What is information? Towards a theory of information as objective and veridical

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Abstract

Information systems is a strong and ever-growing discipline of enormous relevance to today's informated world, and yet, as recent reviews have shown, there is still not an agreed and explicit conceptualization or definition of information. After an evaluative review of a range of theories of information, this paper develops and defends a particular theory, one that sees information as both objective and veridical. By objective, we mean that the information carried by signs and messages exists independently of its receivers or observers. The information carried by a sign exists even if the sign is not actually observed. By veridical, we mean that information must be true or correct in order to be information – information is truth-constituted. False information is not information, but misinformation or disinformation. The paper develops this theory and then discusses four contentious issues – information as objective rather than subjective; information as true or correct; information and knowledge; and information and the ambiguity of meaning. It concludes with a discussion of the practical implications of the theory.

Keywords: Information, information systems, syntactics, semantics, pragmatics, semiotics, truth

Introduction: the problem

"Where is the Life we have lost in living?
Where is the wisdom we have lost in knowledge?
Where is the knowledge we have lost in information?"

(And, one might add, Where is the information we have lost in data?)

T. S. Eliot, "The Rock", 1934

Information systems (IS) are primarily concerned with the generation, storage and transmission of information, generally by technological means[1]. As such, it would seem to be fundamental that it has a clear and agreed conceptualization of its core subject matter – namely "information" (Watson, 2014). Yet, we would claim, this is clearly not the case. As McKinney and Yoos (2010) point out, in a survey of the term information within information systems research:

> This is the IS predicament – using information as a ubiquitous label whose meaning is almost never specified. Virtually all the extant IS literature fails to explicitly specify meaning for the very label that identifies it (p. 329).

This would perhaps not matter if there was general agreement within the discipline about a definition of the term, but there is not. Again, as McKinney and Yoos's survey shows:

> IS research has yet to produce any theory on what information means, its scope or the *implications of its various definitions. IS has nominated a plethora of attributes … But there has* been little debate or dialogue to build a theoretical foundation for information (p. 329).

Another literature survey, by Furneaux and Wade (2011), examined different literature and yet found similar results. After surveying papers published in MIS Quarterly and Information Systems Research they concluded that:

> *"A significant portion of the work reported upon in the field's two leading journals over the past* eleven years has incorporated information only implicitly, by virtue of the presence of an IT

[1] Although IS as an academic field may have wider interests than just this IT tool perspective (Hevner, March, Park, & Ram, 2004; Orlikowski & Iacono, 2001)

> artifact. Those articles that have given explicit attention to information tend to be primarily *interested in the process of information sharing."* (p. 11)

We believe that these surveys are sufficient evidence for our first two claims: that there is no clear and accepted definition of information and that there is very little discussion of this in the literature. Rather, a variety of different, generally implicit, conceptions are in play. It is interesting to note that in one of the most rigorous attempts to define fundamental concepts – the deep structure model of Wand and Weber (1990, 1995) – 28 concepts are defined but information is not one of them.

But, it could be argued that this is in fact no bad thing; that IS is such a wide-ranging and multi-faceted discipline that it is neither possible nor desirable for there to be a single, unified conception of information that could be applied throughout IS, let alone other disciplines.

So, should IS concern itself with the nature of information? We put forward several arguments as to why it should. First, we believe that any academic discipline should, as a matter of principle, do all it can to clarify and define its basic concepts. It seems perverse at the least to demand rigorous research methodology, rigorous literature reviews and rigorous reviewing procedures whilst the same fundamental terms are being used with quite different, and un-explicated, meanings. We very much agree with Lee (2014, pp. 350) when he says:

> *"In our academic discipline of info*rmation systems, there are key concepts that lack agreed-upon definitions (and sometimes even any definitions), or for which the existence of any definitions *seems to make no difference. They include such bedrock concepts as 'information' …. The irony* is t*hat we information systems researchers … insist upon precision in the terminology appearing in our research papers".*

Second, the reviews discussed above saw users and the use of IT systems as being of prime importance along with the IT artifact. Whilst, of course, the IT artifact is of importance, for the users of IS it is merely a mechanism for storing and transmitting what is really important, namely information. Users are not

interested, per se, in IT devices or IS platforms; rather they are interested in what these artifacts can provide for them. The whole *raison d'etre* of an IT artifact is to provide the information that users need, in a timely and efficient manner, and in a way that is easily accessible. Surely, IS will do that more effectively if it has a clear understanding of exactly what information is?

And, indeed, in disciplines outside IS from cognate ones such as library and information science (LIS) and computer science to far removed ones such as philosophy, biology and even physics, there is considerable discussion, debate and development on the nature of information. See for example: Ibekwe-SanJuan and Dousa (2014) Theories of Information, Communication and Knowledge; a special issue of Triple C (11, 1, 2013); special issues of Synthese (175, 2010 and 167, 2009) (a philosophy journal); and a special issue of Information Research (15, 4, 2010). There is now a newly created field called the philosophy of information (L. Floridi, 2002). New concepts such as the "infosphere" and "information ethics" are being developed (Ess, 2014). One of the major figures in the area is the philosopher Luciano Floridi (2002; 2004; 2009a, 2009c, 2011), but his work is rarely referenced in IS papers (some exceptions being Chatterjee (2013), Stahl (2007) and Chatterjee (2009)).

We have provided a review of a range of currently existing information theories, many developed outside of IS in fields such as information science and computing. Because this review is quite extensive, and we wish to focus on the main theory development part of the paper, we have put this review in Appendix A. This section includes an evaluation of these theories and highlights several areas of debate. We can summarize the main issues from the review as follows:

- Should we in fact aim to have a single definition of information or is it so multi-faceted that it is better to simply allow researchers to use it as they wish[2]?

[2] A view that was put by reviewers of this paper

- What is the ontological status of information - what exactly is it - a thing, a concept, a relation, a meaning?
- Is it objective, existing independently of observers or receivers, or is it subjective, created in the mind of observers on receipt of a message? If the latter, then do ICTs, books or newspapers actually contain any information or is it just data?
- Can there be "environmental information", that is signs within the environment that carry information without the involvement of humans?
- Does information have to be true to be information (a veridical version) as Dretske and Floridi maintain? If not do we really want to say that false messages are information?
- Does an information theory distinguish clearly between the related concepts of data, information, knowledge and meaning?
- What about the problem of the inevitable ambiguity of meaning in human communication?

In the first section of the paper, we develop our theory of information as objective and veridical, drawing on but developing beyond existing theories. In the second section we discuss how our theory deals with four of the contentious issues – information as true, information as objective, information and knowledge, and the ambiguity of human communication. Finally, we show the practical advantages of our theory within information systems.

Proposal for a conceptualization of information as veridical and objective

Based on the issues discussed above, the information theory we propose will see information as objective and veridical, but it will recognize the subjective effects of information on receivers through the idea of import, which is essentially a form of meaning. It will recognize the difficulties of determining the truth or correctness of information but nevertheless maintain that data carries[3] information that is true even if we do not recognize it as such. The theory will go beyond semantics to the pragmatic use of information.

[3] We generally uses terms like "carry", "convey" or "transmit" synonymously. Data or a message will have a meaning but the information lies in the relationship between the meaning and that which the meaning is about.

We should also note that the theory is pitched at the level of general human natural language communication rather than being restricted to more formal IT languages and databases. This is because information systems have now developed beyond such administrative tools to "digital infrastructures" (Tilson, Lyytinen, & Sørensen, 2010) which are now the basic enablers of human communication and social activity. We are also following other calls for a general theory of information.

Basic definitions

The theory begins with the idea of simple marks, differences or distinctions (Spencer-Brown, 1972), for, as Bateson (1973a) said, a bit of information is a "difference that makes a difference". It will then move up to the level of full human communicative action.

Events[4] that occur in the world make a difference to it, and the difference can be taken as a mark or token of the event. Information, at its most general, is the relationship between a token, sign or message and the event(s) that caused it. Information must ultimately be manifest in physical differences. For humans these will be accessible through the senses (sight, sound, taste, touch, smell) but there are differences, and therefore information, that exists in ranges beyond our senses, for example, high or low sounds, infra-red or ultra-violet light. This leads to the following basic definitions:

- **Differences** are marks or tokens or signs, including sounds, tastes and smells, potentially not perceptible to humans, that are caused by some event (for example, electric currents).
- **Data** is a collection of signs, derived from differences, put together for a purpose. If it is well-formed and correct (for example, a series of digits or letters) it may carry information. Data tends to be quantitative. More general terms are sign, message or text (J. Mingers & Willcocks, 2014, 2017). Well-formed data may be meaningful, that is it may propositionally represent some

[4] An event has two essential components – a duration, with a start and finish, and a change to something. Events are nothing other than the changes that occur to and within mechanisms and structures (J. Mingers, 2014, Ch 5).

external state of affairs, and as such it is truth-bearing, i.e., it may be true or false (for example company accounts may represent the state of affairs of the company truthfully or not).

- **Information** is the true or veridical propositional content of signs. It is that which could be inferred about states of affairs given that the sign has occurred, but could not be without the sign. (e.g. the true state of a company's finances rather than perhaps those presented for Enron (Rockness & Rockness, 2005)).

Let us consider some formal definitions. Dretske gives this:

> "A signal r carries the information that s is F iff the conditional probability of s's being F, given r (and k, the prior knowledge of the observer) is 1 (but given k alone is less than 1)" (Dretske, 1981, p. 57)

This means that, for example, a petrol gauge carries the information that the car is half full for an observer with appropriate knowledge of cars and gauges (and also assuming that the gauge is working correctly) if the observer can be certain that it is half full with the gauge, but less than certain without it.

