Uncertainty and Information Systems

van der Blonk, H.C.; Huysman, M.H.

1998

Faculteit der Economische Wetenschappen en Econometrie

SERIE RESEARCH MEMORANDA

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Heico van der Blonk
Marleen Huysman

Research Memorandum 1998-15

april 1998

vrije Universiteit amsterdam

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Heico van der Blonk and Marleen Huysman*

Vrije Universiteit Amsterdam, Faculty of Economics
Department of Information Systems, *Department of Business of Finance
De Boelelaan 1105, 1081 HV Amsterdam
Tel +31 20 444 606116062, Fax +31 20 444 6005
Email: hblonk@econ.vu.nl, mhuysman@econ.vu.nl

Presented at the conference "Uncertainty, Knowledge and Skill", Hasselt (Belgium)
7 November 1997

Abstract

This paper is an explorative journey into the design and use of information systems (IS) in organizations. We argue that conventionally IS are constructed from a perspective of Certainty which result in two major problems: the problem of rigidity and the problem of structural blindness. In order to overcome both problems another perspective on the design and use of IS is needed which we have termed Uncertainty. This perspective is described using two dimensions; the systems dimesion and the information dimension. Where the systems dimension is concerned this perspective allows for a continuously changable and changing structure which reflects the dynamic nature of organizational reality. The information dimension of the Uncertainty perspective draws attention to the relevance of ambiguous, unexpected and seemingly irrelevant information. Both dimensions of Uncertainty stress the support of the process which is underlying the functioning of IS instead of the IS as a static and defined entity. We have tried to argue that certain types of IS like internet and CSCW-systems need a different perspective to understand their construction and use.

1. Introduction

This paper is an explorative paper. We attempt to find some guiding principles for studying information systems (IS) in a way that goes beyond common approaches to IS. We do so by describing the intellectual tradition of IS as rooted in a Certainty style of thinking because it is occupied with developing IS of which its structure and knowledge content are presumed to be fixed and stable. This style of thinking has, despite its practical achievements, two main limits that have to do with the fluxing nature of organizational reality and with the need for organizations to explore the unknown and unexpected. To deal with those limits we need a style of thinking which goes beyond Certainty, a style which is termed Uncertainty.

Certainty and Uncertainty as 'styles of thinking' should not be seen as alternatives to each other but more as supplementary to each other (cf. Chia 1995, Cooper and Law 1995, March 1991). In Certainty the focus is on outcomes, while Uncertainty focusses on the process that generates outcomes. In a Certainty style of thinking IS are valued as stable and unambiguous entities, whereas in an Uncertainty style of thinking IS need to be seen as dynamic and open systems both in their structure and their knowledge content. While the Certainty style of thinking helps us identify the underlying assumptions that have shaped and still is shaping the majority of our IS together with the nature of the limitations of this approach, the Uncertainty style of thinking provides us with a radically different view of organizational life that is interesting for designing and developing information systems. In discussing Uncertainty, we will draw on a variety of examples of IS which embody (elements of) this style of thinking.

Despite the variety of conventional definitions of IS we do not aim to define IS. When we use the term we just broadly refer to repositories of information, irrespective of those being automated or informal, routinized or not. Our eventual interest, however, is in IS supported by information technology (IT). We discern IS as consisting of two dimensions: the information dimension, and the system dimension. The first dimension refers to the nature of the information and knowledge which is stored in or generated by the IS. It focusses on the content of the system.The second dimension refers to the structure of the IS or how the content is systemized. The two dimensions can not be sharply distinguished in the sense that the structure of the system already determines what sort of information is collected, stored or generated, as well as that the structure of a system can be presumed by certain types of information. Hence, this distinction in two dimensions is analytical, and enables us to concentrate on different sorts of information systems that we will describe using the Certainty and Uncertainty perspectives.

In the second section we will describe the Certainty style of thinking by using the two dimensions of IS. This leads to the identification of two main limitations of this style of thinking which call for a style of thinking beyond Certainty. In the third section we will describe the Uncertainty style of thinking, again using the two dimensions of information systems. We conclude the paper with a discussion of the relevance of Uncertainty for the development and use of IS in organizations.

