 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). There are a wide variety of statistical analyses used in quantitative IS research to explain the relationships between contributing factors and outcome measures.

Pragmatic explanation is the fourth type of explanation (van Fraassen 1980). A pragmatic explanation is an answer to a why-question which involves not just the relationship between theory and fact, but also the context (Salmon 1989b). This view incorporates the concept of contrast-classes so that a question “Why X?” becomes “Why X rather than X*, X**….?” The suitability of an explanation is dependent on both the context of the question and the purpose of the questioner. In van Fraassen’s (1980) example of the explanation of the height of a tower, the architect’s explanation would result in a description of the plans where the builder’s explanation from might rely on the nature of the construction materials material and stability of the tower. But the answer to a specific contrast question “Why is the height h rather than h*” reveals that the length of the shadow cast by the building was important to the owner. This provides the relevant explanation (Kitcher 1989) for that particular question. 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, which each have different explanations.

Functional explanation, the final type, accounts for cases where legitimate explanations are provided by the end state or goals of a phenomenon (Salmon 1989b). First person descriptions of behavior are frequently couched in these terms: e.g. “Why did I go to the store? To buy spaghetti.” The future goal explains the event, based upon belief that the event will fulfill the goal. The explanation is correct even if the store has no spaghetti. Simply stated, the explanandum (to go to the store) is sufficient for the explanans (to buy spaghetti) given the conditions, but the explanans does not necessarily entail the explanandum. One controversial area relates to the problem of functional equivalents in which multiple mechanisms can bring about the same result depending on the context. This form of functional explanation is counter to the D-N model of explanation and significantly reduces the ability of functional explanations to provide predictive or prescriptive explanations.

[3] Even within Salmon’s “network of causal relations” we must identify which of the numerous antecedents actually caused the phenomenon. This becomes intractable when a specific phenomenon occurs under a wide variety of non-overlapping conditions.
[4] The Ideal Gas Law (PV=nRT) is a non-causal coexistence law which shows the *relationship* between pressure, volume, number of gas particles and temperature. If this type of law can be used in explanations then causes are not invoked by all explanations.

Explanation Type	Definition
Descriptive/ Structural Explanation	Knowledge that a phenomenon occurs, a description of a phenomena, taxonomies and classification scheme. Work involving no theoretical grounding or interpretation of the phenomena; presentation of "objective, factual" accounts of events to illustrate an issue of interest (Orlikowski and Baroudi 1991, p.5).
Covering-law Explanation	An explanation of either the D-N or I-S 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 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. When it has that effect, there is some causal mechanism that ensures *A* continues to exist. When the practice stops having that effect, that mechanism stops working.

Table 1. Explanation Types

Explanation sub-classification

The explanation types described above are characterized by different relationships between the phenomenon and the research outcome. Another distinction between explanations found in the literature is based on scope and completeness of the explanation. Partial explanations are concerned with explaining an event which is a sub-class of a larger phenomenon (e.g. an explanation is provided for why a person purchased an item online but not for why they chose a specific website) (Hunt 1991). Explanation sketches provide a general outline of a phenomenon by identifying some variables that might be related to the event and may include variables that the research determines are not related. Nomothetic explanation is used to explain a class of phenomenon with a parsimonious selection of variables (e.g. the Technology Adoption Model explains behavioral intention with two or three variables). Finally ideographic explanations aim at a full explanation of a single event by describing any possible influence on the phenomenon and context in question. These sub-classifications apply to all the explanation types in § 3 and are presented in Table 2.

Sub-Classification	Definition
Partial Explanation	"a proposed explanation is partial in the sense that [it] does not explain why k occurred but only that some phenomenon of type G occurred and that k is a subclass of G." (Hunt 1991, p.91)
Explanation Sketch	"An explanation sketch implies that only a general outline of the explanation is offered" (i.e. here are some variables which might be related" [to the phenomena in question] (Hunt 1991, p.91)
Nomothetic Explanation	Seeks to parsimoniously explain a class of situations or events with just one or a few explanatory factors (Babbie 1998, p.34).
Ideographic Explanation	Aims at full explanation of a single instance through the enumeration of the numerous, perhaps unique, considerations that lie behind a given action (Babbie 1998, p.34).

