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ABSTRACT

This paper investigates the concept of information. It follows different approaches for defining information before discussing a knowledge-in-action view on information as part of sociomaterial practices. Drawing from Stamper's (1991) extended semiological framework the paper proposes its reinterpretation to study information as a sociomaterial phenomenon. The paper further argues that rather than focusing on finding general definitions for information, intellectual efforts should concentrate on characteristics and attributes of information. Combining earlier efforts in this direction different attributes of information such as novelty, time dependence, or goal relevance. are introduced. Locating those attributes within Stamper's extended semiological framework helps to identify different aspects of sociomaterial context affecting information. Understanding and paying attention to information through its attributes can, therefore, provide guidance for researching information and possibly help advancing the development of information systems.

Keywords

Information, information attribute, semiotics, pragmatics, sociomateriality, information systems

INTRODUCTION

Information is arguably a central concept in the field of information systems (IS). It has become widely understood that IS produce and disseminate information. To do so they acquire, record, store, transmit and process data. But this is rarely that simple. Take for instance enterprise resource planning systems like *SAP*, or Web search engines like *Google* or social networking sites like *Facebook*. The information these systems provide are of different nature and may not be seen to have much in common. While information is a fundamental concept for understanding, defining and developing IS, it has not attracted much attention by IS researchers. The questions such as what is understood by information, what is the nature of information and what are (desirable) characteristics of information are rarely debated in IS research.

Importantly information is a concept of interest to many other disciplines, including information science, information management, marketing, knowledge management, communication studies, and philosophy. A range of views of information have been suggested for different purposes. Arguably diversity in understandings leads to different research approaches towards information. One view of information is seeing information within an hierarchical ensemble stretching from data to information to knowledge (Ackoff, 1989). This view of information as processed data is prevalent within IS research (Introna, 1997; Mingers, 1995). However, it has been criticized, for example, for failing on general assumptions underlining a hierarchical relationship (Fricke, 2009) and for seeing information as a purely objective construct (Mingers, 1995). This paper introduces a *knowledge in action* view on information (Kuhlen, 1991) within a context of sociomaterial practices (Barad, 2007) which allows a particular understanding of attributes of information. The attributes are identified and classified based on Stamper's (1991) semiological framework which is the most comprehensive semiological framework to study information. In addition to syntax, semantics and pragmatics, he adds empirics, the social world and the physical world as three additional layers in his semiological framework.

After a brief review of different views on information this paper shifts the focus from the question of how to define information to the question of what constitutes information in sociomaterial practices. It will therefore explore different attributes of information. that can be used for researching information and advancing IS. By drawing on and reinterpreting Stamper's extended semiological framework of information we examine relevant attributes of information at specific layers of sociomaterial practices. It is proposed that better understanding of information attributes, for example, 'physical layout' at the physical layer or 'novelty', 'time dependency' or 'goal relevance' at the pragmatic layer, will enable greater sensitivity to sociomaterial practices of IS use and deeper insights into continuously emergent user-IS interaction (Truex et al. 1999).

CONCEPTUALIZING INFORMATION

Discussions on information range from defining information as physical property existing independently from humans to information being entirely socially constructed. For instance, Norbert Wiener defined information as a physical property in his work on cybernetics: "Information is information, not matter or energy" (Wiener, 1961:132), a notion that can also be found in more recent works (Seife, 2006). More precisely, Wiener defines information as the degree of organization of a system: "The amount of information in a system is a measure of its degree of organization" (Wiener, 1961:11). Other conceptions of information as a physical property also often relate information to 'entropy' and measures of chaos (see e.g. Stonier 1990).

Other views on information have adopted a more constructivist perspective, seeing it as an inherently subjective phenomenon, as recently discussed in information science by Hjørland (2007) and Bates (2006). According to this perspective information is something which happens within an individual. This resonates, for example, with Pratt's (1978) view of information as 'inward forming' of an individual, or Brookes' (1980) definition of information as changed knowledge structure.