2. Perspective of Certainty

The common, traditional way of developing information systems is divided in a number of phases of development resulting in an IS that aims to support or improve the organization. Typical examples of such IS are accounting and control systems, management information systems, and decision support systems. Although different methodologies for developing IS discern a different number of phases, or use different terms to refer to those phases of development, in general the following phases can be distinguished:

1. Problem definition. Problems, needs and types of solutions are enacted usually by the initiators of the project and the project team. The resulting perceptions of problems, solutions and goals are reported and used as the starting point for the design.
2. Design. This phase includes the functional design in which the organization, or that part of the organization which is relevant for the system is mapped out and modelled. Information

requirements - statements of the information that should be provided by the future system, information flows, functions and relationships within the organization are formally described. The resulting models are then translated into the technical structure for the system, including the design of databases, the structure of the software and the nature of the hardware needed.
3. Technical realization. This phase includes the realization of the the technical system based on the specifications from the design phase. Databases are created, software programmes are written and neccesary computer equipment is determined.
4. Implementation. Users are trained, hardware and software is installed, acceptance tests are run, and then the system is 'operational'.
5. Use and maintenance. Often this phase is also seen as part of the 'system's life cycle'. Due to new requirements and changes in the system's environment the system has to be adapted accordingly.

This general description of the process of information systems development (ISD) is commonly known as the 'waterfall method' because the results of one phase are the input for the next. Several techniques have been developed to improve this general model of ISD. Prototyping for example is a method to quickly build a system that gives a realistic impression of the system to be developed. Using the prototype, future users are able to comment on the design which can be used to improve the design of the system. The protoype is rebuilt and presented to the users again, which is repeated until the users feel comfortable with the system. The idea behind prototyping is to involve users in the design of the eventual system by allowing the users to (re)define their requirements until they feel comfortable with the resulting system. Another method is incremental development in which parts of the system are developed after one another without determining beforehand what the eventual system will look like. In this way, ISD is slowly creeping towards the completed system whatever that may look like (Paul 1993).

The creation of stability is at the heart of methods for ISD. The underlying assumption of the vast majority of these methods, and thus embedded in a lot of information systems, is that an organization can be mapped out, modelled into diverse funtions and the relations between those functions, resulting in schema with information flows and information requirements translated into software programs. Not only is the structure of the organization captured and translated into the information system, also the information which is used and produced in the organization becomes fixed and predefined. This style of thinking about ISD is referred to as Certainty in this paper. Within a context of a Certainty style of thinking, entities are functional, goal-directed, aiming at efficiency and progress. Certainty assumes a pre-existing order that can be mirrored or reflected by IS. Processes of developing and using information systems exemplify such a context, and often reinforce that image. Information systems are commonly presented as solutions to problems that are 'there' because of an assumed pre-existing order.

2.1 The Limits of Certainty

In many instances IS developed from a perspective of Certainty have proven to be valuable. Relatively stable organizational processes provide the rationale for building and using IS with a stable structure and predefined kowledge and information requirements. A good example is an IS that one of the authors encountered on a fieldwork site which was developed for registration of the stock and distribution of company work clothing. The activity of registration was relatively stable (only the style of clothing changed periodically due to the inflence of fashion or safety rules) and the system that was developed for it had not changed for over decades and there was no reason to change it.

Problems do arise however when underlying processes are not stable and do change, when information requirements change, when something 'unforseen' happens, when the relevant becomes irrelevant and vice versa.

Information systems are more too often built for a moment instead of for movement, and thus they do more to stabilize than to destabilize organizations (Hedberg and Johnsson

1978). Broadly speaking, two general sorts of problems can be distinguished: The problem of 'Rigidity', i.e. stable systems operating in a changing setting, and the problem of 'Structured Blindness', i.e. the blindness to potential structures, knowledge and information that may lead to unexpected and unanticipated changes such as innovation. The problem of rigidity refers to the system dimension of an IS; the problem of structural blindness refers to the information dimension of an IS.

2.2 The problem of Rigidity.

The notion that information systems are developed for a point in time instead of a period of time has been emphasized in what has come to be termed the Fixed Point Theorem (Paul 1993). This theorem implies that IS with fixed structures and pre-defined information requirements, no matter how well designed at the moment of design, will experience problems because of the dynamic nature of their organizational surroundings. The Fixed Point Theorem implies that there is a fundamental problem in the way we design and structure IS. Instead systems should be able to adapt to unknown change, and "[t]he question of how this should be done must not be allowed to determine what it is that we want to do" (Paul 1993).