This is quite a formalistic definition and Dretske also limits it to de re knowledge, that is largely perceptual knowledge of things for particular observers. It does not include the idea of signs carrying information even if they are not observed, and it does not include information within social communication. We are expanding the definition of information to cover that which is not ever accessed by observers.

Floridi (2009c) give a more general definition:

σ is an instance of information, understood as semantic content, iff:

- σ consists of data;
- the data are well-formed syntactically (wfd);
- the wfd are meaningful
- the meaningful content is true.

This suggest that information is identical to data that is well-formed, meaningful and true, thus apparently making it objective although Floridi is not wholly clear as to whether it is meaningful in itself or meaningful for somebody, which is the essential question. He does remain somewhat ambiguous over the exact ontological status of information (J. Mingers, 2013). He also recognizes the possibility of environmental information but it is not encompassed within this definition. Again, we go beyond Floridi in recognizing the existence of environmental information, or even human-produced information that is not ever accessed.

We would propose the following which generalizes the definition to include both environmental information and pragmatic information within a social context.

- Information is the propositional content of signs. It is what must be the case in the world for the sign to exist as and when it does. Signs carry information whether or not they are observed. Environmental signs may carry information.
- The information they carry must, by its nature, be true or correct. Information is truth-constituted[5], i.e., it is only information if it is true. Information has other relevant characteristics such as timeliness, completeness, comprehensibility and relevance but none of these are important if the supposed information is in fact false.
- A sign that is false, e.g., mistaken, does not carry the information it would appear to, but still does carry information concerning the actual reasons for its occurrence.
- In the case of human communication, the signs must be:
    - Syntactically well-formed, semantically meaningful and comprehensible within an appropriate linguistic system
    - Pragmatically correct in terms of truthfulness and social norms.

[5] This is different from truth-bearing. Data is truth bearing in that truth is a predicate that can be applied to it, but it may be true or false. Truth-constituted means that the meaning of the data must actually be true to be information.

- The information that is available for a particular observer depends on the prior knowledge of the observer. If the observer does not know the code or language the sign may carry no information for that observer.

- **Import** is the meaning for, or effect on, a receiver of a particular dataset or message. It depends on the receiver's knowledge and state of mind at the time. Thus, information is objective while import is subjective. For us, import is the same as the subjective information of Checkland or Luhmann.

Philosophical underpinning – critical realism

This view of information can be philosophically underpinned by critical realism (CR) (Bhaskar, 1978; J. Mingers, 2004)[6]. One of the fundamental distinctions within CR is that between the intransitive and transitive domains of science. These are not different forms or types of science, but different aspects. The intransitive domain consists of the actual objects or structures that we hope to gain knowledge of. These objects may be physical, conceptual or mental. They exist independently of our knowledge of them and in this sense are objective. Their properties and behaviors affect us when we observe and interact with them. The transitive domain is the domain of human knowledge and scientific activity. This is the actual process of science which produces knowledge. It is subjective or intersubjective as it depends on human thought and activity. Even so, the products of this transitive activity - theories, talks, papers, grants etc – can become intransitive once they have emerged; they too can become the objects of discussion and research.

A similar distinction can be applied to information. Information is intransitive – it is that which is carried by signs and messages even if it is never observed or received. On the other hand, meaning or import is transitive, being the subjective experiences, beliefs and actions generated by our interaction with

[6] Although it is independent of it. One could hold an objective view of information from a positivist stance, or even from a weak interpretive stance if one accepts some degree of ontological reality and the possibility of true or false statements about it.

information. So, there is not intransitive and transitive information, rather information is always intransitive, existing independently of human producers or consumers. When people interact with the signs and messages they can extract some or all of the information through their perceptual and neural systems, but it them becomes import or meaning and exists in the transitive domain.

Characteristics at different semiotic levels

From this simple starting point in physical differences, we now show how each of the semiotic levels brings in new relations of possibility and complexity to the notion of information. These are summarized in Table 1 where we also point out at each level what might prevent the signal or sign from carrying information or being informative. To be clear, it is not that there are different kinds of information; there is only one kind of information – the true propositional content of signs or messages - but information is realized or carried by different kinds of signs, from very simple ones such as footprints or knocks to very complex ones like full human communication and these have effects on both what infprmation can be carried and how it can be accessed.

Levels of information			**Reasons for it not to be information**		
Form	**Dimension**	**Example**	**Problem**	**Example**	**Name**
Differences, marks, tokens, e.g., indexical signs	Environmental / physical	Tree rings, cloud chamber tracks, animal tracks, door knock, geological strata	No difference or causal relation	Randomly generated differences, hard disc wiped clean	Void or blank
Signs involving some form of coding, eg iconic signs	Syntactic	Maps, icons, instruments, graphs and charts, pictures	Not well-formed	Pdf file with wrong coding	Garbage
Signs that are purely symbolic	Semantics	Natural and artificial languages, websites, databases	Well-formed but not meaningful or untrue	"Green dreams sleep furiously" Computer output from test data	Gibberish or mis-information
Speech acts, conversations, communications	Pragmatics	Questions, commands, requests, commitments	WFD, meaningful and true but not sincere or appropriate	Lies, deviance	Dis-information

Table 1 Levels of information and reasons that they may not be informative

We begin with events in the material world that occur[7] and leave traces in the form of physical differences. These traces may be short-lasting (particles in a cloud chamber) or long-lasting (rock strata). The information they carry may be obvious, for example, a paw print, or may require huge amounts of money and knowledge to acquire, for example, the discovery of the Higgs Boson. These traces or tokens can be false and therefore not carry the information they would appear to, for example false trails or decoy ducks. For there to be no information the differences must be erased or must be random although even random events can carry a certain amount of information. For example, in World War 2 the pattern of V1 rocket landings was analyzed and found to be random which carried the information that the V1's did not have guidance systems. They do not constitute data in themselves but data can be created from them. For example, tree rings themselves are not data but measurements of them are.

At the syntactic level, signs have a degree of conventionality or coding but still retain a connection to their referents. For example, thermometers and instruments generally, maps, icons (including computer icons), graphs and charts or clocks. The relationship is generally one of similarity or contiguity (metaphor or metonymy) (Lakoff & Johnson, 1980). To be able to carry information they must be well-formed syntactically (wfd). Consider a map. At the time of its construction it will carry a large amount of (analog) information concerning the physical location it is a map of. Different maps will carry different information (for example, a tourist map vs. an Ordinance Survey) and will differ in their scale. They carry information because of the causal processes of production that have generated them with this purpose in mind. Over many years, the amount of information will diminish, not because the map is changing, but because the territory is. This shows clearly the difference between information and data. The data in the map remains the same because it is simply a characteristic of the map, but the amount of data that is

[7] We follow critical realism in separating the domain of actual events from the domain of the generative mechanisms that cause them (J. Mingers, 2004)

correct will reduce and so will its information content. The meaning or import of the map for a person will depend on two things, their intention in using it and their knowledge of maps. Examples where information may not be carried are a map that has been colored wrongly or a pdf file that has the wrong font generated and is unintelligible.

At the semantic level, we reach sign systems that are fully symbolic and disconnected from their referents in the sense that there is no direct link through resemblance or causality. Signs are connected to their signifieds through the sign system embodied in habits of thought and action (Peirce, 1958, 1.409). Examples are natural and artificial languages, websites or databases query languages. This is the level at which meaning becomes of primary concern because of the arbitrary nature of the signifiers which have to acquire and maintain their meanings within complex social processes (J. Mingers & Willcocks, 2014, 2017). Meaning, in general, has two dimensions – sense (intension) and reference (extension) (Frege, 1952) – what the term connotes in relation to other terms, and what it denotes as objects or entities. To convey information, a message must be meaningful both in its individual terms and as a whole. The example in Table 1 shows a sentence in which each word is meaningful and it is grammatically correct yet it is not meaningful as a whole.

At this level the whole issue of the ambiguity of meaning, to be discussed below, comes to the fore. This cannot be avoided, and it does not mean that information cannot be communicated, but it does make it likely that some degree of mis-communication or misunderstanding is very common. There must be a coherence or consistency between the intentions of the producer of the message, the conventional meaning of the message, and the import or interpretation of the receiver. This requires an already existing, high degree of commonality between the cognitive states of the producers and receivers. We can model the process of conversion of information into import and then action in three stages:

At the first stage, the basic or conventional meaning of the signal/message is understood. This is very much an unconscious process carried out routinely by the body and nervous systems – embodied

cognition (Merleau-Ponty, 1963; J. Mingers, 2001; Varela, 1991). It is equivalent to Peirce's immediate interpretant (Peirce, 1958, 2.28). In general, competent speakers of a language or users of an information system should all acquire roughly the same understanding. At the second stage, again largely embodied, the individual receivers will add to that information the particular knowledge, intentions and concerns that they as individuals have generating the particular import of the information for them (Peirce's dynamic interpretant (Peirce, 1958 #1949, 4.536)). Finally, the meaning and understanding generated will lead to a potential action (for example, a verbal response, or an activity) or, indeed, no action (Peirce's final interpretant). This can also be seen in stages – the intention will be formulated into some form of linguistic response, and this will then be embodied into an utterance, an action, or perhaps interaction with a device.

