Fonseca, F. and Martin, J. (2005) Toward an Alternative Notion of Information Systems Ontologies: Information Engineering as a Hermeneutic Enterprise. *Journal of the American Society for Information Science and Technology* 56(1): pp. 46-57.

Toward an Alternative Notion of Information Systems Ontologies: Information Engineering as a Hermeneutic Enterprise

Frederico T. Fonseca[1] and James E. Martin[2]

[1]School of Information Sciences and Technology *[2]Psychology Department*
Pennsylvania State University, University Park, PA 16802, USA
email: fredfonseca@ist.psu.edu, jxm24@psu.edu

Abstract

In this paper we discuss the construction of information systems ontologies. We summarize and discuss Barry Smith's review of the field in the paper "Ontology". In that essay Smith concludes with a plea for ontologies that reflect the categories of current scientific theories because they represent our best knowledge of the world. In this context, we develop an argument for a hermeneutic approach to ontologies – one compatible with the orientation introduced into information science by Winograd and Flores and that was later developed by many others. In order to do this, we argue that the literature in the philosophy and history of science supports a hermeneutic interpretation of the nature and growth of science. This, given Smith's argument, shows the relevance of hermeneutics to the creation of information system ontologies. The problems associated with understanding and creating information systems ontologies can be addressed fruitfully only if one begins by acknowledging that databases are mechanisms for communication involving judgments and interpretations by intelligent and knowledgeable users. The main contributions of this paper are our conclusions that (1) information system ontologies should take into consideration a perspective of the philosophy and history of science and that (2) hermeneutics as construed by Gadamer constitutes a place from which we can understand the tasks of information ontologists and database users.

1. Introduction

The problem of constructing ontologies for organizing databases is becoming intensified as the need for efficient access to broad ranges of data derived from a variety of sources increases. The goal of constructing an abstract classification scheme (an ontology) that would allow for the integration of information from diverse sources, covering different, but related, conceptual domains has become a kind of Holy Grail for many information systems engineers. In Ontology (2003a), Barry Smith provides a fine review of some of the major issues facing researchers attempting to develop information system ontologies. In the course of this review, he gives a number of reasons why information systems ontologies have, at least until now, failed to live up to the hopes of their creators.

In order to situate our argument, we will begin by summarizing and briefly commenting on the salient points Smith makes. We will then develop an argument for a hermeneutic approach to ontologies – one compatible with the orientation introduced into information science by Winograd and Flores (1986), and later developed by them and others, to be summarized below. Citing Winograd & Flores (1986) and Mallery et al. (1987), Diebner (2003) reminds us that the hermeneutic approach stands where AI fails. Stressing the importance of Hermeneutics for

Information Science, Capurro (1985) discusses the work of Langefors (1966; 1980). Langefors with his infological approach considers that information is knowledge in opposition to being data. Information is seen as a process which is dependent on a certain pre-knowledge which the user of the data brings with him/her. Capurro also mentions Diemer and Henrichs. According to him, Diemer (1974) makes the distinction between what is in a computer (data) and *informemes*, which can only exist as the result of interpretation by the user. Similar to Langefors, Diemer also addresses the importance of pre-understanding both by a single user as well as by a community. Henrichs (1978) stresses the view of information as a process in which meaning, signs, and the interpreter are inseparable. Ingwersen (1992) considers the information retrieval similar to the interpretation process. Later Capurro (1992) argued for information science as a hermeneutic-rhetorical discipline. When discussing relevance of information, Froehlich (1994) argues for three types of hermeneutics: (1) the hermeneutical of the prototypical user, (2) the hermeneutical of placing a text in a information collection, and (3) the hermeneutical of the relation between the system and the user. Finally, in a comprehensive survey about the concept of information, Capurro and Hjørland (2003) emphasize (1) the importance of interpretation as one of the basic constituents of the information process and (2) the multidisciplinary and interdisciplinary character of the interpretation process.

Thus, the concept of pre-understanding of a user and its extension to the pre-understanding of a community is very close to the central role of presuppositions, or prejudices, in framing and guiding the emergence of experience in the work of Heideger (1962) and Gadamer (1975). Hence, attempts to develop ontologies along the lines that Smith describes are flawed because, among other things, they fail to explicitly recognize the hermeneutic dimension of the users' situation, and of the theories, scientific and common sense, from which the categories that structure ontologies are derived.

2. Prior Work and Other Approaches

Smith begins by recounting aspects of the philosophical background of ontological research, drawing comparisons and contrasts between the philosophical endeavor and the modern technological project that bears the same name. Citing central contributions to philosophical ontology from Aristotle to Strawson and Chisholm, Smith not only points to some of the central difficulties associated with constructing ontologies for computer databases, he also suggests some contributions to the engineering task that might be derived from the philosophical discussion of ontologies. One of the most significant of those contributions concerns the assumption of realism placed on ontologies by the philosophic tradition. Smith calls that assumption "The Ontologist's Credo." For philosophers constructing, or discovering, ontologies, this credo involves a commitment to the assumption that "to create effective representations it is an advantage if one knows something about the things and processes one is trying to represent," (Smith, 2003a). Most recent philosophers (for example, Quine (1953)) turn to current scientific theory to discover what the most appropriate categories for representing the world might be. The assumption of a kind of realism is at the heart of this enterprise. However, as will be shown, there is a tension between the presupposition of realism and the limits on ontologies imposed by the classic notions of how information system ontologies would function. One apparently has to choose between the two, leaving the information ontologist who wishes ontologies to be of help in describing reality, in a dilemma.

2.1. Ontologies in Artificial Intelligence

The notion of ontologies has been important in the Artificial Intelligence (AI) literature, and aspects of that discussion are informative for understanding information ontologies. Interestingly enough, mention of ontologies in AI began with the notoriously difficult problem of common sense. In a well-known paper, McCarthy (1980) used the term 'ontology' to describe the categorical framework required for the processing of common sense reasoning. Similarly, Hayes (1985a), a student of McCarthy, proposed constructing a formal theory of "common sense physical reality," (Smith, 2003a).

In subsequent work, Hayes (1985b) moved away from the realist assumption. Perhaps because of the increasingly apparent difficulty of explicating a formal theory of any realm of reality apprehended by common sense, Hayes dropped the condition that the computer should embody a characterization of common sense physical reality. Instead of 'faithfulness to reality', he held that an AI ontology should be explicated in the context of possible world semantics. This means developing 'an idea of a model of the formal language in which the theory is written: a systematic notion of what a possible world is and how the tokens of the theory can be mapped into entities … in such worlds' ((1985b), as quoted in (Smith, 2003b). In the same work Smith quotes John Sowa (1984) as referring to "an ontology for a possible world – a catalogue of everything that makes up the world, how it is put together, and how it works." Hayes' approach faced difficulties because, as Smith points out, 'any first order axiomatization of a theory has an infinity of non-intended models' (Smith, 2003b). In order to ensure a potential fit between the AI ontology and the world, Hayes suggested allowing the real world to be the model of the computationally embedded axiom system embodying the ontology. We see here that, having weakened the condition of faithfulness to reality, Hayes was still struggling to retain some connection between ontologies and reality. We will show that the difficulties faced by information ontologists are not of the sort to be resolved by model-theoretic semantics.