The structure of traditional information systems has close links with the notion of distal organization (Cooper and Law 1995). In the distal view, organization is a definable system with clear and strong boundaries, and it stresses order, hierarchy, and stability. The focus in this view is on states of being, on a finished and explicit totality. When we view organizations this way they are static states, "... as though they were part of the natural order of things." (Cooper and Law 1995, p. 238).

Likewise, in a perspective of Certainty IS are seen as complex but definable systems which boundaries and structure can be clearly defined. Information systems are traditionally designed this way, and carry that distal image of organization implicitly or sometimes even explicitly within them. The structure of an information system more too often is a reflection of the structure of the organization at the time the system is designed. The functional design of an information system is therefore sometimes called the blueprint of the organization. It is an attempt to capture the organizational structure, or "to throw an ordering net over the activities within the organization" (Law 1994), which is subsequently often hard-coded in software, hardware and procedures. As was pointed at in the beginning of section 2 several techniques such as prototyping and incremental development have been introduced to make that reflection of the organizational structure as precise as possible.

Architecture has often served as a constructive metaphor for the development of IS, but ironically the metaphor illustrates a fundamental problem as well, in Stewart Brand's (1994) words: "Architecture, we imagine, is permanent. And so our buildings thwart us. Because they discount time, they misuse time. Almost no buildings adapt well. They're designed not to adapt; also budgetted and financed not to, constructed not to, administered not to, maintained not to, regulated and taxed not to, even remodeled not to. But all buildings (except monuments) adapt anyway, however poorly, because the usages in and around them are changing constantly.".

Like buildings, information systems are ways of creating stability and order thereby imposing a fixed structure on organizations. This would be no problem as long as the organization it supports does not change. Organizations, however, do change and IS are more to often faced with a changing organizational environment (Fitzgerald 1990). In a perspective of Certainty the stability of an IS is viewed as normal and change as accidental and distortive (Cooper and Law 1995), but change and transformation seem to be inherent in social and organizational life.

Every change that affects the information system requires the system to adapt to those changes. As a result huge amounts of money and efforts go into adaptation and maintenance of information systems (Gladden 1982, Lei 1994), and numerous examples are available of situations in which IS resist change, become rigid hindrances to the organization,

or become obsolete. It quite often happens that already during the design phase of a computerized information system the user requirements are 'frozen', i.e. that no changes in the requirements are allowed to be made so that the design team has a concrete and stable point of departure for the technical design and programming of the system. It is no exception that at the very moment when a system is delivered and introduced in the organization, numerous requests for changing the system have been submitted already, or worse, that the system appears to be obsolete at the time of introduction.

2.3 The problem of Structural Blindness.

Next and related to the problem of rigidity is the problem of 'structural blindness'. In situations of (expected) stability, it may be possible to pre-determine what knowledge or information will be needed by future users of the system. The information that is captured in the system should be relevant to the user, unambiguous, and delivered at the right time, to the right person, at the right place. These system-requirements might be effective in situations in which the need for information remains unchanged. Most organizations use IS that are based on this assumption, such as inventory systems, accounting systems and monitoring systems.

A lot of attention within the IS discipline has been given to the way of assessing information requirements as one of the first stages of the design of information system. During this stage, IS designers try to get an overall as well as a detailed picture of what information future users of an IS need. Surely, assessing the information needs is much easier in case activities and decisions are well structured, will not be confronted with significant changes, and of which its users have a clear and detailed picture of their information requirements. Over the years various techniques and methods have been designed to cope with these and other problems of information need assessment.

The problem of IS based on the principle of Certainty is that the information captured in the system is limited to information that, during the design, was perceived as relevant to its users. Information that might be relevant in the future is ignored because it does not fit the existing knowledge framework. Information systems can be seen as complex instruments of selection. Because both the structure and the content of the system are in principle pre-determined, such systems tend to stimulate only this particular perception of reality excluding other potential relevant fields of knowledge. Information systems act as walls, and the focus is on what they're walling in, ignoring what they've been walling out. It is a common tendency of information systems that they are "structured to view the world" (Walsham 1991), thereby enacting their future and the setting in which they operate.

Once (computerized) information systems are designed and implemented, they tend to freeze these pictures of the environment (Boogaard 1994). Hedberg and Johnson (1978) observe that information systems incline to thwart organizational scrutiny and filter away relevant uncertainty, diversity, and change indicators. All information systems contain an implicit model of the world which may become outdated.