At the pragmatic level, we bring in information about more than just the propositional content of the message. Speech acts also carry information about the sincerity and emotionality of the speaker, and also the social or normative rightness of the speech act and its content. Speech acts are of many types, not just giving or requesting information (Austin, 1962; Searle, 1969) but also giving commands, making commitments and enacting formalities. Habermas (1987) argues that a speech act makes four implicit validity claims that can, if necessary, be challenged by an interlocutor and which then need to be justified. The first is truth, i.e., that the propositional content is in fact correct, which is the Dretske (1981) dimension of information. The other three are comprehensibility, sincerity and rightness. Comprehensibility implies that the speech act (usually but not necessarily linguistic – it could for example be gestural or pictorial) is comprehensible to a competent speaker of the language. This is similar to Floridi's (2004) criteria of data being well-formed and meaningful. Sincerity relates to the attitude of the speaker – are they being honest and truthful? Does the speech act genuinely reflect their beliefs and intentions? Or are they behaving dishonestly? Rightness refers to social norms – are the behavioral norms implied by the speech act in fact valid and agreed or are they contentious or not appropriate? With this extended framework, a speech act provides information about not only about factual matters but also

about the intentions of the speaker or originator of the communication, and the appropriate social practices and expectations. A good example is the customer reviews of hotels on Tripadvisor. This has become extremely important when customers decide where to stay but is it really information? We would have to question not only its factual content but also the sincerity of the reviewer and the cultural expectations that they apply.

We do not see the social level as another type of information; hence it is not included in Table 1. Rather, we see social and cultural systems as both enabling and constraining the flow of information (Mutch, 1999). On the one hand, it is only through structures of meaning at the social level, which we all share, that it is possible for us to communicate at all as semiology has demonstrated (de Saussure, 1960 ; J. Mingers & Willcocks, 2014; Peirce, 1907). On the other, it is clear that information has value and generates power and therefore it is continually the subject of forces that try to limit or channel it in particular directions. This is beyond the scope of the paper but for a range of theoretical views on this see Webster's (2014) Theories of the Information Society.

We can summarize our overall conception of information as one that leads us to see information systems as part of the wider human world of meaning processing through communications as shown in Figure 1. As explained above, the term "meaning" has several different references – the intentions of the information producer, the import for the information receiver, the signification of the information itself, and the connotations of the wider social system.

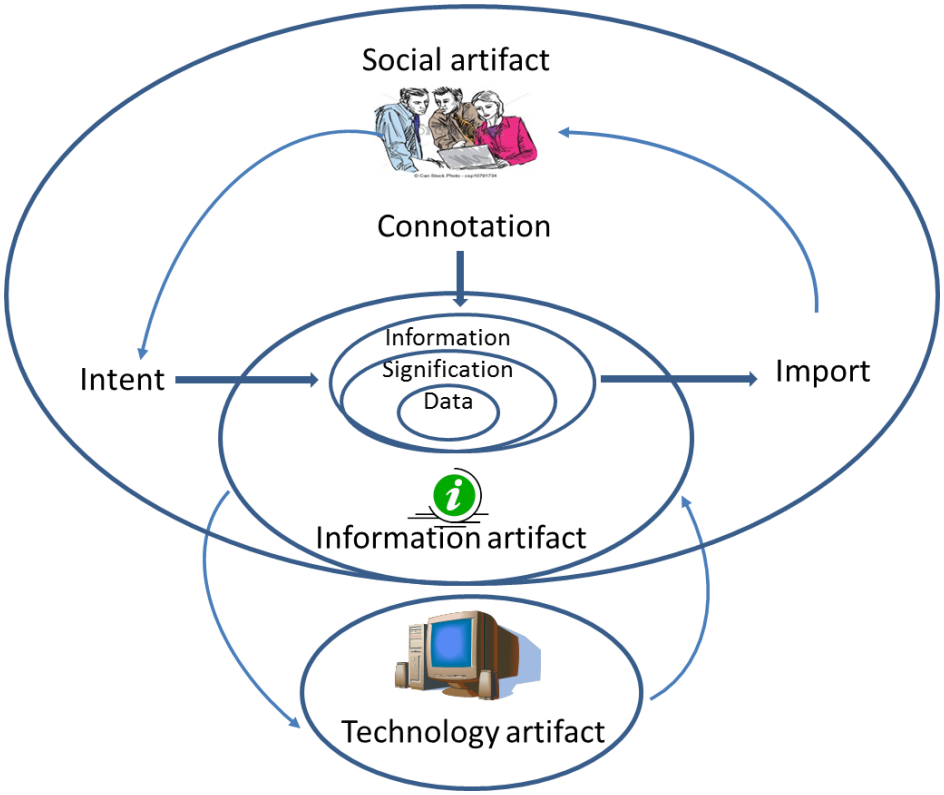

Figure 1 The IT artifact showing the information system (information artifact) as part of a wider meaning system (social artifact)

Here we use Lee's breakdown of the IT artifact into three subsystems – the technology artifact, the information artifact and the social artifact. The information artifact consists of information which is itself true, meaningful (signification) data. This is generated by people with some intention, and is interpreted by people generating in them some import which then leads to further communicative actions. The social artifact provides the conditions for action and consequences of action in a process of continual structuration (Jones & Karsten, 2008; Allen S Lee & Hovorka, 2015). This includes the systems of meanings (connotations) that are necessary for data to have semantic content.

Conceptual issues and implications for a theory of objective information

In the previous section we developed a conceptualization of information that is clear and well-defined, broadly applicable and consistent with normal conceptions of information systems. In this section we will discuss in more detail four of the important questions that have arisen from the review above. Answering these questions fleshes out the theory that we are proposing. The questions are: is information objective or subjective? Must information be true to be information? What is the relation between information and knowledge? What about the problem of the inevitable ambiguity of meaning in human communication?

Information as objective or subjective

The theories reviewed in Section 1 differ in many ways, but we feel that the most significant divergence is the ontological one as to whether information is fundamentally objective, existing even if it is not received or observed, or subjective, only coming into existence when data or a message is interpreted by the mind of a receiver. Dretske, Floridi and Mingers argue for the former; MacKay, Luhmann, Checkland and Hofkirchner for the latter. In this paper we argue that information is objective whilst accepting that the same information may well have different meanings or import for different receivers. In other words, where the subjectivists call the effects of data on individual receivers "information", we call that "meaning" or "import". For us, information generates meaning; for them, meaning generates information. There are several reasons why we put it this way round.

First, if information is to be a purely subjective phenomena, only occurring in the minds of observers, then it means that what we take to be repositories of information – books, newspapers, timetables, websites and above all information systems – cannot contain or process information but only data. When we talk and communicate with each other we can never pass on information since it is not information until it is received, and then it may not be what we intended to transmit. Nothing can contain or carry

information until it is interpreted by a human, so the Rosetta Stone had no information until it was translated, tree rings do not carry information until someone looks at them, and I was not informed about train times by the National Rail website.

Second, the subjective view implies that information could not have existed at all before human beings came into existence, and cannot exist elsewhere in the universe. To argue this is to commit what Bhaskar (1978) calls the epistemic fallacy – that is, to judge or limit the existence or being of something by our own, fallible, human knowledge of it. On the other hand, it seems reasonable that the term "meaning" should be human-centric. Objects and events have meaning or significance for us, as human beings. In times or regions where there are no humans, there may be no meaning but there is still information being transmitted about the events that are occurring.

Third, information has causal effect whether or not humans are involved and if it can be shown that something has causal efficacy then that is an argument for its existence. In the animal world many signs and markers affect behavior, not because of what they are in themselves but because of what they imply or signify, i.e., what information they carry.

McKinney and Yoos (2010) present a powerful argument for the subjective view (that they call the adaptation view) as being the difference that is made to a cognizing system by differences in its environment. We agree with much that they say about the subjective nature of our interactions with technological systems, but we have a fundamental disagreement that these subjective responses should be called information. The problem begins with their first description of the adaptation view:

> The adaptation view requires an ontological paradigm shift, from the belief that there is an objective reality independent of perception, to the recognition that reality is subject to perception (p. 336).

We are being presented here with a false dichotomy – it is not "either/or" but "both/and". There is indeed an independent, causally efficacious world that existed before human beings and will carry on after them;

but it is also the case that our experience and knowledge of it is inevitable mediated by our perceptual and cultural filters. Knowledge is always local and temporal. So, we accept that there are differences in the environment, and there are differences in the interacting system. The question is which should be called "information"? For all the reasons given above, we argue that the external differences are information, and the internal ones are meaning or import.

However, we need to distinguish the ontological question of the nature of information, from the epistemological question of our human access to it. In this regard, the type and nature of the information that is actually available to a receiver does indeed depend on the properties of that receiver. Do they understand the code or language (syntax)? Can they interpret the meaning (semantics)? Do they understand the relevance and implications (pragmatics)? And, what further information can they generate given what they already know? This makes information a liminal concept rather like food – we understand what food is in general, but what counts as food in a particular context depends on what organism we are interested in. What is food for us may be poison for another animal. What is information for one may be meaningless for another, but that does not mean the information does not exist.

Information as true or correct

The question here is, does information have to be true to be information as Dretske (1981), Floridi (2004) and Mingers (2013) maintain? Insisting that information has to be true is a very strong assumption not least because of the difficulty of defining and discovering truth (Colburn, 2000; Fetzer, 2004). There are, in fact, two sides to the question: i) why is it a good idea to insist that information is semantically meaningful data that is also true? And ii) what might we mean by truth and how might we discover it? We will begin with i) as there is little point in debating theories of truth for no good reason.