As these different views seem irreconcilable it has been proposed that finding a unified and comprehensive definition or concept of information is impossible (Pratt, 1978; Wersig, 1997; Henrichs, 2004). While others have tried by applying abstract definitions, for example, by describing information as 'release mechanism' (Karpatschhof, 2000) or as the 'output of a process' (Losee, 1997). Whereas such abstract definitions may apply in a wide variety of circumstances they provide little guidance for those who are interested in concrete instances of information.

In IS research and computer science information is typically defined in relation to data and knowledge. Information is seen as some form of processed or contextualized data (e.g. Ahituv & Neumann, 1990; Davis & Olson, 1985; Laudon & Laudon, 1996), often arranged in a hierarchical fashion where data is a prerequisite for information which in turn is a prerequisite for knowledge (Ackoff, 1989). Ackoff emphasizes the structural differences between data and information but insists they are not functional. Papers criticizing this view are, for example, Fricke (2009) who pointed out problems with basic assumptions underlining a hierarchical view or Mingers (1995) who criticized it for the implicit assumption of information being objective.

In this paper a different understanding of information is adopted called the 'knowledge-in-action' perspective on information (Kuhlen, 1991, 2004). In contrast to the hierarchical view of data-information-knowledge discussed above the knowledge-in-action view of information sees information not as prerequisite for knowledge but as a specific subset of knowledge. It is important to stress here that only what is understood by an individual can become information to an individual. Yet at the moment an individual understands a message it will be integrated into the individual's knowledge, no matter how volatile this knowledge might be. Information is seen as the subset of knowledge that is relevant to someone in a particular context at a particular time. Faced by a problem a specific subset of knowledge will help people to deal with it, to make decisions, etc. whereas a lack of information can block further action. Because of its action enabling character the knowledge-in-action view on information has been affiliated with Habermas' theory of communicative action (Wersig, 1997; Habermas, 1984).

According to the knowledge-in-action view of information, information is context dependent and can vary from individual to individual as different individuals have different experiences, interpretive abilities and goals at different times. Whether a text, a message, a graph or a figure is information depends on a sociomaterial context in which people work, perceive and interpret them and act or perform based on them. There is no information outside of sociomaterial practices and people's knowing and doing that constitute these practices.

This view of information has consequences for the view of IS. In this regard an IS is not a system dealing with information as such, rather it is a system that helps people derive information from its output and become informed. For example, a management IS helps managers analyze a situation and make informed decisions rather than being a system storing management related information. In other words, IS outputs (reports, tables, etc.) can potentially become information for particular users in a given situation.

Most current IS are not paying attention to the specific individual needs of users, but see generic classes of users with similar needs. The success of future IS, like Web 2.0 applications will depend on the level to which they will be able to adjust themselves to the needs of individual users. How can an IS be adjusted to meet specific information needs of individuals working with them? – is an open question. Given that information needs change an information system needs to change and adapt as long as it is used (Truex et al., 1999). While in this paper we are not aiming to answer this particular question we are proposing that a study of the nature of information might help exploring potentially innovative answers. We therefore aim to identify different attributes of information understood as knowledge-in-action.

DESCRIBING INFORMATION

For a better understanding of what is meant by information we can look at attributes or characteristics different authors have ascribed to information. One way for identifying attributes of information is to look at the usage of the term 'information'. Wittgenstein (1953) suggested to undertake 'depth grammar analysis' of the usage of words. In contrast to ordinary or surface grammar analysis undertaken by linguists depth grammar analysis aims to uncover principles underlying the use of language. This can be done by identifying sentences which despite being grammatically correct are senseless, or by placing a word in different language contexts to see how it changes its meaning (Blair, 2006).

Looking at different sentences containing the word 'information' can be used to identify different attributes related to information. Furthermore, a comparison to the terms 'data' or 'knowledge' can be achieved by exchanging these terms in sentences. For example, compare the following sentences:

This is not information I already know it.

This is not knowledge I already know it.

This is not data I already know it.

While the first sentence makes sense the other two are senseless, therefore, failing depth grammar analysis. This example reveals that information in contrast to data and knowledge is associated with novelty. An extensive analysis of information using this method was undertaken by Kuhlen (1991, 2004). In addition, Goguen (1997), Introna (1997), Machlup (1983), and Meadow and Yuan (1997) also provide lists of attributes and characteristics related to information. Combining the efforts made by all these authors a list of attributes of information can be compiled. Furthermore, as attributes of information manifest themselves empirically they have practical use for guiding research on IS. To identify attributes of information relevant for knowledge-in-action view we discuss and reinterpret Stamper's (1991) extended semiological framework.