Table 2. Explanation Sub-Classifications

The Fit of Artifact Designs, Research Frameworks and Mathematical Models

Scientific interest in IS, driven by the pervasiveness and potential impact of information technology, has taken different forms. Although strongly influenced by the natural sciences model with its discovery and justification aspects (Hunt 1991; March and Smith 1995), IS research may also be oriented around artifact design theories, the development of research frameworks or predictive mathematical models (Gregor 2002).

Artifact design research apply knowledge of situations and tasks to create effective artifacts (Simon 1969; March and Smith 1995). Design research fulfills a different purpose than studies whose goal is discovery or justification of knowledge. Rather than producing general theoretical knowledge, design frameworks apply knowledge "to create things which serve human purpose" (March and Smith 1995, p. 253). These articles are technology oriented and the products are judged against criteria of value and utility. This value-laden goal orientation differentiates these studies from value neutral studies of discovery or justification (Bunge 1979).

Research frameworks recommend and motivate research in particular IS areas by identifying specific research questions, presenting theoretical perspectives and prior literature and suggesting dimensions or variable of interest and possible methodologies. This type of research frequently integrates diverse or fragmented literature and models into a comprehensible framework that provides guidance for future investigations.

Mathematical models present a challenge to the standard theories of explanation and have largely been ignored in discussions regarding the nature of scientific explanation (Hafner and Mancosu 2003). The development of non-Euclidian geometries by Riemann and Lobatschevsky dispelled the tradition of mathematics as a-priori knowledge about the universe, which necessarily models the physical world (Kitcher 1983). The literature in the philosophy of mathematics now recognizes two distinct areas of mathematical explanation: the status of mathematical explanations within the domain of mathematics (e.g. the ontological reality of numbers; what mathematical proofs "explain"; for a review see Mancosu 2001; Hafner and

Mancosu 2003) and secondly, what mathematical representation of physical events actually explain.

This current research only concerns itself with the latter case because we view mathematical representation as models, or "encapsulation of some slice of the real world within the confines of the relationships constituting a formal mathematical system" (Casti 1992, p.1). A model is thus the symbolic representation of some aspect of the modeler's reality allowing exploration of the reality mirrored within a formal symbolic system. The quality of the model will depend on how well the observations of the phenomenon are characterized, which observations are selected to form the subsystem of reality, and how the subsystem is encoded to represent the phenomenon of concern. But models per se are not necessarily explanatory beyond describing phenomenon and showing relationships. For example, physical models, such as globes and scale models of objects, fit well into the category of descriptive explanation. Shapiro remarked that "a scientific explanation of a physical event often amounts to no more than a mathematical description of it" (Shapiro 2000, p. 34). Certainly there is something about the material world that makes the tools of mathematics particularly applicable. But how does a mathematical relationship make the physical world intelligible or "explain" a phenomenon? The ability to predict and control aspects of the real world made possible by mathematical models seems to indicate they are more than simple description. The issue of whether mathematical models are a subset of descriptive explanation or another type of explanation represents a difficult question.

The correspondence rules by which observations are represented in mathematical models are critical because "clearly, a mathematical structure, description, model or theory cannot serve as an explanation of a non-mathematical event without some account of the relationship between mathematics per se and scientific reality" (Shapiro 2000, p. 35). So, the first criterion for mathematical models to be considered explanatory of an event outside the realm of mathematics is presentation of the correspondence rules by which the researcher "attaches symbolic expressions to nature" (Kuhn 1977, p. 301). Without these operational definitions, mathematical models are not explanatory outside their own constructs.