The basic argument in favor of this is fairly obvious –there can be an infinite number of statements about states of affairs in the world (including people and their mental states) that are syntactically well-formed and are semantically meaningful (can be understood by competent users of the sign system). Would we

wish to call all of these "information" even if they are in fact false? Would we wish to say we have been "informed" about something if it is not actually the case? The website informs us that there is a train to London at 10.00 but when we get there we discover it is a mistake. The room booking system says the lecture room is free but when we arrive it is not. Surely it is better to use distinctions that already exist and call these examples of misinformation and being misinformed, or even disinformation where it is deliberate, and reserve information for that which is actually correct. False information is not information any more than a false friend is a friend or fake Rolex is a Rolex no matter how much it looks like one. Thus, information is propositional content that is true; misinformation is propositional content that is false but unintentionally; and disinformation is propositional content that is false on purpose (Alter, 2006)

But, following Dretske and Floridi, the argument is stronger than simply a preference for terms. It is that signs carry information about their causal origin – what, given the occurrence of the sign, must be the case – whether or not it is observed or correctly interpreted. This is a version of the physicalist, causal theory of truth proposed by Field (1972). This is relatively easy to accept in the physical examples that Dretske tends to use – instruments, clocks, tree rings – because there are direct physical connections. But what about more general cases such as data in IS or human communications? Consider the 10.00 train. There must still be a set of causal links that have led to this data being in the system, involving people and other computer systems, which would be traceable back to the actual reality of trains, stations and times. If the data is false, it could be for two different reasons. First, just a mistake – the wrong number was keyed in – in which case it still carries information, not about the train but about the reason for the mistake. Second, it could be that there was supposed to be a train at 10.00 but it broke down or was delayed. Here, we can say that the data was actually correct, and therefore information, but some other system intervened. This is very common and is explicitly recognized within critical realism where causal powers may be exercised but not be realized because of the operation of other systems.

In fact, we can say that semantic information is not simply a truth-bearer but is truth-constituted (Luciano Floridi, 2011). What we mean by this is that if we have some data that is syntactically well-formed and

semantically meaningful, which could be a proposition or some other symbolic artefact such as images on a website, then, if it makes some assertion as to how things are it may be true for false – it is a truth-bearer and, in the terminology of philosophy, there must be some truth-maker that can potentially make it true (Horwich, 1991). But this is not yet semantic information – it only becomes information if it is in fact true. As with knowledge, it is constituted by being true, not merely capable of being true.

One argument against the truth assumption is that we can never discover with certainty what is true or correct. Even critical realism maintains a fallibilist view of knowledge, that we can never prove a theory or belief beyond doubt. Thus we would never be able to determine absolutely if something was indeed information. A related argument is that we can never make a statement with absolute precision so that it can never be absolutely true, and thus there could never be information if it has to be absolutely true. Similarly, Fricke (2009) argues that inductive inferences such as "most rattlesnakes are dangerous" cannot be said to be 100% true.

Considering the first argument, we essentially accept it but would distinguish between defining information and warranting a particular piece of information. In other words, information is that which is correct, and much of the time we do indeed transmit information but, if we had to prove the correctness or truth of a particular piece of information, it might not be possible to do it. This situation is analogous to that of knowledge which is generally defined as justified, true, belief. Most philosophers would accept that we cannot prove, beyond doubt, that a particular belief or theory is true.

The second objection is quite serious as it threatens to undermine even the definition of information. Again, we would accept the basic argument that all statements are likely to have a degree of imprecision about them – even the most precise physical measurements have error limits[8]. So, we have to say that correctness, and therefore information, will always be relative to certain limits. For example, an

[8] Even discrete counting cannot be perfect – how would we know that there really were "nine million bicycles in Beijing" to quote a Katie Melua song?

instrument such as a petrol gauge shows the amount of fuel in the tank perhaps to the nearest liter but still provides information if it is working correctly[9]. If we were told there is a train "about 10.00" we might consider that correct if it was actually between 9.50 and 10.10, but not if it was 10.30. What this shows is that information is always relative to a level of precision or detail, what Floridi (2008) calls a "level of abstraction".

Another objection, from Fetzer (2004), is that some kinds of meaningful data cannot be true or false, examples being blood spots, photographs or tree rings. This seems simply to confuse the data with its propositional content. It is not the data in itself that is true or false, but what propositions or inferences may be derived from it about its cause. The blood spot at a crime scene provides (true) information about who shed it and when. How much of that information can be extracted depends, of course, on the technology and is growing all the time with DNA analysis. Indeed, DNA can now provide us with information about human population movements hundreds of thousands of years ago. The information has always been there, it is only now becoming available. Fetzer also raises the issue of propositions whose truth we cannot (at the moment, and perhaps ever) ascertain such as "There is life elsewhere in the universe". However, this objection conflates ontology with epistemology (Sequoiah-Grayson, 2007). Ontologically, the sentence counts as information iff there is indeed life elsewhere and its truth-status is already, in a sense, determined. This is separate from the epistemological question of whether we humans will ever discover the answer.

It is necessary to discuss theories of truth briefly[10]. We should distinguish between theories of truth and criteria for truth. Theories of truth state what truth is; criteria of truth concern deciding if a belief or proposition is, in fact, true. The most common theory of truth is the correspondence theory, developed by Russell (1910) and Tarski (1944), although originally stated clearly by Aristotle: "to say of what is that it

[9] If it is not working properly then it does not transmit information even if, by coincidence, it happened to display the correct reading.

[10] For a current authoritative discussion see the Stanford Encyclopedia of Philosophy entry (Glanzberg, 2014), and also other works such as Lynch (2001)

is, or of what is not that it is not, is true" (Metaphysics 7.27). Thus, truth is a relation of correspondence between a belief, proposition or sentence (truth bearer) and the states of affairs to which it refers (truth maker). The problem is that (Kuukkanen, 2007) we do not have direct access to reality to determine whether particular propositions do in fact correspond. This has led to a range of alternative theories, or perhaps criteria, for truth (J. Mingers, 2008), the most prominent being coherence theory (truth is a matter of the coherence of a proposition with other well-attested theories or beliefs); consensus theory (truth is what is accepted by a community of researchers); and pragmatist theory (truth is that which emerges at the end of enquiry) (Lynch, 2001). In our approach, we take a realist, correspondence view of the nature of truth although we recognize the difficulties of ascertaining whether, in a particular instance, a proposition is true, and is thus information. However, it would in principle be possible to utilize some other truth theory as a way of assessing the validity of some semantic content.

In fact we would prefer to use the criteria of "correctness" rather than truth since it is more general[11] and perhaps less contentious than the term truth. It also leads to practical possibilities of testing semantic information (Luciano Floridi, 2011). At the pragmatic level we are concerned with information in a practical situation of use by enactive and embodied agents rather than a passive, purely epistemological interest. Here, it is information that allows us to interact successfully and this only to the extent that the information is correct. That is, to put it formally following Floridi (2009b), we can regard some putative semantic information as providing a model m of some aspect of a system or situation s. The model can be expressed in the form of a question together with an appropriate yes/no answer. Then, the information is correct if accessing m (i.e., receiving the information) enables the receiver to also successfully access the situation, s.

[11] In philosophy, truth is usually taken as some form of correspondence between a proposition and states of the world, and generally concerns synthetic (empirical) rather than analytic (definitional) statements. But we would like to include analytic statements such as "a square has four equal sides" which can be correct or incorrect, or indeed other modalities such as fictional truth, future truth, moral truth or negative truth. For a defense of truth as semantic correctness see (Horgan, 2001).

To summarize, the actual information transmitted is always that which is correct but it may be difficult in a particular case to prove unequivocally that it is so. And, information always has a degree of imprecision about it and correctness can only be judged relative to those limits.

Information and its relation to knowledge

Implicit in much of the discussion of information is the data, information, knowledge hierarchy (Rowley, 2007) – the view that data generates information and information generates knowledge - but this approach is much too simplistic. As Tuomi (1999) points out, we could also reverse the hierarchy. In order to be able to interpret and understand events and messages as information, we need to have a good deal of knowledge. We need to know the language or symbol system, and we need to know quite about the context or domain, for example, one could not gain any information from a profit and loss account without a lot of knowledge of business, economics, accounting and so on. Equally, especially in the IS world, when one creates a system one needs to know what information is required in order to design the data collection and data formatting requirements. In other words, in actuality we begin from knowledge and then proceed to information and data.

We accept Tuomi's argument and envisage a complex and mutually dependent relationship between information and knowledge. Information, as well-formed, meaningful and true data, can indeed generate knowledge of certain types, and under certain circumstances. In terms of types of knowledge, Mingers (2008) identifies four – propositional (know that), performative (know how), experiential (know of) and epistemic (know that and why). Of these, information may be upgraded to propositional and epistemic but not performative or experiential since information, on our account, is essentially propositional.

In terms of the conditions under which information, more precisely "being informed that", can convert into knowledge, or "knowing that", Floridi (2012; 2014) argues that it is not sufficient for a person to be informed, i.e., simply hold the information, that p is the case. One also needs to be aware of or understand the information, and the information needs to be justified and not merely chance. The first point seems

valid – a messenger may carry an encrypted or sealed message, or a computer may contain or transmit information, but if they do not understand the message or information they cannot be said to know it. They may carry the information that p, but they do not know it. The second point seems more contentious. It suggests that in order to "know that" something is the case, one needs to have the information that it is the case; to understand that information; and also be able to give some account of why it is the case.

Moving in the opposite direction, then it is clear that we do need knowledge in order to be able to access information, and the knowledge we have conditions both the amount and nature of information that is available to us.

Information and the ambiguity of meaning

When we move from simple situations such as physical events or facts in databases to consider full human communication, it soon becomes clear that there are huge amounts of potential ambiguity in the meaning of a speech act. Given that meaning is necessary for, but not the same as, information this ambiguity may well affect the information available in messages.