2.2. The Ontologist's Credo and Information Science

According to Smith, the implication of the Ontologist's Credo for ontology in information science has been that "one must know not only about the specific token objects (customers, payments, debts) recorded in one's database, but also about objects, properties and relations in general, and also about the general types of processes in which objects, properties and relations can be involved," (Smith, 2003b). This condition has led to the attempt to formalize the "conceptual schemes" that constrain application domains. These formalizations were put forward as declarative representations of application domains. In the technological context, it was but a small step to ontologies. Data analysts wanted to construct declarative representations with maximum generality and reusability, but corresponding as nearly as possible to the projected set of application domains. Thus began research in ontologies in information science (Smith, 2003b).

2.3. The Tower of Babel Problem

A fundamental barrier in the way of developing fully general and reusable ontologies is what Smith calls the Tower of Babel problem. The difficulty is that insofar as database engineers attempt to accommodate, with the same database, groups of users possessing distinct conceptual schemes, they must address the problem of integrating information in ways that are compatible with the perspectives of all significant stakeholders (potential users). This is a significant problem. It might be possible to integrate a limited number of alternative conceptual schemes, working out correspondences among conceptual schemes for a limited domain of data on a case-by-case, ad hoc, basis. However, such solutions are, by their nature, incompatible with the technological imperative behind the development of ontologies. They will be idiosyncratic, and are not general and reusable.

Accordingly, in order to achieve more general and reusable solutions Guarino (1998), for example, has suggested using the techniques of logical and analytic philosophy to develop formal ontological structures with terminological consistency and subject to certain computationally convenient and efficient organizational principles. The problem of integrating databases derived from differing conceptual schemes or ontologies is to be solved by requiring designers to conform, from the beginning, to an ontology. That is – the Tower of Babel problem is resolved by eliminating ontological differences from the beginning, requiring all database designers to submit to first-order logic and/or whatever other formal and substantive constraints are compatible with a consistent ontology. Consequently, the complexity, subtlety and possibly surprising multidimensionality of the data, and the categories that organize them, must be limited in order to fit the needs of the database engineers. Smith (2003b) claims that those working on the Knowledge Interchange Format (KIF) (Genesereth & Fikes, 1992) and Ontolingua (Gruber, 1992) projects have employed similar strategies.

We name this kind of solution to the Tower of Babel problem, the Newspeak Solution, after George Orwell's introduction of the term in his novel Nineteen Eighty Four. The reader will recall that, in order to meet the demands of the technological society envisaged by Orwell, there was a continual effort to create a reformed English, Newspeak, which was simpler, and less capable of expressing the ambiguity inherent in different points of view than traditional English. The consequence was that it became less expressive, and thus reduced the complexity of thought for those using it.

The Tower of Babel problem arises because the complexity of reality, and the points of view taken with respect to it, cannot be reduced to a single classificatory scheme, nor to a single set of neutral facts upon which a classificatory scheme might be based. As long as one tacitly subscribes to the Ontologist's Credo, the incompatibility among ontologies will be a problem since one is concerned to maintain a systematic relation between the ontology and reality – a relation such that the ontology is in some sense true of the general character of reality. The Newspeak solution to the Tower of Babel problem involves flatly denying the epistemic value of alternative, possibly inconsistent, conceptual schemes. Its universal implementation would, as Orwell suggests, probably require an exercise of authoritarian political power.

The difficulties associated with constructing a more complex alternative to Newspeak ontologies on a general scale are overwhelming to say the least. How, for example, could one provide a common, or neutral, framework for organizing and integrating all of the distinct descriptions that have been offered for any reasonably complex conceptual realm, not to mention, though Smith does, "a common ontology of world history"? (Smith, 2003a) The answer to that question is, of course, that one cannot provide a common ontology. If there is something like a common framework, it does not lie at the level of ontologies at all, but at the level at which users from different communities (paradigms) may learn to communicate with one another. This is a hermeneutic level of analysis.

2.4. An Instrumentalist Alternative

In this context, it has been suggested that the difficulty might be avoided if, in a way similar to the solution adopted by the AI researchers mentioned above, one were to hold that ontological research is the study of instrumentally useful formal models, not the formal properties of reality. This move allows the investigator to deftly avoid the claims by users that a given ontology does not coincide with his or her view of reality. The developer of ontologies can reply that what is at issue is not whether the ontology is true, but whether the models it defines are useful, or adequate, for some (limited) purposes. An ontology may have useful relevance to a narrow range of problems without being true. Good instrumentalist examples can be found in Friedman (1953) and Lakatos (1970).

However, instead of being supposed to be grounded in neutral facts, instrumentally grounded ontologies are assumed to be justified by the relevance of a certain set of problem solutions. But notice that the issues of generality and reusability arise again at this point. If considerations of context dictate that another set of problem solutions are relevant, then the instrumental ontology will be of no value.

Thus, while this instrumentalist strategy may appear to be suitable for limited domains, Smith thinks it cannot be successful for ontologies aimed at broader areas of reality. Such ontologies will eventually have to be compared with users' views of reality if one is to decide on their utility. It is for these reasons, Smith (2003a) says, that "the project of building one single ontology, even one single top-level ontology, which would be at the same time non-trivial and also readily adopted by a broad population of different information systems communities, has largely been abandoned." Smith concludes that information system ontologies, in the sense associated with the Ontologist's Credo, have failed.

Nevertheless, work on specific domains continues. The strategy has changed in ways already noted above. Database designers are "increasingly using ontological methods as part of their effort to impose constraints on data in such a way that bodies of data derived from different sources will be rendered mutually compatible from the start," (Smith, 2003b). Such ontologies may be interpreted in terms of what he calls the "closed world assumption." In this case, what Gruber (1995) asserts for AI, will be true of ontologies: 'what "exists" is that which can be represented.' Ontologists will be speaking Newspeak.

But, if so, ontologies may have little relevance to the actual situations in which it has been hoped that computers would be helpful. Smith demonstrates that communication about three actual realms – Enterprise Ontology, Financial Ontology, and Medical Ontology – involves taking into account a variety of ambiguities which can only be deciphered by considering the actual complex and often confusing and imperfectly understood world that is the object of the communication. Accordingly, he concludes with an appeal for the epistemic realism implicit in the Ontologist's Credo, "Rather … (than taking as its starting point … surrogate worlds) …it (research on information system ontologies) should address reality itself, drawing on the wealth of scientific descriptions of the different dimensions of this reality, with the goal of establishing, not only how these various dimensions … are linked together, but also how they are related to the manifest image of common sense," (Smith, 2003b).