Another perspective on mathematical models is gained by contrasting them with the types of explanations presented in §3. Statistical relevance explanation, which relies on mathematical analysis of the probabilistic influence of factors on outcomes, might appear to be closely related to mathematical models and invites close comparison. In science, all propositions rely on a set of auxiliary assumptions. During the process of scientific inquiry, the failure of propositions to pass critical tests may subject auxiliary assumptions to question and revision rather than cause rejection of the over-arching theory (Lakatos 1973). In contrast, mathematical propositions, such as 7+5 =12, are often considered necessary truths not subject to question. Central mathematical beliefs do not undergo radical changes in understanding and auxiliary mathematical assumptions are not revised. In addition, mathematical models are based upon proofs, which eliminate all doubt, not just reasonable doubt, and generally do not contain probabilistic predictions of outcomes (Shapiro 2000).

The relationship between mathematical models and pragmatic explanation is more problematic. Whether explanations within mathematics can be answers to why-questions is the subject of debate (for discussion see Resnik and Kushner 1987; Sandborg 1998). Additionally, mathematical models do not account for the context and contrast-classes inherent in pragmatic explanations. Although individual models could be argued to contain elements of pragmatic explanation it is not a clear fit in most cases.

Despite the appearance of certainty and law-like behavior of variables within models, the lack of general laws in the human aspects of information systems phenomena makes classification of models as covering law explanations inadequate. Finally, although functional phenomenon (e.g. evolution) can be modeled, most mathematical models are built to predict specific outcomes under a known set of conditions and do not contain the post hoc goal orientation of functional explanations.

The difficulties in unambiguously fitting mathematical models into the theories of scientific explanations used in this research lead us to treat such papers as a separate category. This classification indicates that mathematical models do not fit the standard theories of explanation and leaves the question of whether such models are explanatory for future discussion.

Research Study

To understand explanation in Information Systems, a review of published research literature in two IS Journals in the years 1990-91 and 2000-01 was conducted. Target journals were Information Systems Research (ISR) and Management Information Systems Quarterly (MISQ). These journals are consistently ranked as the top two IS journals and provide a suitable sample for focusing attention on the differences between research explanations. Non-consecutive years of publication were selected to provide a longitudinal view across a ten-year span and allow changes to be tracked. The total number of articles reviewed (167) is consistent with previous literature describing characteristics of IS (e.g. DeLone and McLean 1992; Orlikowski and Iacono 2001).

The primary classification and sub-classification of articles was based on the type of explanation presented earlier and shown in Tables 1 and 2. The ontological perspectives described in §2 and research method for each study were also coded. Research methods are from Orlikowski and Baroudi (1991) and include experimental, case study, survey, field study, mixed method, instrument development, and action research. The duration of the research: cross-section/snapshot, multiple snapshot, and longitudinal was also recorded.

Although assignment of explanation types to individual papers was usually clear, some cases were ambiguous, requiring interpretation due to the difficulty in specifying exact classification boundaries and the presence of multiple explanatory elements in some studies. For example, some pragmatic explanations relied extensively on statistical analysis (and vice versa) and some mathematical models relied on extensive description of the phenomena. Other combinations of overlaps also occurred. In these cases we interpreted the primary purpose of the research (e.g. was the paper presenting a model with a description of the problem or was the research testing a model and presenting statistical evidence?).

Coding was performed by three coders. Two primary coders were responsible for coding the entire data set and a "coding moderator" resolved differences between the primary coders (DeLone and McLean 1992). Two coders were faculty as major research universities and one was a fourth year doctoral student. The two coders and the moderator met regularly over the course of nine months to discuss and resolve ontological, explanatory, and methodological differences coded from the articles. The rate of coding agreement is shown in Table 3.

Coded Category	Percent Agreement
Explanation Type	79%
Explanation Subclass	86%
Ontology	91%
Research Method	92%
Research Duration	90%

Table 3. Coding Agreement

Findings

The goal of this work is to stimulate reflection on the types of explanations provided by research in Information Systems. The research demonstrates that IS research articles have a variety of distinct investigative purposes and produce different types of explanation. There were three research types represented in this sample (Table 4); 49 articles present either designs for systems, frameworks for research or mathematical models (30% of total articles). These research articles were not intended to produce explanatory results of the types distinguished by the philosophy of science but rather present artifact designs, research programs or representations (models) of phenomena. Therefore, these articles were not coded for sub classifications, ontology, research methods or durations.