STAMPERS EXTENDED SEMIOTIC FRAMEWORK

The classic semiotics (Morris, 1946) distinguishes three different levels of communication: *syntax*, *semantic* and *pragmatic*. Syntax is concerned with the rules and principles for constructing sentences in natural or artificial languages. Semantics is concerned with how different syntactic structures relate to meaning. For example, the word order in sentences, 'man bites dog' versus 'dog bites man'. And lastly pragmatics is concerned with larger structures and the purpose those structures fulfill in human communication. For example, language games for giving orders or disobeying them. Stamper observed that in this framework the ability to distinguish different characters at the syntactic level is already taken for granted. Therefore, Stamper (1991) argued that a fourth level which he called 'empirics' precedes the syntactic level (Figure 1).

Empirics is concerned with the ability to distinguish different signs with a high level of reliability, a problem so called 'information theory' (Shannon & Weaver, 1949) is concerned with. When we are looking at syntactic problems we already assume that signs can be distinguished and that '1' is different from '0'. In contrast 'information theory' is concerned with the reliable transmission of bits, providing a measure for ensuring that the difference between '0' and '1' can be transmitted from sender to recipient. The question of what a bit or a specific sequence of bits stands for is of no concern to 'information theory'.

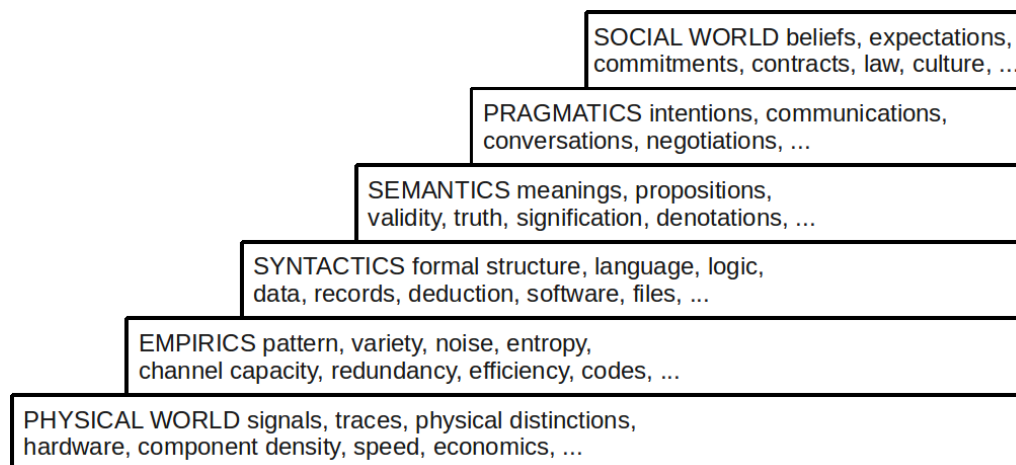


Figure 1: Stamper's semiological framework (adapted from Stamper, 1991)

In addition to empirics Stamper (1991) also introduces the 'physical world' (Figure 1). The physical world is the world where all empiric phenomena take place. It, therefore, precedes 'empirics'. The physical world involves material entities and flows which are seen or recorded as signals or signs captured at the empirics level. On the other end of the model, Stamper (1991) added the social world which is created and shaped through language games taking place at the pragmatic level of semiotics. For example, different languages and cultures allow different conceptualizations of the world.

Stamper's model (1991) made an important contribution to understanding both the physical and social dimensions of information. He pointed out the connection between material flows, physical recordings and transmission of signals on the one hand and the meanings of these signals and their value in a particular context for human actors and their social worlds on the other hand. This model of information, while by far the most comprehensive, assumes ontological separability of the physical/material and the syntactic/semantic/pragmatic/social layers. It is consistent with dominant views in the broader IS and information science literature that assumes separation between the material and the discursive, the non-human and human, nature and culture. An alternative sociomaterial approach (Barad, 2007; Orlikowski and Scott, 2008) is critical of and rejects the assumptions of their separate existence and provides an opportunity to revise the concept of information and Stamper's framework by assuming inseparability of the physical and the social layers of information.