Miller (1994) refers to so called Focussed information systems that institutionalize and routinize gaps in organizational intelligence: "Management information systems do not track the things managers believe to be unimportant or unchanging, but instead focus attention on what is thought to have mattered in the past.(..) Their information systems then fix upon this and ignore everything else.". Information captured in IS is often in line with existing goals, values and opinions, in other words with the identity of the organization (Huysman et al. 1995, van der Blonk et al 1997). Executive Information Systems for example are designed to reproduce the organizational identity by directing attention towards pre-determined elements in the environment. Vital information which is alien to the frame of reference of an organization is filtered out, or is reinterpreted or 'rationalized' so as to remove discrepancies.

Walsham (1991) provides an example from the Vietnam War taken from Halberstam (1972) to illustrate this self-referential functioning of information systems. Halberstam describes how the internal organization of the American intelligence gathering operation in

Vietnam was inadequately structured to cope with an understanding of the evolving conflict. "Senior decision makers in the American military and political hierarchy concentrated on the 'information' coming from the field rather than questioning, until it was too late, the adequacy of the information systems structure which was supplying their own self-referential view of the world" (Halberstam 1972, p. 91).

The problem of structured blindness has an interesting link with March' (1991) distinction between exploitation and exploration as two forms of organizational learning. Whereas exploitation is directed at learning of things already known, exploration focusses on the learning of things not yet known. Learning processes that focuss too much on exploitation may result in stability or even self-destruction as a result of structured blindness. On the other hand, learning processes that are too much focussed on exploration are likely to result in chaotic, uncontrollable sitations. All learning processes involve a trade-off between exploration and exploitation (March, 1991). Consequently, organizations should balance the occurance of exploitation versus exploration.

Because Certainty-related ISs capture information about the past and present with the purpose to reduce uncertainties, these systems support the exploitation-side of learning. While using Certainty-related IS, the evolution of organizations as a result of learning tend to be path dependent. Uncertainty-related IS to which we turn later, are used to support exploration in the sence that they enhance the search for the unknown.

3. Perspective of Uncertainty

If fixed structures lead to problems of rigidity, then we need to explore the character of systems with dynamic structures. And if predefined information leads to blindness, we need to explore ways of finding information that is not expected but turns out to be relevant. Not only the described problems which have to do with the Certainty style of thinking stress the need for a different perspective, but also different types of IS which we will discuss in this section, such as the Internet are in need of an alternative perspective. We will explore this perspective, Uncertainty, both from a theoretical side, and with exemplary systems from which we derive sensitizing ideas.

3.1 The systems dimension

A Certainty style of thinking is to be seen as one way of ordering and structuring reality which is in a constant state of flux and transformation. We have argued that precisely this dynamic nature of social reality is the reason why systems rooted in a perspective of Certainty portray problematic features. A radically different style of thinking sheds a very different light on common themes and shifts attention to new issues. This style of thinking, Uncertainty, does not focus on static structures (such as organizations or information systems) but on the processes that generate them. Whereas IS are often seen as solutions to problems in this perspective solutions to problems are problemized; organizations and information systems themselves are problemized instead of assuming their validity on the basis of a pre-existing order. The stability of IS, as well as their functioning, is precisely what needs to be explained: it is not systems that suffer from what has been termed the 'trauma of change' but it is the staticness of systems themselves which is highly remarkable, and thus needs problemizing.

Given the fluxing nature of organizational and social reality, from a perspective of Uncertainty IS should not be seen as structures but as processes of ordering and structuring. In postmodern organizational analysis (Cooper and Burrell 1988, Chia 1995) all forms of knowledge and discourse, including information systems and organizational structures, are seen as representations of an undetermined, fluxing and transforming reality. Such a representation is the (evolving) surface or appearance of a more fundamental underlying process of ordering and structuring social reality. Where in Certainty IS are seen as static entities, in Uncertainty they should be seen as processes that are never finished, never reach a state of rest, but are always changing. Whereas in a Certainty perspective IS support a stable organization, IS from an Uncertainty perspective support the process of organizing itself

not by imposing a static structure but by facilitating and enabling that very process itself. An IS based on a perspective of Uncertainty therefore can't be defined in terms of its structure or its goals.