Of the articles whose purpose was to present discovery of explanations of IS phenomena, descriptions/structural explanations (41%) and statistical relevance explanations (59%) dominate the types represented. Over the four years of articles in the twelve-year span examined, the percentage of descriptions decreased (from 30% to 20%) and researchers relied more heavily on statistical analysis of factors (28% increasing to 42%). Pragmatic explanations (15%), which are differentiated based upon the explicit reliance on contrast classes, frequently rely on statistical methods of analysis. If these articles are classified on that basis, the reliance on statistical relevance is more dominant. But the slight increase in occurrence of pragmatic explanations may be due in part to explicit comparison between contrast classes (e.g. “Why system X rather than System X*”) and increasing interest in specific aspects of systems (e.g. “Why did these users adopt the system” vs. “Why did these users adopt this system rather than that one.”)

There are few occurrences of functional explanation despite the goal-orientation of information systems. This may be due, in part, to the emphasis in IS on prediction and intervention. Functional analysis may represent a useful perspective particularly for explanations of phenomena influenced by human intentionality or modeled as evolutionary processes.

Additionally, 76 (64%) of studies were *explanation sketches* providing only some relevant variables. The percentage of explanation sketches increased from 58% to 69% of all explanatory research between the two time periods. Since these studies identify only some of the factors involved in the phenomena, they represent an opportunity for further research that can provide more complete explanations and for research to produce more parsimonious, nomothetic explanations.

		1990-1991	2000-2001	Total
Explanation Type	Description/Structural	24 (30%)	17 (20 %)	41 (25%)
	Covering Law	0 (0%)	0 (0%)	0 (0%)
	Statistical Relevance	23 (28%)	36 (42%)	59 (35%)
	Pragmatic	6 (7%)	9 (10%)	15 (9%)
	Functional	2 (2%)	1 (1%)	3 (2%)
Other research	Framework/Model	21 (26%)	17 (20%)	38 (23%)
	Mathematical Model	5 (6%)	6 (7%)	11 (7%)
	Total	81(100%)	86 (100%)	167 (100%)

Sub-classification	Partial	2 (4%)	0 (0%)	2 (2%)
	Sketch	32 (58%)	44 (69%)	76 (64%)
	Nomothetic	5 (9%)	7 (11%)	12 (10%)
	Ideographic	16 (29%)	13 (20%)	29 (25%)
	Total	55(100%)	64 (100%)	119 (100%)

Table 4. Explanation Types

		1990-1991	2000-2001	Total
Ontology	Positivist	37 (69%)	56 (92 %)	93 (81%)
	Positivist (Narrative)	9 (17%)	1 (2 %)	10 (9%)
	Interpretivist	8 (15%)	4 (7%)	12 (10 %)
	Positivist & Interpretivist	1 (<1%)	2 (<1%)	3 (<1%)
	Critical Theory	0 %	0 %	0 %
	Total	55 (100%)	63 (100%)	118 (100%)
Research Method	Experiment	10 (18%)	17 (28%)	28 (24%)
	Case Study	12 (22%)	13 (20%)	25 (21%)
	Survey	11 (20%)	14 (22%)	25 (21%)
	Field Study	8 (15%)	7 (11%)	15 (13%)
	Mixed Method	7 (13%)	2 (3%)	9 (8%)
	Instrument Development	3 (6%)	0 (0 %)	3 (3%)
	Other	4 (7%)	10 (16%)	14 (12%)
	Total	55 (100%)	63 (100%)	118 (100%)
Duration	Snapshot/Cross-section	36 (66%)	36 (58%)	73 (62%)
	Multi-snapshot	4 (7%)	7 (11%)	11 (9%)
	Longitudinal	15 (27%)	20 (31%)	35 (30%)
	Total	55 (100%)	63 (100%)	118 (100%)

Table 5. Ontologies, Research Methods, and Durations

Ontologies, research methodologies, and research durations from the sample are presented in Table 5. Of the 93 (81%) articles that are positivist, 32 (31%) are description/structural explanations. Of these descriptions, 10 (9%) are narrative descriptions with no quantitative analysis. The appearance of interpretivist studies decreased (from 15% to 7%) and few studies viewed the phenomenon from both perspectives. Overall these results are consistent with results from previous studies of ontologies in IS (Orlikowski and Baroudi 1991).