ATTRIBUTES OF INFORMATION IN A SOCIOMATERIAL FRAMEWORK

The sociomaterial view of information, we suggest, assumes that the nature of information (unlike data) is both physical/material and semantic/discursive. The physical/material side of information refers to information production via particular media such as IT, paper, or voice. In the context of IS the material aspect of information refers to technologies, tools, and techniques for capturing, recording, storing and processing of data so as to produce outputs that become information within actors' sociomaterial practices (e.g. designing an accounting IS that generates accounting reports for managers or designing crawling algorithm for Google searches for public use). These mechanisms of output (that have a potential to become information) can be called *apparatuses* in Barad's (2007) sense. Importantly apparatuses involve both discursive practices that specify a particular content and structure of data to be collected and stored and the way they are processed (e.g. algorithms) together with material configurations of data capturing, recording, processing and presenting (e.g. IT infrastructure, database physical and logical structures, interface design). Apparatuses of IS determine the production of information; when interpreted and used the IS output becomes information embedded in users' particular sociomaterial practices.

Stamper's model (Figure 1) can be usefully reinterpreted within the sociomaterial perspective on information. Instead of separate layers we assume a continuum from the physical/empirics to the pragmatics/social. Information as a sociomaterial

PHYSICAL WORLD LAYER	
physical existence	- information needs a physical carrier
EMPIRIC LAYER	
detectability	- information has to be distinguishable from background noise
SYNTACTIC LAYER	
apprehensible	- representation of information needs to be understood by recipients
SEMANTIC LAYER	
comprehensibility	- information needs to be comprehensible for a recipient
level of detail	- too much or too little detail can hinder information
PRAGMATIC LAYER	
novelty	- information has a novelty character
goal relevance	- information is useful for achieving goals and making decisions
value	- information is valuable to a recipient
time dependency	- temporal context affects the informational character of messages
contingency	- whether something is information or not depends on prior events
SOCIAL WORLD LAYER	
cultural dependency	- cultural context can affect interpretation of messages
subject domain	- domain specific context assumes different knowledge prerequisites
specificity or depth	- required specificity depends on user's sociomaterial practices
matter of trust	- users' trust towards a source affects information

Figure 2: Attributes of information at different sociomaterial layers

phenomenon appears at multiple layers along this continuum with some specific characteristics or attributes associated with each. Attributes closer to the physical world are more closely associated with technical solutions and media of transmission, processing and presentation. Whereas attributes closer to social world are focusing on information use and their action enabling features in users' practices. In Figure 2 we list different attributes of information that are related to sociomaterial layers. Note here that these attributes are defined assuming integrative nature of the layers. All layers and the attributes are relevant for knowledge-in-action view of information as part of sociomaterial practices of users.

Physical attribute of information

The physical layer refers to physical aspects underlying information: data recording, transmitting, storing, and processing, as well as presentation and consumption by human beings. For example the invention of paper as carrier of text (data) significantly changed human information behavior as well as data storage systems it made possible (Wright, 2007). The invention of the printing press, the telegraph and later silicon based transistors made possible the construction of sophisticated and complex data manipulation apparatuses and ways of data arrangement and presentation that dramatically affected the role and importance of information in business and everyday life. We can conclude that the physical aspects of apparatuses underpin all other layers of information as a sociomaterial phenomenon.

Physical existence underpins information. This does not mean that information is merely a physical phenomenon, but that it is bound to a physical carrier. This could be sound waves, marks on a paper or electric signals in a data processing apparatus. Also the mere existence of a physical signal does not constitute information, but what constitutes information is bound to some form of physicality. As the examples above underlines extended ability to use and manipulate the physical world will enable different and possibly new ways for dealing with potential information. Take computer or video screens, and textual or graphical presentations (e.g. on a screen or a paper) which can be more or less suited for human users performing tasks in a particular context. A user may have preferences or limitations in terms of the physical layout of technological tools and designs. For instance the design and position of a control panel, screens and forms of presentation in an air-traffic control room has huge implications for air-traffic controllers' performance.