It may seem to be difficult to think of a 'system' that is not a static entity, but a constantly changing process which structure is not fixed and static but rather dynamic. When trying to apply such a view to traditional IS, at first sight this seems to be nonsense. However, such a perspective may be very valuable to evaluate traditional IS because it makes transparent the process of ordering and the roles and intentions of the actors involved that has produced the eventual system. But let us first discuss some IS that embody (elements of) this Uncertainty style of thinking. Our discussion involves IS with dynamic, malleable structures, and interestingly they seem to overlap with systems that are (re)structured by the users themselves according to their own individual purposes.

The internet provides us with some challenging issues of structure, the most important that it seems to have no structure. At least not a general structure, and certainly not fixed. At the most one could argue that the technical protocol that is used for communication between computers of a very different type, or some moral codes of 'how to behave' on the internet are elements of some general structure. The structure, however, is different for each user and he or she is able to structure the internet him- or herself by selecting information that is relevant for his or her purposes. Search engines and lists of links to other 'relevant' sites may help the individual user to structure the internet, but certainly not in a determinative sense. From the viewpoint of the user the structure of the internet may become more stable when he or she develops routines or reportoires of behaviour for approaching the internet and searching for information. Maintaining lists of bookmarks give this structure a more fixed character.

The structure of the internet is not pre-determined, but it is fluxing. Its structure is the evolving result of many individual but not intentional efforts which can change and do change constantly. It is therefore difficult or even meaningless to search for a structure or something else that characterizes the internet. The term 'the internet' itself is highly misleading because it suggests a form of stability and unity which does not exist. Those who offer information (whether that is an academic department, an artist presenting her artwork or a terrorist group publishing their statements) have little control over who is being reached, and what is done with the information. That depends on other users, who use the information within their own structurings.

Besides internet, other interesting developments are taking place in a field called Computer-Supported Cooperative Work (CSCW). CSCW researchers study collaborative group processes and develop software (called groupware) to support these processes. Groupware takes communication structures rather than the information itself as the basic principle for building software. As an example, research is being done to enable a group of users to specify their own system, and change it whenever somebody feels the need to (de Moor 1996, 1997). The system aims to support a process of communication and interaction between a group of people. The outcome of this interaction can be defined, and redefined, by the users themselves, as well as they can (re)define their roles and responsibilities.

This approach to development of IS is based on three ideas (de Moor 1997) which are different from the conventional waterfall way of developing IS (as was discussed at the beginning of section 2). Firstly, the users themselves (instead of an authorized project team) in the sense that they determine the activities the system should support, and which technical tools they should use to achieve their goals. Secondly, the approach to development is evolutionary which means that the system gradually evolves, instead of evolutionist which is focussed on a logical development through several stages towards a clear end state (King and Kraemer 1984). And third, development is not driven by one dominant bird's eye view, but by multiple ants' eyes views which are knowledgeable about the inividual part of the system in which that particular user is involved in. The method presumes an egalitarian group of people who to some extent collaborate to produce something. Two examples of application of this system are the writing of a report on deforestation in British Columbia in Canada, and the

starting up of an electronic Law journal.

3.2 The information dimension

As mentioned, from a perspective of Certainty, IS are used that capture pre-determined information that is believed to be relevant for the user. Using these IS supports the exploitation of existing knowledge. Next to these Certainty-related IS, organizations and their members use information systems that support their need to gain knowledge about things that are not and cannot be known beforehand. They need systems that help them scan the environment for unknown or seemingly irrelevant knowledge. In case of Uncertainty, organizations and their members do not know what information is or will become relevant. Both types of IS's are valuable in itself, but using Certainty-related IS's to support exploration will be as problematic as using Uncertainty-related systems to support exploitation. Although both IS have their own purpose and are in itself important means to become informed, IS scholars draw their attention mainly to Certainty-related IS.

Whereas Certainty-related IS's are focussed on the outcome by presenting information that is believed to be relevant for its user, Uncertainty related IS's are used to support the process of searching for surprises by assuming that the relevance cannot be known beforehand. By exploring new avenues, users allow for information that may question their current knowledge. To put it differently, whereas the purpose of IS from the perspective of Certainty is to *increase certainty,* the essence of IS seen from the perspective of Uncertainty is to *increase* diversify without any striving for Certainty. Systems that support explorative ways of learning do not bother about the outcome. Rather, they are more focused on the process of learning in such a way as to extend the scope of information that might possibly be relevant in an organization's future and to stimulate coincidental "findings" or serendipity. Hence these alternative IS's consist of information that has not been thought of until it is gained, implying that one cannot specify the information requirements ex ante. IS's that support these requirements have been called Alien IS's (AIS) (Huysman et al 1995).