3. Information System Ontologies Viewed From the Perspective of the Philosophy and History of Science

Smith's discussion of information system ontologies seems to us to reveal fundamental difficulties, not only with information system ontologies per se, but also with the standpoint from which Smith develops his criticisms. What we have seen is that the concern for truth (i.e., the

Ontologist's Credo) is in tension with the apparent diversity of truth claims across differing epistemic and pragmatic perspectives (i.e., the Tower of Babel Problem).

Smith (2003a) concludes his paper with the proposal for directing research on ontologies he sees as consistent with realism. While we agree with much of the spirit of this proposal, there is no way, within the limits of standard approaches to ontology design, to imagine that one can avoid the Tower of Babel problem other than by assuming that scientific understanding, and common sense, are univocal. But this is not obvious enough to assume. Smith's proposal does not deal adequately with the Tower of Babel problem. If we reject the use of artificial surrogate worlds, as Smith correctly does, then we are faced with the fact that the image of science as a repository of universally accepted facts and theories is false. Moreover, in some of the most interesting potential applications of databases, there may be radical disagreement among users concerning the relevant facts, theories and applications.

Insofar as science is taken to provide the standard for information system ontologies, it is remarkable that Smith did not discuss the status of ontology research in relation to the extensive arguments concerning the nature of scientific knowledge found in the literature on the philosophy and history of science. By following this course, we hope to develop a perspective from which some of the above mentioned difficulties associated with information system ontologies may be addressed.

3.1. The Conventional Nature of Science: The Sophisticated Falsificationism of Popper/Lakatos.

In our view, one of the most significant recognitions of the 20th century has been the fundamental role of human judgment in the scientific process. The positivism that arose from Wittgenstein's early writings was justificationist in the sense that it was held that scientific propositions were a matter of empirical proof – results derived automatically through the application of logical rules and simple observation of the facts, (See J.R. Weinberg, (1960), for an excellent and detailed analysis of the early positivist position).

One could, it was said, see the truth of an empirical proposition as a result of empirical investigation. The statement, "Over there is a black swan," would be verified by observing a black swan over yonder. Positivists admitted, however, that they had no way of justifying induction. The fact that I have seen only black swans in no way justifies the proposition, "All swans are black." Accordingly, they were forced to give an instrumentalist account of the inductive process. The development of universal claims like "All swans are black" was said to result in propositions that, although meaningless because unverifiable, were useful as instruments for generating verifiable and therefore meaningful predictions – for example, a singular proposition such as "This swan is black."

However, the positivists failed to see the parallel between induction and the recognition of the truth of a singular proposition such as "this is a black swan." "All swans are black" was said by them to be meaningless because it cannot be verified. On the other hand, they held that "this swan is black" can be verified by direct observation. But Karl Popper (1992) pointed out that such statements are no more verifiable than "All swans are black." Just as with universal statements derived from induction, so singular statements can never be verified, but can only be falsified. Given the possibility of theory-saving auxiliary hypotheses, there is an infinite set of tests that we might perform to assess the hypothesis that what we have before us is really a swan, and that it is really black. Because the list is infinite, at no time could we stop and say to ourselves that we had proved the thing before us to be a black swan, and thus verified "This swan is black."

This state of affairs led Popper to conclude that the claim that "This swan is black" which might be important in falsifying "All swans are white," is not the result of a verification procedure, but the result of human judgment. Accordingly, if a community of scientists were to jointly judge the object in question to be a black swan, then their decision to reject, "All swans are white" would not be a matter of proof, but would be a kind of convention – a decision taken by experts who had examined the data and found them to be sufficient to support the decision, at least for the moment. As such, crucial turns in the evaluation of a scientific theory were said to be matters of convention established by human judgment, rather than strict proof.

But this is not all, even the application of *modus tollens*, touted by Popper as the instrument of falsification is said not to be an automatic procedure. Rather, the use of *modus tollens* to falsify "All swans are white" given "This is a black swan" depends crucially, for Popper, on context (1992). In particular, the application of *modus tollens* and the consequent falsification of "All swans are white" on the basis of "This is a black swan" depends on the human judgment that there is another theory for which there are good reasons that are not falsified by "This is a black swan." For example, if there were good reasons to consider the proposition "All swans are black" – say, it is a part of a rather elaborate theory with considerable corroborated empirical content – then finding what one judged to be a black swan might, in conjunction with other factors, be sufficient reason to decide that "All swans are white" has been falsified. Popper held that scientists may not reject a theory merely if it is inconsistent with an apparent fact. Typically, there is an elaborate process of consideration that scientists go through before they judge that a previously accepted theory has been falsified.

One of the most striking examples of this process involves the invention of auxiliary hypotheses whose purpose it is to save the theory under attack (cf. Lakatos, 1970). The discovery of what appears to be a black swan in the context of a widely accepted theory about swans which contains a sentence, "All swans are white," is very likely to result in the invention of auxiliary hypotheses which, if not falsified themselves, will save the entrenched theory. For example, it might be argued that the apparently black swan in question had been living in a habitat where an unusually high concentration of a particular mineral in the water had caused a staining of the swan's feathers. The argument would then go as follows. The statement "All swans are white" was not claimed to be unconditionally true. It was only claimed to be true, ceteris paribus – that is, other things being equal. For every scientific theory, it is assumed that there is a list, perhaps infinite in length, of unspecified conditions, that both hold, and are necessary to the truth of the claim that "All swans are white," when that claim was made. The existence of an apparently black swan does not refute the original theory if any of those hitherto unspecified conditions turns out not to hold. In fact, under those circumstances, it would make sense to question the factual status of an alleged black swan. Auxiliary hypotheses, which are invented to save the theory, are hypotheses about some of those conditions not holding.

The existence of such an assumed context, or background, has led Lakatos to assert that none of the most admirable theories in the history of science ever, by itself (i.e., without a tacitly presumed context), makes any predictions at all, (p.100). Scientific predictions are derived assuming a context that their users judge to be appropriate to the presuppositions of the theory in question. In this way it becomes clear that the connection between theory and prediction is indirect, being mediated by human judgment. It is scientists, not theories, who make predictions.

We think it is a fair representation of the history of the philosophy of science in the 20th century to say that it is, among other things, the history of a retreat from the procedure-driven justificationism of the early Positivists to the conventionalism of Popper, and, as we will show, Kuhn. The role of human judgment turns out to be central to the scientific process. That process is not, in general, algorithmic. At every stage, it depends on human sagacity. When these judgments are the consensus of a scientific community, we call them conventions. Scientific knowledge is not the result of proof, or algorithmic necessity, but of the considered judgment of experienced experts. Moreover, when theories break down in some way – for example, not leading to expected observations – scientists attempt to explicate a hitherto unmentioned context, the explication of which is intended to adjust or replace the theory so as to eliminate the breakdown.