Empiric attribute of information

Detectability means that information has to be distinguishable from background noise. While it is dependent on a physical existence, information detectability depends of information transmission and sociomaterial apparatuses of information production. If a message or signal cannot be recognized as such it cannot contain information. As already discussed above the ability to distinguish signals is the concern of so called 'information theory'. It is important to note that therefore the term 'information theory' is misleading (Capurro & Hjørland, 2003). It implies a general approach towards information, while it is only concerned with the transmission of distinguishable signals between a sender and a receiver. However, reliable transfer or a signal does not indicate that the signal helped a recipient in a particular context to solve a particular problem or for making a particular decision. Therefore, while successful transmission is a necessary condition for information, successful transmission it not a sufficient condition for information. A successful transmission of a signal does not mean that what was transmitted was information for the recipient.

In information systems design detectability plays, for example, a role in the creation of ergonomic interfaces. High contrast levels or good color combinations can facilitate detectability. A hidden function in an IS that a user is not aware of is not likely to be used. If a user interface contains red and green contrast for distinguishing different options, say saving or discarding a change, it might undermine detectability of the difference for some groups of users being color blind.

Syntactic attributes of information

Apprehensible at the syntactic level refers to the fact that information has to be represented in a form that follows syntactic rules and principles understandable to a recipient. If the syntax of a text, table, figure or other form of representation is not understood by a recipient a message cannot convey information. Even though '八三六九' and '8369' are representing the same sequence of numbers the ability of both of them for conveying information may differ between individuals. This does not mean that any syntactic representation that can be understood by a recipient must also be information for that recipient. But for a message to be potentially informative it needs to be presented using a syntax understood by the recipient.

Apprehensibility is not only related to syntax of natural languages.. In case of a spreadsheet model, a user needs to understand and be able to check the rules and calculations in the fields of a spreadsheet. As this example shows apprehensible representation is necessary for comprehension – an attribute of information at the semiotic layer.

Semantic attributes of information

Comprehensibility. At the semantic level information has to be comprehensible for a recipient (Meadow & Yuan, 1997). A message has to be integrated into a recipients' knowledge in order to become information for them. Only something that is comprehended by a recipient can be information for them. If something is described in a way that it is not understandable by a particular recipient it cannot be information for them. For example, complex sentence structures in a textual report or complex interface design can hinder something from being informative. In the information quality literature this attribute of information is described as 'interpretable' or 'easy to understand' (Lee et al., 2002)

Level of detail is another attribute of information at the semantic level. Information has to be balanced between too little and too much detail. IS should be designed in a way to give a high enough level of detail while not overwhelming users. When necessary a user should be able to go deeper into more detailed information or request additional information. Adaptable systems should consider this attribute of information by providing users with an overview while allowing to probe deeper where desired.

Pragmatic attributes of information

Novelty character of information. As was mentioned above, a central attribute of information is novelty (for example, Capurro & Hjørland, 2003; Kuhlen, 1991, 2004; Machlup, 1983; Meadow & Yuan, 1997). Something that is already known by an individual cannot be considered information. For this reason in most cases redundant display of the same message will not be useful to an individual. If a system displays the same error message over and over again, the users will not become more informed about the problem but possibly more frustrated. Regarding the development of advanced IS, systems should keep track of different information displayed to the users, avoiding redundancy information and possibly highlighting new aspects, trends, links and facts as the user comes across them.

It is important to mention that in some cases the novelty aspect of information is not essential. In special cases when a message contains information that an individual already knows the message may still be informative by confirming what one knows. In other words, the message increases the degree of trust in something one knows. In this case instead of conveying new knowledge information helps to reassure or verify something one already knows. Despite the content not being novel, it may still convey information as it is coming from different sources. This approach is, for example, used by journalists to confirm information or by academics for cross validating evidence towards particular phenomena.