In order to be clear we will consider a simple message from A to B like "I did not see him at the meeting yesterday" (AB). First, we need to follow Mackay (1969) and distinguish between at least three different meanings attached to this message: the intended meaning of the sender (intent), the meaning generated in the receiver (import), and the conventional meaning of the message (intension and extension). Now, theoretically for us to be able to say that (true) information has been transmitted from A to B it would be necessary that all three meanings coincided so that the receiver's import was indeed the sender's intent. Often, this is the case, especially with simple, direct communications or information in computer systems but equally it may not be and the import may be more, less or just different from the intent. Ambiguity is generated because meaning is underdetermined in a variety of ways. We will discuss three forms – levels or contexts of communication, indexicality and polysemy.

Semiotic Level	Function	Different Modalities at each Level that can affect Meaning
Empiric	Transmission	Speech, handwriting, gestures, printing, electronics (SMS, email, social media etc.)
Syntactic	Data representation	Binary, digital, figures, maps, diagrams, pictures
Semantic	Expression of meaning	Same thing said differently; tone of voice, body language, sub-text, emotion
Pragmatic	Purpose/effects	Illocutionary and perlocutionary effects, deception
Social	Context	Norms, functions, context, distortion, suppression, the media

Table 2 Levels of independence in communication

First, if we consider the implementation of a particular communication there are multiple choices at each of the semiotic levels and they can all potentially affect the meaning (Table 2). Messages may be transmitted in many ways: physically, virtually, electronically, and this will affect both the meaning of the message and the way it is received (Nellhaus, 2010). Consider for example the effects of being sacked or breaking up a relationship via text message rather than face-to-face. Syntactically, the same data can be represented using a variety of different coding systems, for instance if we look up a particular location in Google we could get physical coordinates, a map, a satellite photo, a street view or a description.

Semantically, we can say the same thing in a variety of ways which may have different connotations (see below). We can also modify the overt meaning by tone of voice or body language thus expressing emotion. This is one of the well-known problems of text or email messages which led to the development of emoticons (Daft & Lengel, 1986). Equally, what is not said may be a highly relevant part of the meaning (as mentioned above, absence can also be a source of information). For example, in the AB message, the sub-text could be "I wish I had seen him" or "He should have been there".

At the pragmatic level we are concerned with the intentions of the sender and the effects on the receiver of the message (Austin, 1962; Habermas, 1979; Searle, 1969). Is it to be interpreted as a question, an order, a request or just a description? Is the speaker being sincere or are they being strategic or deceptive? Finally, the social context of the communicative event sets the normative expectations for what is or is not

appropriate, or the way in which the communication may be interpreted. For example, an intimate health question would be inappropriate outside a clinical situation. An accusation of murder would mean different things in a court as opposed to a theatre[12].

Second, indexicality in this context refers to messages in real conversations that often use underdetermined terms such as "he" or "then" where the referent should be obvious from the prior conversation or the context. In the AB example you would only know who was not at the meeting from a previous message. This works fine where everyone involved is fully aware of the whole conversation but can cause misunderstanding when the term could refer to multiple people, or the recipient forgets or was not part of the conversation. This can happen in email trails only part of which gets copied to later recipients. It is an example of the more general view that language is always "situated" (Suchman, 1990), i.e., its meaning is always heavily dependent on its context.

Polysemy refers to the fact that signifiers, for example, words, often have multiple meanings which may or may not be related (Ravin & Leacock, 2000). Equally, the same signified (idea) may be expressed in different ways, each of which may have additional connotations. Some examples are: "I put on a light coat" could mean the coat was not heavy or not dark. "I was close to the bank" could refer to a financial institution or a river bank. Sometimes the ambiguity is not in a particular word, but in the sentence as a whole – for example, "they are flying planes", "time flies like an arrow, fruit flies like a banana" or the well-known book title, "Eats, Shoots & Leaves" (Truss, 2003). Often, the appropriate meaning can be determined from the context but, as with indexicality, it can sometimes simply remain indeterminate and is certainly one of the biggest problems with automatic language understanding.

What this shows is that full linguistic human communication is incredibly complex and is in continual danger of misunderstanding and miscommunication. Does this thereby undermine our conception of

[12] This is not confined to humans - experiments demonstrate that animals' communicative actions are also context dependent. For example, a recent study of male chickens (Smith & Zielinski, 2014) showed that they issued warnings about predators when females were present but did not in the presence of competitor males.

information as the true propositional content of meaningful data? We need to distinguish carefully between meaning and information. As Luhmann (1990b) says, humans are meaning processors. We exist in and with meaning and are continually generating and interpreting meanings. Generally, but not always, the meanings are successfully transmitted and, if the meanings are also true or correct, then information is transmitted as well. Ultimately, if meaning and information were not transmitted regularly then our very complex and interconnected society would simply break down.

Practical implications for IS theory and practice

The question here is: what difference does it make? How might IS, as both a practical and scholarly discipline, be different if the conception of information that we are proposing were accepted? The answer we would give is rather enigmatic –the difference is everything and yet nothing. It is nothing because our theory essentially fits in with the implicit view of information systems as was outlined in section 1 so there does not need to be any radical overhaul of IS as a discipline. But, it is everything because it has the potential to provide a coherent, consistent and explicit definition of some of IS's core concepts. As we saw in the introduction, information must be at the heart of information systems for researchers, designers and users. There would be no "information technology artifact", or even "IS artifact" (Allen S. Lee, Thomas, & Baskerville, 2015), without information to generate, store, represent and transmit; and information, or that which we call information, is central to our purposeful interactions within the world. So the question that we have pursued is, "what is this thing we call information that is so ubiquitous in our technologically-enabled daily life?" We have proposed an answer that we believe is clear and unambiguous but that also fits in with conventional usage – information processing, information systems, information technology, repositories of information, being informed, and informing people.

In terms of IS theories, we would suggest that our conceptualization provides an under-pinning for any theories that take information to be some form of adequate representation of states of real-world systems.

One of the main example of this type of theory is representation theory (Wand & Weber, 1990, 1995; Weber, 2003):

> *"[W]e became convinced that "representation" was the essence of all information systems. The raison d'etre for information systems was that* they tracked states and state changes in other *systems. ... we will establish a theory of the core of the information systems discipline ... if we* can articulate powerful, general theories to account for the characteristics of representations that *enable 'faithful' tracking of other systems" (p. viii)*

This theory has been extended more recently by, for example, Burton-Jones and Grange (2012) who use it to develop a theory of the effective use of IS including both semantic and pragmatic levels, and Strong and Volkoff (2010) who use it to better understand enterprise systems. This strand of theory stresses the necessity of the representations that information systems hold being "faithful" and surely the obvious thing is to say that an IS is faithful if its information is faithful which ties to the idea that information must be correct to be information. Thus, in one respect nothing changes, most of the ways that we have used the term are still perfectly valid. The taken-for-granted assumptions about information, which were made without a proper foundation, can now be seen to arise from a clear and well-defined conceptual basis which:

- Specifies that information, to be information, must be both correct and objective whilst recognizing that this can never be known with certainty in any particular instance.
- Articulates the relationship between information and meaning. Meaning is essentially the medium for the embodiment and transmission of information, but meaning (import) is also the interpretation that the information generates within the receiver.
- Recognizes the subjectivity and ambiguity of actual human interaction – information systems are but a part of the wider "meaning processing system" that is human communication.

In contrast, we argue that other approaches to a conceptualization of information have inherent flaws. The first approach is simply to allow several different, but presumably equally valid, concepts. An example of this is Lee et al (2015) who aim to produce a theory of the "IS artifact" as something wider than the IT artifact, constituted by an information artifact, a technology artifact and a social artifact. However, their definition of the information artifact simply echoes McKinney and Yoos (2010):

> *"With an information artifact, the function or goal in instantiating informa*tion can be (1) to *'process data', (2) to 'reduce entropy', (3) to 'form meaning' or (4) to 'achieve viability" (p. 8).*

Examples of these are given as: (1) numbers. Letters or symbols devoid of content; (2) relationships among numbers, letters or symbols, for example an equation; (3) accounting numbers that form meaning; and (4) a 'difference that makes a difference' (they just quote McKinney and Yoos' generic definition without creating an example, possibly because it is so abstract that it is difficult to come up with one). None of these seem to us very satisfactory. (1) What is the point of simply processing meaningless symbols, surely it does not constitute an information system? (2) Do we really have IS to 'reduce entropy? Relationships between symbols (syntax) are of course important but unless the symbols have some meaning can they be said to be useful or informative? (3) Forming meaning (semantics) is indeed central but would we wish to design IS artifacts for the purpose of disseminating false information? (4) Information will, of course, have effects on receiving systems but the effect will depend significantly on the structure of the receiver and so not be part of the IS artifact. Would not the whole concept of an IS artifact, with which we agree, be much more useful and robust with a single, well-defined and practical concept of information?

The second approach is a single, largely implicit, view of information as processed data. The problems with this approach are the lack of clarity and rigor in defining information initially, and then differentiating it from the other related terms such as meaning, data and knowledge. Many studies, especially quantitative ones, have "information" as one of their basic constructs. One would expect that if

such studies are properly rigorous then these constructs would be rigorously defined. Petter, Straub and Rai (2007) carried out a study into properly specifying formative constructs in IS research. In this, they highlighted what they considered to be research with properly specified constructs, including some that covered "information". Two such were Malhotra et al (2004) concerning information privacy and Wixom and Todd (2005) concerning user satisfaction with IS. In both studies the term information is used without any explanation or definition and, indeed, is used inter-changeably with the term data. For example, in Wixom and Todd we find:

> *"Completeness, ac*curacy, format and currency serve as antecedents to **information** quality, with *accuracy and completeness serving particularly important roles. … Timeliness was not found to* be an important antecedent belief in this context. Typically decisions based on data warehouse **data** *are strategic in nature".* (Wixom & Todd, 2005, p. 98).