These reflections entail a number of consequences for information system ontologies. Some will be considered later, when we are exploring the implications of hermeneutics for information system ontologies. For the time being, it is sufficient to note two points. First, the entry of data into the database is a matter of judgment that the data are appropriately classified by the database. Second, the decision that the ontological generalizations are appropriate to the realm from which the data were derived is also governed by judgment, not by rule. The appropriateness of such generalizations is only held <u>ceteris paribus</u>. The apparently direct (i.e., transparent) connection between the ontology and the world is not only a convention, it is an indication of our perpetual ignorance and an invitation to Nature to show us wrong so that we may invent a better story about its behavior.

3.2. Incommensurability–the Impossibility of a Formal Approach to Unified Ontology: Kuhn/Feyerabend.

A second argument from the philosophy of science literature that has important implications for research on information system ontologies concerns the thesis of incommensurability. Insofar as what we take to be the facts arise as a result of human judgment that may reflect the perceived theoretical context, and not solely from physical stimuli, we must grant that the theoretical context may condition our perception of the facts. The scientific theories in terms of which data are to be recognized can be significantly different from one another in a variety of ways. It is not at all clear that they, or their similarities or differences, can be organized in the axiomatic fashion required by model theoretic semantics. Once we leave the realm of unambiguous "surrogate worlds," the complexity of the ontology project increases considerably. It is apparent that the real world is, to a very significant degree, ambiguous. People with different theoretical dispositions and agendas see different (in some sense, <u>incommensurable</u>) worlds.

Two consequences have been held to follow from this state of affairs. In the first place, it has been argued, for example by the historian of science, T. S. Kuhn (1996), and the philosopher Paul Feyerabend (1993), that there is, in general, no neutral set of facts that provide a framework for comparing competing theoretical perspectives. These authors hold that instead of living in the same factual world and subjecting it to different interpretations, proponents of competing paradigms (theoretical perspectives) practice their trades in different worlds, (cf.Kuhn, 1996). In some areas of their endeavor, scientists in different paradigms may learn to see different things. This means that, at least for these crucial areas of difference, the facts they would notice would not be neutral, but would have their existence only relative to a given paradigm. Kuhn insists that the notion of a deeper, and hence neutral, classificatory scheme, is illusory. All classifications of the facts are relevant to some theoretical framework, in Kuhn's view. A so-called deeper classificatory scheme would not be neutral but relative to its own theoretical perspective.

Likewise, the data populating a database are not neutral, but are collected in the context of particular purposes and theoretical assumptions. Two consequences for information system ontologies follow from this fact. First, the issue of ontology integration: How can we integrate differing accounts if the nature of the accounts is sufficiently incommensurable in the sense that differing accounts recognize different facts? Obviously, there are limits on the degree to which information generated by users committed to different ontologies can be integrated. The automatic integration of a pair of ontologies seems to suppose that they are fundamentally compatible. Of course, one might hope for integration of differing sub-ontologies of the same overarching ontology – for example, if one were integrating data derived from different areas of a domain understood in terms of a common paradigm.

Second, since it is a natural constraint on ontology that it reflects the pragmatic orientation of the data gatherer, as well as the gatherer's theoretical paradigm. Even the fact that two investigators view a domain in terms of a common paradigm may not be sufficient to ensure the utility of a common information ontology. Insofar as questions of practice lead to different priorities, it may be expected that different classifications of data and different classificatory schemes may emerge between investigators with different practical concerns.

The absence of an underlying neutral language (set of categories) has significant implications for communication (transfer of information) between databases. In Kuhn's terms, the absence of a common neutral set of categories to which different categorical schemas could be reduced means that the different schemas are incommensurable with respect to the criteria in relation to which they are evaluated, and, to some extent at least in respect to the fact that even the same terms can sometimes have different empirical and theoretical meaning in different paradigmatic contexts (and Bernstein, 1983; cf. Feyerabend, 1993). Clearly, there will be limits to automatic transfer of information among incommensurable ontologies. We are here again addressing the Tower of Babel problem. Actual science, (the ostensible standard for information system ontologies), does not result in a neutral ontology, nor in a set of easily inter-relatable ontologies. Even in cases where users stay within the same paradigm – which might be possible for large sections of the physical sciences, somewhat smaller sections of the biological sciences, and still smaller sections of the social sciences – problems of application may interfere with the easy integration of data. Criteria for data recognition vary with the context of application, even within paradigms.

There are also profound implications for the growth of knowledge to be derived from Kuhn's analysis. In the absence of any apparent way of integrating alternative scientific perspectives, or paradigms, Kuhn, among others, claimed that the issue of truth was irrelevant to comparisons among paradigms. The incommensurability of paradigms meant that the standards against which paradigms could be legitimately measured were paradigm specific. If one accepts a correspondence approach to truth, the absence of any set of neutral facts that could provide a standard against which alternative paradigms could be evaluated entails that questions of truth be limited to intra-paradigmatic considerations.

For Kuhn, new paradigms are not valued because they are truer than previous perspectives, but for pragmatic reasons. New paradigms are superior to their antecedents because they constitute better conditions for carrying out the puzzle solving activity Kuhn called 'normal science.' Science also grows, according to Kuhn, in its use of technological instrumentation, which allows a general and irreversible movement to increasingly precise measurement, but again, not toward truth. Accordingly, Kuhn's accounts are particularly destructive of a particular kind of ontologically oriented global theorizing. From Kuhn's perspective as a historian of science, the notion of a common ontology of scientific history, not to mention Smith's projected 'common ontology of world history,' would be nonsense.

3.3. Ontologies of Limited Domains: The Problem of Application.

For ontologists sympathetic with them, one of the consequences of Kuhn's views might be to justify a focus on limited domains, ignoring Smith's plea for global ontological structures (e.g., transcategorical relations). Such a focus would result in what Smith has recently dubbed, "lightweight ontologies." So-called lightweight ontologies are organized around limited domains and typically focused on facilitating some narrowly defined set of interrelated applications. The relations at issue in the development of such ontologies are anything but transcategorical. What the lightweight ontologies have in common with each other and their "heavy weight" counterparts is largely in the taken for granted background. The research imperative is to make something that will be of practical value. This move harks back to the instrumentalist approach to ontologies discussed above.

However, even this limited and domain specific approach to ontologies has run into problems. For example, even in a domain as limited as Finance, any ontology designed to facilitate communication will have to be adjusted to the fact that "objects in the realms of finance, credit, securities, collateral and so on are structured and partitioned in different ways in different cultures," (Smith & Zaibert, 2001). In the relatively simple area of Financial Reporting, "it has not been possible to develop an algorithm for the automatic conversion of income statements and balance sheets between two systems, since so much depends on … case law and subjective interpretation." Whenever one is forced to apply an ontology to a domain structured by the subtleties of human judgment and local contexts, the requirement that the application of the ontology be adjusted to those subtleties and contexts seems to block the aims of the sort of automatic information processing ontology designers have hoped for.