Goal relevance is another central attribute of information. Most authors stress that information has the characteristic of 'being useful' (Machlup, 1983), 'relevant' (Introna, 1997) or 'having an effect on action and decisions' (Kuhlen, 1991, 2004; Meadow & Yuan, 1997). This characteristic of information was succinctly described by Bateson (1972:459) as "a difference which makes a difference". As a result, a central characteristic of IS is that they provide information that help their users to make informed decisions by making sense of particular situations. Something which only can be achieved if what is provided by the IS has relevance for the users goals.

Value to a recipient is a further attribute of information (Feeney & Grievies, 1994; Introna, 1997). The attribute of value has been defined narrowly as instructional value (Meadow & Yuan, 1997) and economic value (Kuhlen, 1991, 2004; Meadow & Yuan, 1997). Instructional value helps people or organizations to reach decisions and to come up with solutions for problems; while economic value will help them to make profit or to avoid costs. In cases where information is considered being of economic value the 'value' of information can be assessed. A question economics is concerned with when talking about 'perfect information' (Sengupta, 1993). In contrast, the instructional value of information usually cannot be easily assessed. Information may also have other than economic value. Information shared among friends in social networking sites may be valuable for building relations with community ('social capital') or for mobilization for action (e.g. youth activism).

Time dependence as attribute of information has been highlighted by a number of authors (Goguen, 1997; Kuhlen, 1991; Meadow & Yuan, 1997). Something might only be information at a particular point in time, while being irrelevant at some other time. Most obviously this could be, for example, course critical information released by a stock company. Whereas knowledge about mergers and acquisition will be highly relevant to shareholders when they are announced, their informational character will rapidly decline. One feature of advanced IS could be that they take time into consideration. Users could be notified about critical information; or systems could prefer some recent events over older ones when they are considered being more important.

Contingency of information is related to time dependency (Goguen, 1997). In contrast to time dependency, contingency of information stresses that if something is information or not is depending on previous events. While something is not considered to be information, it might become information after certain incidents. If one drives by a hardware store on the way to work every day, knowledge about the store's existence and proximity to home cannot be considered information. The

day the main fuse of the house burns out, just before some friends come over for dinner, the informational character of this knowledge might change rapidly. Referring to an advanced email system one would not give preference to a message by an unknown sender. However, if this email triggered further messages by other 'important contacts' it might be relevant to display this message before the ones send by known contacts.

Attributes of Information and the Social World

Cultural dependency refers to the fact that information depends on the cultural context in which it occurs. Requirements towards information may change depending on cultural settings. Cultural dependency can range from more narrow understanding of culture like organizational culture to wider understanding associated, for example, with different countries or regions. One example for how culture can affect information is the level of openness of a cultural setting. In some cultural settings knowledge destabilizing the current status, questioning current practices and approaches might be welcomed. Whereas, in other settings such knowledge might be less welcomed or even discouraged. Goguen (1997) calls this the emergent character of information.

Subject domain dependency. Meadow and Yuan (1997) have pointed out the subject domain as another attribute of information. The social world of different subject domains place different requirements on information. This is reflected, for example, in different levels of detail of available vocabulary in different subject domains. Whereas low level of distinctions towards a particular phenomena is sufficient in one subject domain much more detailed vocabulary for the same phenomena is needed in another. IS, therefore, have to consider the industry or potential user groups they are developed for. Systems stretching across different subject domains could be advanced, for example, by adjusting their interface according to the different domains rather than the functions needed in particular contexts. Depending on the domain the same functionality might be represented in different ways.

Specificity and depth is another social attribute of information (Meadow & Yuan, 1997). Specificity or depth of information depend on the social context. While some situations demand highly specific information, in other situations the same request may require a more general response. When fast response is necessary succinct short information may be required over long and detailed explanations, for example, a fire alarm. Accordingly requirements towards specificity and depth of information depend on the situational context. Advanced IS should consider the situation in which they are used and adjust the level of detail accordingly. A drug IS for a hospital would, therefore, adjust the specificity of information on a particular drug differently when used in the emergency room, on the ward or by a doctor diagnosing a patient.