This paper is a good example of Lee's point above – much of the paper is devoted to justifying the rigor of the methodology and the resulting statistical analysis but it is all based on ill-defined constructs. With a proper definition of information, we could distinguish between the correctness of data in terms of its syntax (does it conform to standards?), format (is it presented in the best way?), timeliness (is it up to date?) and completeness (is it all that is necessary?); the semantic correctness in terms of appropriateness (does it capture the right aspects of the situation?) and relevance (is it fit for purpose?); and the informational correctness (is it true and accurate?). There is little point in having relevant, timely and easily accessed data that is, in fact, false. Indeed, this is possibly worse than having no data as it gives a misleading view, witness all the accounting scandals in recent years (Rockness & Rockness, 2005).

In Malhotra et al we find:

> *"When applied to* **information** *privacy, SC theory suggests that a firm's collection of personally* identifiable **data** is perceived to be fair only when the consumer is granted control over the

> **information** *and the consumer is informed about the firm's intended use of the* **information***"* (Malhotra, et al., 2004, p. 338).

Again, it is vital to be clear about data, meaningful data, and information. Data are the result of, often complex, processes of production both physical (as in instruments recording data) and human (input, calculation etc.). Further processes of elaboration are applied to data to ensure that it is well-formed, meaningful and truthful in order to produce information and this involves issues such as privacy and transparency (Turilli & Floridi, 2009). What is important is that the production processes themselves are made open and transparent otherwise it will not be possible to tell if they have been carried out according to ethical principles – e.g., fairness, accountability, privacy and accuracy.

The third approach would be to adopt a subjectivist view of information. This would mean that information no longer exists as any kind of external "thing" (albeit not a physical thing) that can be stored, recorded or transmitted and can inform us about states of affairs in the world. All of the normal references to "information" would have to be replaced by "data", and "information systems" would return to "data processing". We had hoped to analyze some papers that adopted the subjective view but we have not been able to find any. As mentioned, McKinney' and Yoos' survey only found one paper in this category and it was actually Schultze's (2000) paper about confessional research methodology. Many other papers from an interpretive stance are actually about research methodology, i.e., researching the views and behaviors of IT users from an interpretive perspective rather than the users themselves holding an interpretive view of information. Schultze and Leidner (2002) reviewed four different discourses in knowledge management, one being interpretive. They identified an exemplar interpretive paper – Stenmark (2000-2001) – but on inspection whilst they had an interpretive view of knowledge as tacit their conception of information was very traditional. Similarly, Price et al (2008) wrote about developing a measurement instrument for subjective aspects of information quality but the subjectivity was very much in terms of the quality characteristics, information was taken as given. So, whilst there are theories of

subjective information there are no empirical studies of it based on those theories which perhaps shows that they are not of great practical relevance..

Conclusions

This paper has addressed the foundational issue of the nature of information by proposing a theory that information is both objective and veridical, and that the subjective interpretations or effects of information are actually meaning rather than information. It also reviewed four significant questions for any such theory: whether information was subjective or objective; whether information had to be true to be information; the relationship between information and knowledge; and the problems of the inherent ambiguity of meaning.

Although this paper has been wide-ranging, there is much that it has not been able to cover. In 2004, Floridi published a paper titled "Open Problems in the Philosophy of Information" (Luciano Floridi, 2004)[13]. In the paper he covered five main areas: analyzing the concept of information; semantics and information; artificial intelligence and information; information and nature; and values or ethics and information. Within these five areas he highlighted eighteen significant questions. Of these, we have touched on perhaps eight or nine in this paper: What is information? How is information produced? Is a grand unified theory of information possible? How can data acquire meaning? How can meaningful data be true? Can information explain truth? Can information explain meaning? What is the ontological status of information? Can there be environmental, i.e., non-human information? Many of the others are both interesting and of importance for information systems: Can cognition be analyzed in terms of information processing? Can intelligence be implemented non-biologically? Can information be audited only against other information? Is computer ethics simply ordinary ethics applied to ICT or does it have a unique grounding? We would like to think that IS researchers could make contributions to these debates.

[13] Crnkovic and Hofkirchner (2011) updated it in 2011

Perhaps the most important, in an age when our most personal and private information can be electronically harvested almost at will, are the questions about computer and information ethics.

Appendix A: A review of theories of information across disciplines

McKinney and Yoos (2010) surveyed 60 recent papers in IS but found that very few explicitly specified the conception of information that they were using. Nevertheless, they argued that there were four implicit views of information which they termed token, syntax, representation and adaptation. Of these, the token view was by far the most common occurring in 80% of the 60 papers[14]. They define this as:

> Information in the token view is synonymous with data: both refer to tokens manipulated by *processes. ... Information in the token view is an undifferentiated commodity of data bits that are* processed, not a particular relation among the bits (syntax), nor how a bit represents an object to an observer (representation), nor how a bit alters the system (adaptation) (p. 331).

Under this view, information cannot be distinguished from data, it is simply another word for data, and McKinney and Yoos suggest that it should not be used – computer systems that simply process data tokens should just be called data processing systems.

A similar view was expressed explicitly by Buckland (1991). He identified three uses of the term information – information-as-process, information-as-knowledge and information-as-thing. The first concerns the process of being informed that X is the case and thereby changing one's belief or knowledge. It is similar to McKinney and Yoos' interaction view. The second concerns that which one is informed about, that is, the fact, state of affairs, or event which is the subject of the information. This is equivalent to McKinney and Yoos' representation view. Finally, and the one that Buckland actually concentrates on, is the view that information is in fact the form in which the information is represented or expressed, such as a message, a sign, a text, a set of data or a picture. This corresponds to McKinney and Yoos' token view.

[14] Only one paper was classified as adaptation and that was Schultze's "confessional account of ethnography" (Schultze, 2000) which is hardly a conventional IS paper

Kettinger and Li (2010) suggest that there are three basic models of the relationship between data, information and knowledge. Model 1, the value-chain model, is the traditional view that data is facts about objects or events; information is processed data; and knowledge is information that can be generalized and applied in other contexts. This is equivalent to the token view. Model 2, the materialization model, reverses the hierarchy (Tuomi, 1999) suggesting that knowledge determines what information is needed, and then structured information specifies data to be collected. Model 3, the interactive model, is based on Langefors' (1980) infological equation which suggests that information is the interpretation of some data made by a person based on their pre-existing knowledge. This is similar to the adaptation view.

However, when we widen the scope of our review to include related disciplines we find many more information theories. It is clear that the term "information" can be used or applied across the whole spectrum of disciplines from physics to history (Robinson & Bawden, 2014)[15]. Indeed, it may be more pervasive or general than concepts such as matter and energy which are limited to physical systems. It is, therefore, an open question as to whether or not a single, very broad, definition of information could ever fit all these fields, or whether there needs in fact to be several, or many, definitions dependent on context. We shall not cover this debate specifically although we do support those who are trying to develop a genuinely transdisciplinary conceptualization of information such as Brier (2008), Floridi (2011), Beynon-Davies (2010) and Hofkirchner (2013). We would argue that, at the least, a theory should be broad enough to cover information systems and its cognate disciplines such as library and information science, computer science, AI, cybernetics, and business and management.

[15] For overviews that include other theories we have not been able to cover see: Mingers (1996), Bates (2010), Capurro and Hjørland (2003), Zins (2007) and Case (2012).

A structure for the review

In order to structure this review we will employ two major dimensions, although the theories differ in many other ways as well. The first dimension is the semiotic level (to be explained below) that the information theory primarily deals with – syntactic, semantic, pragmatic or social. The second is whether the theory conceptualizes information as objective or subjective. These two dimensions have been chosen because of their prevalence in the literature and also because of their significance. Díaz Nafría (2010) also uses these dimensions along with a third – disciplinary background – which we will not employ here, as do Kettinger and Li (2010) to be discussed below. McKinney and Yoos' (2010) taxonomy partially fits this framework - their syntax view corresponds to our syntactic level; their representation view corresponds with our semantic level; and their adaptation view covers theories that we have at both semantic and social levels, such as Checkland, Luhmann and Hofkirchner, and also includes the subjective dimension.

The semiotic dimension

Considering the first dimension, Morris (1938), building on Peirce's (1992) theory of semiotics, suggested that symbols need to be viewed in terms of three fundamental relationships: the relations with other signs and symbols; the relations with objects and events; and the relations to people involved in the communication. He named these relations the syntactic, semantic and pragmatic respectively. The syntactic relations cover all the formal relationships between signs within a language or sign system including non-linguistic and non-human systems. This is what we might generally see as the grammar of a language system whether it is formal, such as a programming language, or informal. Semantics covers the actual meaning of terms within the system – how terms acquire their meanings and how they relate to what they represent. Pragmatics covers the origin, use and effects of signs, or speech acts- in other words, the practical use of information and communications by people in real situations (Habermas, 1979).

This basic trichotomy was developed, within information systems, by Stamper (1973, 1991) into what is known as the semiotic ladder. He added the social level above the pragmatic to reflect the use and effects of semiotics within organizations and society beyond the individual sender or receiver. And below syntax he added two levels - the level of empirics which involves the storage and transmission of the physical code tokens and, at the bottom, the physical level of actual marks and differences in which codes are embodied - "no it without bit" (Wheeler, 1990) – and in which we would include fundamental atomic and quantum states. In this paper we will not deal with theories that only concern the physical and empirical levels[16].