Although there is a tendency for specific research methods to produce specific explanation types (e.g. experiments result in statistical relevance explanations in 78% of the papers), experiments can also result in descriptive, pragmatic and functional explanations. Conversely, other research methods can also be used to produce statistical relevance explanations (e.g. case study, survey, field study, mixed method). Explanatory outcomes are unrelated to research durations. The lack of binding of specific explanatory outcomes to specific research methods or research durations poses both opportunities and pitfalls for researchers. Producing a richer set of explanations does not necessitate a change in method or duration. But at the same time, changing methods does not necessarily avoid replicating previous explanations of the phenomena. The relationship between explanation type, research method and research duration is presented in Table 6.

		Explanation Type			
		Descriptive	Statistical Relevance	Pragmatic	Functional
Research Method	Experiment	3 (11%)	21 (78%)	2 (7%)	1 (4%)
	Case Study	18 (72%)	2 (8%)	5 (20%)	0
	Survey	7 (28%)	14 (56%)	2 (8%)	2 (8%)
	Field Study	7 (47%)	5 (33%)	3 (20%)	0
	Mixed Method	3 (33%)	5 (56%)	1 (11%)	0
	Instrument Development	1 (33%)	2 (67%)	0	0
	Other	3 (21%)	9 (64%)	2 (14%)	0
	Total 118				
Duration	Snapshot/Cross-section	21 (30%)	38 (52%)	10 (14%)	3 (4%)
	Multi-snapshot	1 (9%)	7 (67%)	3 (27%)	0
	Longitudinal	20 (57%)	13 (37%)	2 (6%)	0
	Total 118				

Table 6. Explanation Types, Research Method, and Research Durations

Lastly, while not directly related to explanation, the research showed that ontological perspectives are not bound to specific research methods or durations. This supports the argument that a pluralist methodology is possible within single ontological perspectives (Mingers 2001). It is research methods, not ontology, that "focuses on different aspects of reality" (Mingers 2001, p. 241) and through mixed-methods a variety of explanations of particular phenomena can be provided. Table 7 shows the ontology-research method relationship.

Discussion

This study of explanation in Information Systems is informative in four ways. First, we argued that the prescription of a singular "best practice" explanation type is not possible in the interdisciplinary field of Information Systems. This thinking extends Simon (1969) who suggested that specific disciplines carry specific explanation types used to describe phenomena in the field. We contend that in order to fully understanding research phenomena and build research streams in Information Systems, researchers should recognize parallel, supportive explanation types from a variety of reference disciplines, whether natural science or computer science. Not recognizing the varieties and limitations of explanations in research may lead to confusion about the meaning and scope of research results.

		Ontology	
		Positivist	Interpretive
Research Method	Experiment	27 (26%)	0
	Case Study	19 (18%)	5 (41%)
	Survey	25 (24%)	0
	Field Study	10 (10%)	5 (42%)
	Mixed Method	7 (7%)	0
	Instrument Development	3 (3%)	0
	Other	12 (12%)	2 (17%)
	Total 115*		
Duration	Snapshot/Cross-section	64 (62%)	6 (50%)
	Multi-snapshot	9 (8%)	1 (8%)
	Longitudinal	30 (29%)	5 (42%)
	Total 115*		
	* 3 studies not included in this total specifically used both positivist and interpretive approaches and varied methods or durations within the same study		

Table 7. Ontologies and Research Methods and Research Duration

Second, by explicating the language and terminology used in describing types of explanation, we increase the understanding of what research results mean, both in terms of the relationship of the results to the objective and interpreted world and of the scope and completeness of the explanation. This provides additional criteria for assessing research results and can lead to insights about future research. Additionally, we provide a clearer picture of the variety of outputs produced in IS research by recognizing the distinction between research intended to design systems and research intended to discover explanations of phenomena.