What is at stake here, at least in part, is the problem of applying ontologies to real world contexts, even limited and pragmatic ones. The conversion of income statements and balance sheets between two systems, for example, must embody the capacity to interpret case law and other factors that are not algorithmically resolvable. As mentioned above, how a particular fact should be appropriately named, and entered into a particular classificatory scheme of a database, will depend upon the applications to which the data are assumed to be relevant. Thus, the decision in question will inevitably be a matter of judgment requiring considerable expertise concerning not only the facts, but also the problems associated with the practices at issue. Seen in this light, Smith's critique of the instrumentalist approach to ontologies, discussed above, has considerable force.

3.4. Concluding summary

Assuming the Ontologist's Credo, and taking science to be the prime modern example of knowledge, we have examined some of the consequences of the discussion in the philosophy of science for research in information system ontologies. We have shown that scientific knowledge and understanding are not strictly rule-governed activities grounded in a set of neutral facts, but depend at crucial junctures on human judgment. In the first place, analysis and classification of data and the relation of those data to the corroboration or falsification of theories, are matters settled by human judgment. Secondly, and consequent on the foregoing, not only do differences in the perceived facts constrain differences in judgment about theoretical perspective, but the converse is also true. Differences in synthetic theoretical perspectives constrain differences in decisions concerning the facts. There is no set of neutral facts that determine conceptual schemes. Rather, perceived facts and theoretical perspectives interact in a back and forth, or circular, fashion. Thirdly, these decisions go on in the context of application (their presumed consequences for practice of one sort or another).

4. Ontology Engineering as a Hermeneutic Enterprise

We reflect on the above summary by pointing out that the three, above mentioned, aspects of the conventions structuring human knowledge, analysis, synthesis, and application, are precisely the dimensions that are central to the Heideggerian/Gadamerian analysis of the so-called hermeneutic circle. As discussed below, Bernstein (1983) has argued that the literature on philosophy of science to which we have referred above points to a fundamentally hermeneutic understanding of both the natural and social sciences. It is important to clarify that philosophic hermeneutics did not arise out of the issues in philosophy of science, but instead that a certain impasse in the philosophy of science, namely the central problems of communication and incommensurability, led Bernstein and others to introduce the hermeneutical discussion into the philosophy of science arena. In this context, we take up an attempt to approach the processes of database construction, interpretation, and application, in terms of the categories of hermeneutics. In taking this approach, we hope to frame a notion of databases and ontologies that would overcome some of the limitations on ontologies described above. In what follows we will continue to use the term "ontology" in the sense conventional to information science. We emphasize this because the references to Heidegger might mislead the reader. For Heidegger, "ontological" refers to a discussion of <u>what it means to be</u>. In referring to this essay – a discussion of the categories that organize databases – Heidegger would use the term "ontic."

In particular, we hope to show that a hermeneutic contextualization of ontology construction and use can make room for communication among users who hold different ontologies. Representation of diverse ontologies can be a setting within which users with differing conceptual schemas can learn to understand one another. If we stay strictly within the ontological level of analysis, the Tower of Babel problem is insuperable. However, if we can design a hermeneutical context – a place where users may come to learn from one another in a way much more fundamental than merely exchanging information within a mutually accepted paradigm – then we can avoid the limitations of Newspeak and surrogate worlds without being subject to the Tower of Babel problem. But in order to do this, we must first come to explicitly recognize the hermeneutic context that is always present, though largely invisible when there are no disagreements about ontologies. For, it is in this context that the adjudication of disagreements must go on.

We are in agreement with Smith's plea for the Ontologists's Credo, and for an account of common sense. We believe that he has shed light on serious deficiencies of the current research in information system ontologies. However, we think that two philosophical literatures – literatures that Smith does not address – can help frame an understanding of ontologies and their proper use. In particular, we have examined an important argument from the literature on the philosophy/history of science, and we now turn to arguments from the literature on hermeneutics in the tradition of Heidegger and Gadamer. In our view, only a hermeneutically oriented approach to knowledge can overcome the problems of incommensurability that arise in science, common sense, and, therefore, information ontologies. The literature on philosophical hermeneutics, dealing, as it does, with problems of interpreting foreign perspectives, and, therefore, communication among persons holding different perspectives, must have central relevance to the construction and use of databases.

In other quarters, beyond the work on ontologies, the relevance of hermeneutics for the information sciences has been widely recognized. Already Winograd and Flores (1986) have proposed that, in light of the importance of a hermeneutic analysis of computation and cognition, the communicative function of computers should be given increased recognition. We follow many of their arguments in developing our own proposals. Mallery *et al*. (1987) discussed the importance of hermeneutics in A.I. They see the challenge introduced by hermeneutics as a stimulus for innovative research in the field. Software design and hermeneutics was the subject of subsequent important work. First, Coyne (1995) examined the relation of philosophic schools to information science stressing the importance of hermeneutics to computer software design. Snodgrass and Coyne (1997) argued that design was not in the domain of natural science but belonged to the domain of the human and hermeneutical sciences. Capurro (1996; 2000) argues that an approach information technology that intends to be ethically responsible should take into account the process of interpretation that is needed for the constitution of meaning. He considers that the trying to fit the event of information into a fixed structure is a hopeless enterprise and that alternative ways should be sought. Accordingly, Capurro points to the centrality of hermeneutics for the study of information and information science (1985; 1996; 2000). Hjørland and Albrechtsen (1995) and Hjørland (1998; 2000; 2002) have opened up new ground by arguing the relevance of philosophical analysis, including hermeneutics and critical theory, for information science, both with respect to applications in library science and in relation to fundamental questions in epistemology. Both Hjorland and Floridi (2003) have pointed out the philosophical nature of the issues raised by information science and claimed a central role for the philosophic study of information. Chalmers discussed the importance of interpretation and a hermeneutic approach for information retrieval (1999; 2002). Finally, Benoit (2002) devoted a very sophisticated review to the analysis of information systems from the point of view the history of philosophy in the 20th century, including an excellent study of hermeneutics. Although there are other examples, these are introduced to enable the interested reader to explore the growing conversation to which this paper is intended as a contribution. They also corroborate our recognition of the importance of hermeneutics to the information sciences.

Nevertheless, much current work in information system ontologies tacitly assumes the justificationist position of the early Wittgenstein and his followers in the Positivist camp (Weinberg, 1960). The conventionalist nature of facts, and their dependence on theory and issues of application, are not explicitly recognized. Accordingly, disagreements about classifications (the Tower of Babel problem) are therefore often taken to be reason to give up on realism, and focus on surrogate worlds, in which what is taken to be equivalent to what can be represented.