The ontological dimension

The second dimension is ontological, that is, concerning the basic mode of existence of information. Is it objective in the sense that it exists in the world outside of, and independent of, individuals who may receive or interact with it? Or, is it essentially subjective or intersubjective, created in the minds of those who receive communications depending on their particular knowledge and interpretations, and ultimately existing only as a subjective mental state, or change in state, of a person?

Selected information theories

Table A1 shows the theories that we will review categorized according to these two dimensions. These are themselves only a subset of all theories but even so, for reasons of space and clarity, the text will only deal with exemplars of the various categories.

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[16] For interested readers, some physicists argue that information might be a fundamental property of the physical world, along with matter and energy (Brillouin, 1929; Landauer, 1991; Zurek, 1989). Two other relevant theories are the idea of quantum information (Nielsen & Chuang, 2000) and the holographic principle (Bekenstein, 2003; Bousso, 2002).

Empiric level

Theories at this level essentially equate information with the data or tokens or signs that are generally said to carry or contain information. As discussed above, many IS texts implicitly take this view but Buckland (Buckland, 1991) does so explicitly. We argue that this is an impoverished and reductionist view. Whilst it is, of course, true that information must be represented or embodied in some way – there must be some form of differences in some medium in order for information to be received or transmitted – information cannot be reduced to data or sign. This would be equivalent to saying that a Beethoven symphony was only the score; an Eliot poem only the book it is written in; or the Mona Lisa only some pigment on a canvas.

Consider a USB stick – would we wish to say this is information? At base it is just a collection of electrical charges. Given a protocol, these can be interpreted as binary values; given a syntax these in turn can be interpreted as numbers and letters; given a semantics these may or may not have meaning and thereby be informative. The stick may have had random data written all over it which would be quite meaningless – surely we would not wish to call this information? Each level is emergent from the lower one, and requires new structures and knowledge for it to occur.

Semiotic Category	Information as Objective, Independent of the Receiver	Information as Subjective, Constructed by the Receiver
Empiric (concerned with the tokens of data that are stored and processed)	**McKinney and Yoos** token view **Buckland** information-as-thing	
Syntactic (concerned with the rules governing the symbol system in use)	**Shannon and Weaver**: information as the uncertainty associated with messages; entropy **Weiner**: information as a measure of the degree of organization; negentropy **McKinney and Yoos** syntax view	
Semantic (concerned with the meaning of information, i.e., what it represents)	**Dretske**: information as the propositional content of signals **Floridi**: Information as well-formed, meaningful, true data **Buckland:** information-as-knowledge **McKinney and Yoos** semantic view	**Bateson**: a difference that makes a difference **MacKay**: change in receiver's cognitive structure **Langefors:** the infological equation **Checkland**: information = data + meaning **Maturana and Varela**: information structurally determined **Buckland:** information-as-process **McKinney and Yoos** interaction view
Pragmatic (concerned with the intentions and effects of information on senders and receivers)	**Mingers**: similar to Dretske but including personal and social dimensions	**Kettinger and Li**: developed from Langefors
Social (concerned with the social context of information)		**Luhmann**: the surprisal value of a communication for the receiver's cognitive expectations **Hofkirchner**; The effect that differences in the environment have on a self-organizing system

Table A1 Theories of information organized by the semiotic framework and the objective/subjective dimension. Note that some theories apply across more than one level

Syntactic level: Shannon's mathematical theory of information

Shannon was an engineer who was interested in the transmission of information from a source to a receiver, particularly in terms of accuracy and cost. He developed a measurement for the amount of information that a particular code or message could contain, developing earlier work by Hartley (1928). It was published in a paper with Weaver (Shannon & Weaver, 1949)[17]. He recognized explicitly that his theory did not deal with the content of messages (semantics) but only their possible structure (syntax) and transmission – "These semantic aspects of communication are irrelevant to the engineering problem" (p. 3). Nevertheless the theory has become widely adopted and has formed the basis for other, semantic and physical theories.

The fundamental idea is that the amount of information depends on the number of possible messages or symbols that are available, and their relative probabilities. The more possible symbols or messages, and the more equally likely they are, the greater the amount of information conveyed by any one. This is measured in the formula $H = -k\Sigma p_i \log(p_i)$ where p_i is the probability of symbol i; k is a constant to define the units; log is generally to the base 2. The minus sign ensures that the result is positive. To give a simple example, taking k as 1, a binary digit has an information value of 1 (assuming 0 and 1 are equally likely); a decimal digit has an information value of 3.32, so a decimal symbol can carry more information (reference more states) than a binary one.

So far this seems reasonable – the more possible messages there can be, and the more equally likely they are, the more information the receipt of a particular message will convey. This also relates to the value of information – the greater amount of information (as here defined), the greater its value. Shannon also linked information to the physical concept of entropy which, as it happens, has an identical formula. Entropy measures the amount of order or disorder in a physical system in terms of the number of possible

[17] For an excellent historical account of the development of this theory see Gleick's (2012) The Information.

states and their probabilities. Thus, a disordered system with many equally likely states has high entropy (and information) while an ordered system with a small number of differentially likely states is low entropy and low information. However, this equation between information and entropy is controversial (Muller, 2007), for example entropy has defined units (kelvins per joule) while Shannon and Weaver's information is dimensionless.

Moreover, there are counter-intuitive implications. Languages such as English are generally well structured – letters and words are not equally likely, they are often quite predictable and have high redundancy. This means that they carry less information than random strings of letters or words. Equally, would we not usually say that a highly ordered or structured system (low entropy) contained more information than a random one? One of the other founders of cybernetics, Weiner, also defined information in a similar way but with a reversed sign so that it is equated with negative entropy or "negentropy" (Weiner, 1948).

There are no information theories at the syntactic level that are subjective and it is hard to see how there could be since syntax only deals with signs and the rules governing them and not their meaning

Semantic level: objective theories

In considering semantic information we are moving to include the content or meaning of signals and messages, not just their quantity. There are significant issues in this area: is information different from or the same as meaning? Is information objective, subjective, or perhaps both? Does information have to be true or correct to be information? How does information relate to knowledge? We will firstly consider objective theories and then subjective ones.

Dretske (1981, 1995) produced a theory of semantic information in which information is seen to produce meaning, and ultimately knowledge, for the individual. Dretske's fundamental idea is that all sorts of signals, primarily physical one, carry information. In particular, they carry information concerning their

own causal origins. Given that a particular sign or event has occurred, what must be the case because of that, but not necessarily otherwise? What must have happened to have generated it? This is what he calls the propositional content of the signal and is what he identifies as semantic information[18]. Thus, a knock on the door carries the information that there is someone there. A fuel gauge in the car carries the information that the tank is half full. A database carries the information that there are 15 widgets in stock[19]. A photo carries much information about the scene it portrays.

Dretske next considers how information can be transmitted from a source to a receiver (which may be machines rather than people). For this, there must be a causal link or chain of links between the two such that the state of one affects or generates the state of the other. The knocking on the door causes sound waves, which cause me to hear it (assuming I am not deaf), which causes me to know that someone is there. Thus information is transmitted and generates knowledge that something is the case. Information, on this view, is objective in that it is carried and transmitted whether or not it is received or understood by anyone. However, if it is received, the amount of information available to the receiver does depend on their prior state of knowledge. Suppose that we are expecting someone particular to arrive and have arranged for them to give a special knock. When we hear that knock we can derive the information that it is that particular person. Someone who did not know the special knock would only derive the information that a person was there.

The issue of causality should be clearly distinguished from correlation or "mere" association. Consider an example. When flying there is usually a map on the screen showing the flight of the aircraft and we generally take it that is does indeed carry information (inform us) about the approximate position of the plane. There are two ways the map could be generated: a) it could simply be a recording which starts when the plane takes off and shows where the plane should go. b) It could be generated directly from the

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[1818] Formally, "A signal r carries the information that s is F iff the conditional probability of s's being F, given r (and k, the prior knowledge of the observer) is 1 (but given k alone is less than 1)" (Dretske, 1981, p. 57)

[19] Assuming that it is correct or true. This will be discussed later

plane's actual position either through the plane's instruments or by satellite. Both maps will appear the same provided that the plane does actually follow its proper path but only b) actually carries information since it is causally connected to the plane's actual position. a) is only correlated to it. We would see the difference if the plane had to divert because then only b) would be correct.

Another aspect of Dretske's theory is that information can be held in analogue or digital form. A photo of a room, for example, has a large amount of information in analogue form. When someone looks at the picture, they cannot process all this information (as an electronic mechanism could) but rather they focus on particular aspects of it, depending on their prior interests and expectations, and generate a much more specific concept or description (for example, "that's nice wallpaper") that only contains some of the information. This intentional process Dretske calls "digitalizing the analogue".

This sophisticated theory has several important implications for the nature of information:

1. Information is objective and independent of the receiver. It exists whether or not it is received, and whether or not it is understood.
2. The information that is carried by a signal must be true, i.e., it only carries the information about what is actually the case. So, if the knocking on the door was actually caused by a branch blowing in the wind that is the information it carries even though we might mistakenly think someone was at the door.
3. Meaning is necessary for information but not identical to it. A meaningful sentence may not carry any information if it is not true. The same information may be carried by different sentences, or in different forms (for example, train times in a timetable, on a website, over a loudspeaker). Messages that reference the same thing can carry different information (for example, "there was an accident on my way to work" and " the accident on Baker Street")
4. The actual information available depends on the prior knowledge of the receiver. First, the receiver must have the knowledge to understand the signals (for example, know the conventions

> or language) to gain any information. Second, there may be different levels of expertise (for example, if there are flashing lights on a machine that does not work, an engineer will be able glean more information about the problem). Third, specific knowledge of the context may be used (for example, if you are told that the winner of a horse race is a grey, and you know that there is only one grey, you can identify the horse).