Matter of trust. Information is also a matter of trust towards the source and the apparatuses used in its production. Information typically refers to states of affairs in the objective world, legitimacy in the social world and truthfulness or sincerity in relation to the subjective world (Habermas, 1981). In relation to the objective world – defined as the world in which we claim something exists or is the case – information can be true or false. In the social world – defined as our shared world of values and norms – information can be wrong or right, and legitimate or illegitimate. Information from an individual, referring to his/her subjective world, can be judged as truthfully or sincerely expressed or not. The plausibility – correctness, legitimacy and truthfulness – of a piece of information for a recipient depends on the perceived reliability of a source or sender (Meadow & Yuan, 1997; Kuhlen, 2004). Depending on where particular knowledge came from it might either be considered irrelevant or information. One example for the source influencing trust towards information is people's preferences towards different websites. Websites judged to be more trustworthy than others might be considered as better sources of information than others. Trust as an attribute of information is important in the development of complex and distributed information systems as it will affect the use of the system. Trust has to be seen as a dynamic attribute – it can change by facilitating social networks between users for establishing trust towards particular information.

CONCLUSION

This paper introduced different conceptualizations of information before arguing for a knowledge in action view of information. According to this viewpoint information is a particular subset of knowledge that allows recipients to act. This view acknowledges that not everything that is known by an individual is relevant or useful in a particular context and thus constitutes information. Knowledge in itself is not sufficient if it cannot enable action, for instance, to approximate solutions for problems or for making decisions. Furthermore, it argues that for something to be informative it needs to be integrated into the knowledge structure of an individual first. Something that is not understood by an individual and cannot become part of an individual's knowledge about the world cannot become information for them. It is important to note that knowledge about the world can be volatile and non permanent. This view of information has consequences for the view of IS. In this regard an IS is not a system dealing with information as such, rather it is a system that helps people to become informed. This understanding of information is then investigated within a sociomaterial framework employing Stamper's (1991) extended

semiotic framework.

Using Stamper's framework the sociomaterial nature of information was highlighted. According to this viewpoint information is both a physical and a interpretive/social phenomenon. Information has to have a physical carrier in order to be communicated to human beings and interpreted in sociomaterial contexts. The sociomaterial nature of information is reflected by its attributes stretching through all layers in Stamper's extended semiotic framework. It is thus argued that how information helps people to become informed can be investigated through attributes of information. These attributes stretch from 'lower' semiotic layers to 'higher' semiotic layers. Attributes at lower semiotic layers are, for example, *understandable representation* or *comprehensibility*. At higher semiotic levels attributes are, for instance, *novelty*, *cultural dependency* or *trust towards a source*.

Attributes at lower semiotic layers can be more readily addressed by IS than attributes at higher semiotic levels. For a system to correctly anticipate what is new to a user and therefore more likely to be information is something more difficult to achieve than an understandable representation of content. However, for IS it will become increasingly important to consider attributes at higher semiotic layers. This will allow to further advance personalized outputs from IS. For example, advanced search engines will be able to give varying set of results to different people typing in identical queries. The paper, therefore, also discussed how attributes of information can be used for advancing IS.

It is important to note that attributes of information are not entirely independent and can influence each other. Understandable representation at the syntactic level is affected by the social world. For example, depending on the cultural context understandable representation of items would mean arranging them from left to right or right to left. Another example is chronological order which depending on the cultural context is better expressed from left to right or top to bottom.

It should also be noted that the notion of information as something reducing uncertainty mentioned, for example, by Machlup (1983) seems to be a red herring when looking for attributes of information. It is possible in some cases, that information may actually increase the uncertainty of an addressee (Kuhlen, 2004). The ability of information to question the current state and to destabilize existing structures can be important, for example, to allow flexible adaption in a changing environment (Romm, 1997). In such circumstances promoting uncertainty will actually be an important quality of information. However, as Kuhlen (1991, 2004) mentioned recipients might decide to block new information if it contradicts their current views and plans. For example, tobacco companies managed to block knowledge about health consequences of smoking for many years.

Looking at information through its attributes allows us to address the phenomenon of information more concretely than by applying abstract definitions. Whereas describing information as 'output of a process' (Losee, 1997), 'inward forming' (Pratt, 1978) or 'processed data' (Ackoff, 1989) little is gained for practically addressing information. By comparison, attributes of information allow us to dissect information into different aspects that can be observed empirically and therefore practically guide research and development of IS.

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