From the Positivist perspective, talk about inconsistent perspectives sharing a degree of validity must appear to be abject relativism. Of course, from a conventionalist point of view, one can recognize a number of situations in which human judgment may arrive at different (inconsistent) conclusions, but where some degree of validity may be associated with each alternative. For conventionalism, lack of univocality does not entail know-nothing relativism, for it does not imply that all judgments are of equivalent validity. While justificationism tends to create the conditions for an endless, and pointless, debate between justificationism and the relativism it spawns, conventionalism of the sort we have in mind appears to embody a kind of middle way.

Relative to the nature of science, this middle way has been addressed in terms of the hermeneutics of both Heidegger and Gadamer by Richard Bernstein (1983). Following these authors, we accept the task of understanding to be a hermeneutic task. If hermeneutic analysis makes possible a valid characterization of scientific activity, this entails that information system ontologies should be designed in light of the fundamentally hermeneutic character of the scientific enterprise. In this context, we propose to address the structure and place of information system ontologies in relation to a hermeneutic conception of knowledge and application.

4.1. Toward a Framework for a New Conception of Ontologies

A hermeneutic approach is to be clearly distinguished from the Cartesian rationalistic orientation that constitutes the received framework for much research on information ontologies. In the course of his hermeneutic account of understanding, Heidegger recognizes the central role of presuppositions, or prejudices, in framing and guiding the emergence of experience. It is important to see that this tacit level of analysis is not closed but always open to revision and adjustment in light of the object of inquiry - the thing itself. Nevertheless, for Heidegger, the tacit dimension has temporal priority in the development of experience. To give an often-cited example, in the act of hammering, the hammer is not the object of focus, but there is no doubt that the hammerer has a kind of access to the hammer. This access is tacit inasmuch as the object of explicit attention is the nail. In this case, the hammer is said to be ready-to-hand. In this ready-to-hand mode, the hammer is not cognized as an object with a certain set of properties, but it is simply integrated into the skilled actions patterns of the user. It is a part of the tacit context of the activity of driving the nail.

Suppose, however, that the hammerer misses the nail and strikes his thumb. Now, what Heidegger calls breakdown has happened. The hammer becomes the object of explicit attention. The hammerer may examine the hammer in order to determine what properties it has that led to the accident. Viewed in this light, the hammer is present-at-hand. It is evident that the mode of scientific analysis aims at presenting objects as present-at-hand. That is, the goal of scientific investigation is to reveal the properties of the objects under investigation. Heidegger's point, in this connection, is to show that the mode of scientific experience - experience of the world as present-at-hand - is not fundamental, but it is derivative from a prior immersion in the world as ready-to-hand. The world is, first of all, a ready-to-hand context for effective action, and only subsequently, a present-at-hand object of scientific analysis.

The Cartesian stance is not fundamental, but derivative from a more fundamental mode of being in the world. It is from this latter perspective that breakdown, for example breakdown of communication, can occur. It is, therefore, from this perspective that differences in paradigms and ontologies can be appreciated and dealt with. Moreover, it is pointless to talk about the existence of objects and their properties in the absence of commitment to concernful activity with its potential for breaking down. What really is, is not defined by an objective omniscient observer, or an individual computer programmer, but rather by a space of potential for human concern and action. This is a space of value and possibility. Information system ontologies, as we know them, are the result of invention in the face of breakdown. Information system ontologies should be constructed in light of anticipated breakdown and so as to enable users to avoid breakdown, as much as possible. As such, ontologies embody commitments, or promises, that the world is arranged in such-and-such a way. The framework of such commitments and assumptions is called a horizon. An ontology should not be considered to be static, and thus closed to the problems occasioned by new breakdowns, but instead, ontologies should be essentially flexible, and open to development – adjusting to breakdowns and incorporating their resolutions.

Understanding an interlocutor, for example someone who has constructed, or is using a database, requires fusion of horizons – every horizon is a limited, but open, perspective, comprised by a set of assumptions and values. Fusion of horizons, through which horizons are enlarged and enriched, is achieved through playful movement around the hermeneutic circle – and achieving “effective historical consciousness” – concrete recognition of the effective role of history in constituting horizons from which we view events. In this effective historical consciousness, we become aware that the object is what it is from a perspective that we have arrived at as a result of our own history. But this does not entail a mere relativism. Instead, Gadamer is clear that “it is the task of effective historical consciousness to bring to explicit awareness the historical affinity” between the object of inquiry and the inquirer (Bernstein, 1983).

“True historical thinking must take account of its own historicality. Only then will it not chase the phantom of an historical object, which is the object of progressive research, but learn to see in the object the counterpart of itself and hence understand both. The true historical object is not an object at all, but the unity of the one and the other, a relationship in which exist both the reality of history and the reality of historical understanding.” (Gadamer, 1979)

So then, hermeneutics as construed by Gadamer constitutes a place from which we can understand the tasks of information ontologists and database users. It provides a context from which we may address the various problems facing ontologists and users – choice of ontological categories, ontology integration, communication among users residing in different horizons, etc. The key is to see that a database, as well as the world to which it refers, is itself an object of interpretation, and that, as such, those who use it are engaging in hermeneutic activity. Moreover, this activity of interpretation is strongly constrained by the applications users have in view.

Finally, the hermeneutic orientation we propose provides a context within which we may naturally direct the attention of ontologists to the horizons of meaning presupposed by both the users of ontologies, and the ontologists themselves. In this setting, it may be possible to acquire some insight into the problem of the growth and development of ontologies. In this connection, the hermeneutic point of view we propose here will make possible a more explicit recognition of the implicitly hermeneutic activity that has already been present in the construction and the use of information system ontologies. Such recognition would be the first step toward designing systems that facilitate communication among users and designers who hold different views of a given domain.

5. Summary and Conclusions

There are some advantages and differential characteristics of a hermeneutic approach to the analysis of information system ontologies. In the first place, as has been noted above, Smith and others have recognized a number of difficulties associated with conventional approaches to ontologies. We think a hermeneutic approach provides a promising venue for addressing those difficulties. Consider, for example, the Tower of Babel problem. This problem arises because the creators and users of ontologies either deny, or are not sufficiently explicit about, the interpretive nature of data. Hence, the manifestation of differing perspectives, even differing ontologies, appears to present an insuperable barrier to their project. On the other hand, the presence of 'historically effective consciousness' in both creators and users of ontologies would open up a space in which breakdown resulting from different consequences of human judgment would not be surprising. On the contrary, ontology designers would explicitly attempt to anticipate breakdown, insofar as possible. Also, a variety of general strategies could be made available to users that would provide guidance for the resolution of breakdown and the re-establishment of a more ready-to-hand access to the world referred to through an ontology.