Although these ideas may sound as contradicting to mainstream assumptions within the IS literature, they are not totally absurd. In fact, libraries, as one of the oldest and most universal IS's are often based on these very information requirements (Heng and Koh forthcoming). Libraries consist of information sources whose relevance cannot completely be determined beforehand. In fact, the greater part of a library's inventory will never even be used at all. Librarians, in contrast to information managers, do not determine in detail the information requirements of potential users before they conclude whether an information source has relevance and thus should be incorporated or not. Therefore, libraries serve the purpose of providing a large reservoir of new knowledge most of which is irrelevant at the present but could be of relevance in the future.

Another important characteristic of libraries is that its use often leads to unexpected or serendipitous findings (Foskett 1984). Although a lot depends on the way the books are arranged as well as the pleasure the individual derives from visiting a library, browsing along the shelves and using cross-references provides knowledge one never had thought of or which has been forgotten: "Those who confine their interpretation of information to its narrowest sense of factual data seem to forget that browsing among the shelves of a good library provides a conspectus of any field of knowledge far wider than the compass of one individual mind, and offers a choice of approach and treatment which can lead to what W.I.B. Beveridge calls a 'eureka situation"' (Foskett 1984, p. 53).

The image of a library as an IS provides us with two central features of AIS's that support the search for surprises. First, Uncertainty-related IS's contain a large inventory of knowledge without the constraining issue of relevance. Secondly, these IS's provide the opportunity to encounter unexpected and serendipitous findings. This means that the supply of information should not be arranged too much so that it might result in Certainty-related IS's.

Besides libraries, we could think of various systems of information that organizations

and their members use in order to explore new knowledge. Networks of informers, story-tellers and gossipmongers for example are often consulted in situations in which we do not know what we might need to know. As March and Sevon (1988, p.436) wrote: "... idle talk is likely to be an attractive information system for many organizations and many individuals. It provides information in a timely and inexpensive way. The information may or may not turn out to be relevant in the long run, but future decisions are sufficiently unclear as to make such uncertainties characteristic of almost any information that is available"[1].

Mass-communication also serve as metaphors for Uncertainty-related IS. By reading newspapers and novels, by watching television and theaterplays, by attending conferences within other' disciplines and reading their journals, we gain knowledge that might be useful in the future. In fact, if we do not make use of these Uncertainty-related information systems, we might become certain about ones own field of expertise and skills, ignoring the possible value of alternative fields of knowledge.

Internet facilities and in specific the World Wide Web also provide possibilities for the support of exploration. The WWW is open by its very nature and has no predetermined goal. By surfing on the web, the user can learn from often unexpected knowledge. The use of internet, as with all other examples of Uncertainty-related IS given above, is almost opposite to the use of "traditional' decision support systems. In contrast to the information requirements of 'traditional' information systems the information provided by the internet and other Uncertainty-related IS:

- does not have to be correct. Multiple sources can even be contradictionary: Who is the judge?
- need not be unambiguous. The existence of various interpretations is not perceived as problematic;
- might be redundant. The existence of information that is recorded more than once is not a problem;
- does not have to be delivered to the right person at the right time. The relevance of the information is not determined beforehand.
- need not reduce uncertainty. The system is not based on pre-defined information-needs. In a way we could say that it *reduces* certainty in that it may allow for creative new insights that disrupt the existing beliefs and theories in use.
- need not be linear. Information is presented in a more unstructured way, which may stiumlate serendipitous findings.

4. Further research

This paper is the result of a thought-structuring effort and further research is needed to theoretically ground this perspective of Uncertainty on the design and use of IS. Further, more attention should be given to the practical consequences for systems design and technical feasability of these ideas of Uncertainty. To demonstrate the value of this perspective more empirical work should be presented in which existing IS and IS design projects are described and analyzed using the Uncertainty perspective. Efforts in this line of thinking are currently being made with a descriptive case study on the introduction of a standarized software package in an organization that is going through a phase of reorganization, and the construction of an IS explicitly based on principles which are at the heart of Uncertainty.

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