Semantic level: subjective theories

We begin with Bateson's (1973a) view that information is a "difference that makes a difference". Although this concept remains at a very general and undefined level in Bateson's work, it has been fruitful in informing many other information theories including Floridi (2004), Brier (2001), Hofkirchner(2013) and Mingers(J. Mingers, 1995). This is because it provides a link between the physical world, wherein information must be embodied or represented, and the cognitive world of the mind. A difference is fundamentally a relationship not a thing. The differences between an egg and an apple are not located in the egg or the apple or even in the space between them, but rather in the relations between the two. For Bateson, the fundamental characteristics of the macro physical world are differences – differences in physical qualities – light, sound, texture etc. – which are then endlessly transmitted and transformed circularly.

> *A 'bit' of information is definable as a difference that makes a difference. Such a difference, as it* travels and undergoes successive transformation in a circuit, is an elementary idea (Bateson, 1973b, p. 315).

Between any two things, or between a thing and its environment, there are an infinity of differences. Only particular ones with be selected by, or impose themselves on, an observer and thereby become differences that are noticed, differences that make a difference. In terms of Korzybski's (1933) map and territory, only certain of the differences in the territory get inscribed on the map, and these are what becomes information. But what gets inscribed is ultimately dependent on the mind of the receiver.

Moving to theories more specific to IS, we saw in the introduction that the most common view in IS has traditionally been that information is objective and (implicitly) true, being processed data. One of the earliest to argue against this was Langefors (1973) who summarized his model in the infological equation I = i(D, s, t) where Information is the interpretation (i) of some Data, made by a receiver based on their pre-knowledge or receiving structure (s) during some time period (t). This makes it clear that information depends on the receiver – different people, with different cognitive structures (that can be seen as knowledge) may generate different information from the same data.

This is similar to Checkland, the founder of soft systems methodology (SSM), who proposed that "information equals data plus meaning" (P. Checkland & Scholes, 1990. P. 303). His approach stems from a phenomenological position (P. Checkland, 1985).

> The most important feature of this analysis of data, capta, information and knowledge is that the act of creating information is a human act, not one which a machine can accomplish. It is the *human being who can attribute meaning to the selected data … in a context which may well be* shared by many people but may also be unique to an individual (P Checkland & Holwell, 1998, p. 91).

What this means is that data provides basic facts about the world but these facts are interpreted differently by different people according to their intentions, beliefs, values and expectations (meaning), and information is what results for the individual receiver. Thus, if a system records that there are 15 widgets available (data) one person may conclude that that is sufficient for what they need, another that more should be ordered, and a third that the system is wrong as there are only 12 (information). This is in many ways an appealing view as it seems clear that we do indeed interpret the world differently, but it is rather vague – what exactly are data, meaning and information, and how does meaning interact with data to produce information? It also means that information becomes subjective, only existing in the minds of

observers and thus information systems, books, newspapers, timetables etc. cannot be said to carry information.

Pragmatic level: Objective theories

The semantic dimension only concerns the meaning of a message. The pragmatic dimension goes further to consider both the intentions of the sender of the message, and the effects that the message and its information may have on the receiver(s). Mingers (1995, 1996) developed a theory of information based broadly on Dretske's but with significant enhancements. We will outline these developments here and then discuss the theory more extensively in the theoretical part of the paper.

There are two main developments. First, Mingers (2001) presented a model of the process by which information is converted into meaning through the brain and nervous system of the recipient. This was based on the neurophysiological theories of Maturana and Varela (1980a) Maturana (1980b) and theories of embodied cognition (Merleau-Ponty, 1962; Varela, 1991). It is in opposition to the standard representationalist or computational paradigm of cognitive processing in that what can be a message or trigger for the nervous system, and the effects that it has, are structurally determined by the nervous system, not the communication itself. In other words, the information that is received triggers a particular response in the receiver that depends on their own cognitive states. This is called the import of the information for the receiver. It is equivalent to that which is called information in subjectivist theories. To be clear about this, whereas subjectivist theories suggest that objective data generates subjective information, this theory suggests that objective information generates subjective meaning, i.e., import. That is not to say that the response will be purely individualistic. We have all, through processes of socialization, become structurally coupled to our physical and social environments and so are likely to interpret similar stimuli in broadly similar ways. This model suggests three stages for the receipt and processing of the information carried by signs into meaning (import) and ultimately action.

Second, Dretske confined his theory to what he called de re knowledge – that is generally perceptual knowledge of our natural and social environment (tree rings, knocks on doors, instruments etc.). He did not include the full pragmatic use of information within human communications. Mingers extended this by bringing in Habermas's theory of communicative action (Habermas, 1984 1987) which itself was based in part on semiotics (Habermas, 1979). With de re information, the sign or signal carries information about is cause – what created or produced it. This is its propositional content or truth. In considering full human communications from a pragmatic perspective, Habermas takes the basic unit as a speech act (Austin, 1962; Searle, 1969) as part of an on-going conversation oriented towards reaching an understanding.

Pragmatic level: Subjective theories

The model of Kettinger and Li (2010), a knowledge-based theory of information (KBI), fits into this category. Their theory is a development of Langefors' informetric equation in which:

> *"Information is the meaning produced from data based on a knowledge framework that is associated with the selection of the state of conditional readiness for goal directed activities"* (p. 415)

Data are measures or descriptions of objects or events, and knowledge is justified, true belief[20] concerning relationships between constructs. We can clearly see relations to other theories beyond Langefors - the reference to "states of conditional readinesses" draws on MacKay's (1969) theory of information and the description of information as meaning sounds similar to Checkland but in fact it is not. For Checkland, data + meaning = information; for Kettinger and Li, data + knowledge = information (which is the same as meaning). This neatly illustrates the problems in developing an information theory which properly differentiates between these various terms.

[20] "Justified, true belief" is the traditional philosophical definition of knowledge (J. Mingers, 2008)

The reason that we assign this theory to the pragmatic category is because it goes beyond simply meaning to also consider the importance of purpose and intentions. In fact, Kettinger and Li also use the semiotic dimensions as do we, and suggest that information can be generated at each of the levels. To develop their example, consider the set of signs |it is raining|. At the empiric level, knowledge of signs (e.g., the English alphabet) and sign transmission can generate the information that this is a sentence in English. At the syntactic level, knowledge of English can generate the information that it is a well formed English sentence. At the semantic level, knowledge of the meanings of words can generate the information that it is raining. At the pragmatic level, knowledge of intentions aand behaviors can generate the information that you should take your umbrella.

It is clear that information is user-dependent – "The production of information from data needs knowledge, and when knowledge varies, so does information" (p. 416) although Kettinger and Li appear to be somewhat ambivalent about this subjectivity:

> *"The above discussion on i*nterpretations and perceptions does not imply that the content of knowledge and the corresponding interpretation process are subjective. We suggest that both are objective or at least inter-subjective*"* (p. 416, our italics)

Surely there is a wide gap between objective and inter-subjective?

> *"Nevertheless, we acknowledge that the use of knowledge varies by person ... so that the interpretation is bound within a person's knowledge domain or rationality"* (p. 416 author's italics)

Which sounds rather subjective.

Social Level

So far, information has been seen primarily in terms of the individual subject – the sender or receiver of a message – although Habermas's (1979) pragmatic view does bring in the idea of social norms. But

information also has a social dimension beyond the individual, first because meaning and language is intrinsically social – communications only work because we share a complex system of rules and representations that extends before and beyond the individual. And second because the social and organizational world shapes the information that may be available and the effects that it may have.

We will look at a major German sociologist – Luhmann (1995 (original 1984)) who developed a sophisticated theory of society based on autopoietic, self-producing, communications (J. Mingers, 2002). Luhmann is a radical constructivist (Luhmann, 1990a). He envisages two separate but interacting systems – the social system which consists of networks of interacting communications, and the psychic systems of individual subjects' cognitions. What connects these two is the structure of meanings that constitute both cognition and language and which exist outside of, and prior to, the individual consciousness.

Following Mackay (1956), Luhmann sees the primary function of meaning as selectivity (Luhmann, 1990b) – selecting from a range of possibilities what will become an actuality. Thus in sending a message, the many possibilities - things that could be said, and ways in which they may be said – become reduced to just the one (Shannon-like) that actually is said. Meaning is the relation between what is selected ("presenced") and what is not, the selection being characterized primarily in terms of its difference to what was not selected. In this way, meaning generates a selection but at the same time remains related to all the alternatives that were not selected. Meaning thus acts as the gateway to the next instant by opening up further, related, possibilities. Equally, when a communication is received, it selects from within a range of possibilities within the psychic or cognitive domain of the receiver. The particular selection made depends on the existing set of readinesses or expectations, and the resulting experience may change these expectations. It is this change that Luhmann terms information – the surprisal value of a meaning complex for the receiver's structure of expectations.

As with MacKay and Checkland, this makes information subjective, relative to the individual, while meaning is objective, or at least intersubjective. The same messages may generate different information

for different people, and a repeated message is still meaningful but not informative. Whilst Luhmann's actual definition of information is basically semantic, it is the fact that he locates this within a sophisticated social theory (Luhmann, 1995 (original 1984)) and discusses the effects that society's functional differentiation has on communication (Luhmann, 1993, 2000) that leads us to locate it at the social level.

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