Ontology integration, now a very tough nut to crack given the relative incommensurability of differing ontologies, would be approached in terms of Gadamer's notion of the 'fusion of horizons.' Here again, such fusion could be facilitated but not automatized, through the encouragement of effective historical consciousness on the part of users. The point is that the question of ontology integration only arises in the context of a previous ontology dis-integration (i.e., a breakdown, in Heideggerian terms). Moreover, a breakdown is an occasion for the revelation of a hitherto unrevealed structure or distinction, the revelation of which allows for a resolution of the breakdown. In this case, that resolution might entail an ontology integration. But it is important to understand that the diagnosis of the breakdown as well as its resolution cannot be done without considering horizons of those who experienced it. This leads to a very important consequence. The theory and practice of ontologies cannot be developed through an analysis of machines and their programs alone, but must always be accompanied by a deepening understanding of the users of those machines and programs, especially an analysis of their horizons.

The framework we are suggesting directs us to construe information system ontologies as representations of the world as present-at-hand, which are the result of progressive response to various sorts of breakdowns of the ready-to-hand. Such representations should be incorporated because they have (or, may) become part of a resolution of breakdown, and thus have (or, may) become part of the new ready-to-hand background to effective action in the world. In this context, the importance of practice (application) for the development of ontologies becomes apparent.

Winograd and Flores note that the computer can be viewed as a device that enables communicating. Capurro (2000) views the process of information retrieval as an interaction of the open horizons of the user (inquirer) and the fixed horizon of the system (database). This way the information-seeking process can be seen as an interpretation process in which the context and the background of the user and database designer are very important. Communication is, after all, the function of a database and the ontology that organizes it. The database contains information intended to be used in a variety of contexts, some of which, but not all, are anticipated. In other words, the data in a database, from the perspective of its creators, have a point. It is not too much of a stretch to say that there is a sense in which a database is a kind of stylized text. Appropriate use of the database will therefore require an interpretive activity on the part of its users. In order to interpret the data, the user will be required to situate the data in the historical context and thus draw whatever conclusions he can from it. If it does not speak directly to him, he may give it a point by seeing its implications for his own concerns. Our ability to appropriate data for our concerns depends on our knowledge of the context – probably also common sense understanding of the situation in which its use will be made.

In the hermeneutical context, we can now understand why common sense has been so difficult to capture in computational terms. Common sense may not be stored as a present-at-hand representation of reality, but may rather be an original invention to solve breakdown. The reason common sense cannot be formalized ahead of time may be that it is not a kind of prior, if unconsciously held, knowledge, but is instead largely invented, on the fly, in response to breakdown. In this sense, it is a response to prior ignorance. A person with so-called common sense is not a person with a head filled with a stock of everyday facts, or general maxims, or principles, but a person of ingenuity – capable of inventing solutions to the myriad breakdowns that beset us daily. Accordingly, the hope that one will be able to construct an ontology for a database that represents commonsense may be an empty one.

Finally, we concluded that ontologies and the databases they may organize can be seen from two perspectives. First, they may, and usually are, seen as representations of the present-at-hand world that has been elucidated to resolve past breakdowns. On the other hand, they may also be construed as a part of the active ready-to-hand access to the world. When they are being used without breakdown, by a skilled user, the components of an ontology or database are not so much pictures of the world, but tools through which the user discerns the intention of those who have constructed the computational tool. They have become useful tools precisely by leaving the realm of present-at-hand representation and being transformed, through regular use, to a ready-to-hand tool through which one sees a particular aspect of the world, not something that is merely like that aspect of the world. In this way, the computer and its database can become a kind of instrument–like the blind man's cane–through which an entity or relation that another has pointed out, may, in absence of breakdown, be clearly seen.

5.1. Future work

In this paper we addressed the discussion of ontologies and information systems from a high-level perspective giving some principles that can be used as foundations of a hermeneutic ontology editor. Nevertheless some readers may want to know about some practical methods to solve differences and fuse horizons in the process of building ontologies.

Perhaps the key point is to see that an ontology editor is distinct from ontologies. We conceive it to be a ‘place’ where persons assuming different conceptual schemas may come to learn from one another through interaction with each other and with their texts. This would involve a back and forth process which includes dimensions of understanding, interpretation, and application.

The hermeneutic ontology editor builds ontologies from texts. All the concepts and relationships are first laid down in a narrative. Later on the text is mined, and concepts and relationships are transferred to an ontology. In a first step this process is to be performed by ontology engineers but studies to automate the transfer will also be carried out. As we suggested in this paper, the process of creating an ontology is a hermeneutical enterprise. Therefore, it is necessary to have a space for interaction. The interaction is achieved through the use of questions. Once a version of the text is released, potential users of the ontology go through the text and ask questions for clarification. The reply to the questions come as changes in the text. These changes will in their turn lead to changes in the concepts and relationships in the ontology.

Changes in the text (and consequent changes in the ontology) may happen in different degrees. Sometimes the texts will go through minor editing with little change in the ontology. Other times changes may be major including addition or deletion of concepts. Therefore, a study of change in what it applies to ontologies is also necessary and it is being performed. An ontology versioning framework, which is also part of this project, includes a an ontology version tracker that is used to manage the many versions created as the ontologies evolve.

Fonseca, F. and Martin, J. (2005) Toward an Alternative Notion of Information Systems Ontologies: Information Engineering as a Hermeneutic Enterprise. *Journal of the American Society for Information Science and Technology* 56(1): pp. 46-57.

Acknowledgements

The authors would like to acknowledge their debt to Professor George B. Kleindorfer with whom they have spent many delightful hours studying the texts referred to in this paper. Frederico Fonseca's work was partially supported by the National Science Foundation under NSF ITR grant number 0219025, by an AT&T Industrial Ecology Faculty Fellowship, and by the generous support of Penn State's School of Information Sciences and Technology. The authors also would like to acknowledge the many helpful comments from the anonymous reviewers.

References

Benoit, G. (2002). Towards a Critical Theoretic Perspective in Information Systems. *Library Quarterly, 72*(4), 444-474.

Bernstein, R. J. (1983). *Beyond Objectivism and Relativism : Science, Hermeneutics, and Praxis*. Philadelphia: University of Pennsylvania Press.

Capurro, R. (1985). *Epistemology and Information Science*. Stockholm: Royal Institute of Technology Library.

Capurro, R. (1992). What is information science for? A philosophical reflection. In P. Vakkari & B. Cronin (Eds.), *Conceptions of library and information science : historical, empirical, and theoretical perspectives* (pp. 82-98). London: Taylor Graham.

Capurro, R. (1996). Information Technology and Technologies of the Self. *Journal of Information Ethics, 5*(2), 19-28.

Capurro, R. (2000). Hermeneutics and the Phenomenon of Information. In C. Mitcham (Ed.), *Metaphysics, Epistemology, and Technology* (pp. 79-85). New York: JAI.