Third, we demonstrate that the IS field is focused on the models of material and efficient causation, which lies at the core of the natural science model. IS research is dominated by positivist studies which predominantly produce statistical relevance explanation. These are usually sketches of some of the variables related to phenomena. This reveals opportunities to pursue more parsimonious nomothetic explanations focused on the variables or antecedents most significant to the outcome. This study reveals opportunities to exploit other types of explanation in the pursuit of fuller explanations. In particular, pragmatic explanations may be of interest to practitioners who are interested in asking questions based on specific perspectives. Since the field involves the study of goal-oriented systems, the pursuit of functional oriented research may provide valuable insights.

Finally, this research shows that, although there is a propensity to produce specific types of explanations after choosing specific ontologies and methods, the explanation type produced is not determined by those perspectives. This presents opportunities and problems as researchers seek to extend scientific understanding through triangulation or the mixing of methods. Mingers (2001) presents arguments for "critical pluralism" in research programs to achieve greater understanding of the phenomenon under investigation. His arguments are based upon the ability to combine positivist and interpretive perspectives and utilize a variety of methods within these perspectives. But the choice of method and perspective for subsequent research is not clear. It is possible to unintentionally replicate previous explanations even with a different ontology and different research methods. Analysis of the type of explanation provided by previous research may present guidance for subsequent research and result in fuller explanation of the phenomena. For example, a descriptive explanation of the phenomenon can provide background, show boundaries and context of the research, and lay out the researcher's relationship to the setting. Subsequent experimental methods may provide a statistical relevance explanation sketch of certain variables related to phenomena within the context. This may be followed by survey or interview based research providing pragmatic explanation of specific aspects of the phenomena in a parsimonious (nomothetic) manner. Each aspect of the research is guided by the explanation provided in preceding work and in aggregate this process provides a fuller explanation than any single piece of research.

To illustrate the critical pluralism approach with regard to explanation types, research streams within Information Systems can be built on the variety of explanation types produced as a basis for deepening scientific understanding of particular phenomena. Early work on media richness theory was based on predictive ability and the formation of generalizable laws (covering-law/nomothetic explanation). The theory proposed that media have specific structural characteristics that define the ability of the media to reduce equivocality or uncertainty. The original framework defined the relationship between media channels and equivocal and uncertain tasks and was later extended to predict how organizational design can support information needs (Daft and Lengel 1984). Later work extended media richness theory by accounting for the role social influence and organizational context played in defining media richness (see Schmitz and Fulk 1991; Markus 1994; Lee 1994). These examinations showed how an apparently simple information request was actually a message rich with information and subtle meaning and these studies generally represented pragmatic/ideographic explanations where single instances of media richness were explained through contextually dependent environments. Media richness was then examined by Ngwenyama and Lee (1997) who applied the critical theory ontology to the work of Daft and Lengel (1984) and Markus (1994). Ngwenyama and Lee effectively used a new ontological perspective through which a new theory of media richness was developed (pg.

163). Resembling the pragmatic/ideographic explanation used in the earlier social influence studies, the Ngwenyama and Lee study actually distanced itself from earlier media richness work through new theory development. This allows for what appears to be the "reuse" of the same explanation type to actually be a unique instance of an explanation type in the investigation of new theory.

These research projects formed a collective research stream through which media richness theory was examined from different ontological perspectives, using different methods and producing different types of explanation. Further studies are needed to identify research streams in Information Systems and the types of explanation that has been provided across the studies. This would give researchers a detailed understanding of how phenomena within that stream are explained in addition to identifying the ontology and methods used. Identifying gaps in the way phenomena are explained provides researchers new avenues through which to advance scientific understanding and shape the evaluative criteria, identified problems, models and exemplars of the IS disciplinary matrix.

Both the academic and practitioner communities will benefit from understanding the scope of research explanations and the implications for the relevance of research. By examining explanation types and associated terminology and showing the relationships between explanations, ontologies and methods, researchers are better equipped to understand what the research literature and their own research is, in fact, explaining.

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