Capurro, R., & Hjørland, B. (2003). The Concept of Information. *Annual Review of Information Science & Technology, 37*(8), 343-411.

Chalmers, M. (1999). Comparing Information Access Approaches. *Journal of the American Society for Information Science and Technology, 50*(12), 1108-1118.

Chalmers, M. (2002). *Hermeneutics and Representation*. Paper presented at the "Interpretive" Approaches to Information Systems and Computing Research, Brunel University, West London, UK.

Coyne, R. D. (1995). *Designing Information Technology in the Postmodern Age: From Method to Metaphor*. Cambridge, Massachusetts: MIT Press.

Diebner, H. H. (2003). Operational Hermeneutics and Communication. In H. H. D. a. L. Ramsay (Ed.), *Hierarchies of Communication*. Karlsruhe: Verlag ZKM.

Diemer, A. (1974). Information Science - A New Science. In S. C.-R. o. t. T. B. o. Information (Ed.), *International Federation for Documentation* (pp. 192-203). Moscow.

Feyerabend, P. K. (1993). *Against method*. (3rd ed.). London ; New York: Verso.

Floridi, L. (2003). Information. In L. Floridi (Ed.), *The Blackwell Guide to the Philosophy of Computing and Information* (pp. 40-61). Malden, MA: Blackwell.

Friedman, M. (1953). The Methodology of Positive Economics. In M. Friedman (Ed.), *Essays in positive economics* (pp. 3-16,30-43). [Chicago]: University of Chicago Press.

Froehlich, T. (1994). Relevance Reconsidered - Towards an Agenda for the 21st Century: Introduction to Special Topic Issue on Relevance Research. *Journal of the American Society for Information Science, 45*(3), 124-134.

Gadamer, H.-G. (1975). *Truth and Method*. New York: Seabury Press.

Gadamer, H.-G. (1979). The Problem of Historical Consciousness. In P. Rabinow & W. M. Sullivan (Eds.), *Interpretive Social Science : A Reader* (pp. 103-160). Berkeley: University of California Press.

Genesereth, M. R., & Fikes, R. E. (1992). *Knowledge Interchange Format* (KSL-92-86): Stanford University, Knowledge Systems Laboratory.

Gruber, T. (1992). *A Translation Approach to Portable Ontology Specifications* (Technical Report KSL 92-71). Stanford, CA: Knowledge Systems Laboratory, Stanford University.

Gruber, T. R. (1995). Toward Principles for the Design of Ontologies Used for Knowledge Sharing. *International Journal of Human Computer Studies, 43*(5/6), 907-928.

Guarino, N. (1998). Formal Ontology and Information Systems. In N. Guarino (Ed.), *Formal Ontology in Information Systems* (pp. 3-15). Amsterdam, Netherlands: IOS Press.

Hayes, P. J. (1985a). Naïve Physics I: Ontology for Liquids. In J. R. Hobbs & R. C. Moore (Eds.), *Formal Theories of the Common-Sense World* (pp. 71-108). Norwood: Ablex: Ablex Publishing Company.

Fonseca, F. and Martin, J. (2005) Toward an Alternative Notion of Information Systems Ontologies: Information Engineering as a Hermeneutic Enterprise. *Journal of the American Society for Information Science and Technology* 56(1): pp. 46-57.

Hayes, P. J. (1985b). The Second Naïve Physics Manifesto. In J. R. Hobbs & R. C. Moore (Eds.), *Formal Theories of the Common-Sense World* (pp. 1-36). Norwood, NJ: Ablex Publishing Company.

Heidegger, M. (1962). *Being and Time*. New York: Harper.

Henrichs, N. (1978). Informationswissenschaft und Wissensorganisation. In W. Kunz (Ed.), *Informationswissenschaft* (pp. 150-169). München: Oldenbourg.

Hjørland, B. (1998). Theory and Metatheory of Information Science. A New Interpretation. *Journal of Documentation*, *54*(4), 606-621.

Hjørland, B. (2000). Library and Information Science: Practice, Theory, and Philosophical Basis. *Information Processing and Management, 36*(6), 501-531.

Hjørland, B. (2002). Epistemology and the Socio-Cognitive Perspective in Information Science. *Journal of the American Society for Information Science and Technology*, *53*(4), 257-270.

Hjørland, B., & Albrechtsen, H. (1995). Toward A New Horizon in Information Science: Domain Analysis. *Journal of the American Society for Information Science, 46*(6), 400-425.

Ingwersen, P. (1992). *Information Retrieval Interaction*. London: Taylor Graham.

Kuhn, T. S. (1996). *The structure of scientific revolutions*. (3rd ed.). Chicago, IL: University of Chicago Press.

Lakatos, I. (1970). Falsification and the Methodology of Scientific Research Programmes. In I. Lakatos & A. Musgrave (Eds.), *Criticism and the growth of knowledge*. Cambridge [Eng.]: University Press.

Langefors, B. (1966). *Theoretical analysis of information systems*. Lund,: Studentlitteratur.

Langefors, B. (1980). Infological models and information user views. *Information Systems, 5*(1), 17-31.

Mallery, J. C., Hurwitz, R., & Duffy, G. (1987). Hermeneutics: From Textual Explication to Computer Understanding? In S. Shapiro (Ed.), *The Encyclopedia of Artificial Intelligence*. New York, NY: John Wiley and sons.

McCarthy, J. (1980). Circumscription - A Form of Non-Monotonic Reasoning. *Artificial Intelligence*, *1-2*(13), 27-39.

Popper, K. R. (1992). *The logic of scientific discovery*. London ; New York: Routledge.

Quine, W. V. (1953). *From a Logical Point of View : 9 Logico-Philosophical Essays*. Cambridge: Harvard University Press.

Smith, B. (2003a). Ontology. In L. Floridi (Ed.), *The Blackwell Guide to the Philosophy of Computing and Information* (pp. 155-166). Malden, MA: Blackwell.

Smith, B. (2003b). Ontology and Information Science. In E. N. Zalta (Ed.), *The Stanford Encyclopedia of Philosophy*. Stanford, CA: The Metaphysics Research Lab, Center for the Study of Language and Information, Stanford University.

Smith, B., & Zaibert, L. (2001). The Metaphysics of Real Estate. *Topoi, 20*(2), 161-172.

Snodgrass, A., & Coyne, R. (1997). Is Designing Hermeneutical? *Architectural Theory Review, 1*(1), 65-97.

Sowa, J. F. (1984). *Conceptual Structures : Information Processing in Mind and Machine*. Reading, MA: Addison-Wesley.

Weinberg, J. R. (1960). *An Examination of Logical Positivism*. Paterson, N.J.: Littlefield Adams.

Winograd, T., & Flores, F. (1986). *Understanding Computers and Cognition : a New Foundation for Design*. Norwood, N.J.: Ablex Pub. Corp.