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Scientific and Philosophical Aspects of Information and the Relationships among Data, Information, and Knowledge

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Abstract

In this paper we propose ways to better understand the term information and its relationship to data and knowledge not by looking at the problem from an information science perspective but from what might be described as a modern science one. We will look at experiments such as the double slit experiment (DSE), the Einstein-Podolsky-Rosen (EPR) experiment and important ideas derived from special relativity theory that we believe shed new light on the notion of information. Together these ideas can help us better understand the terms data, information, and knowledge and the relationships among them.

Keywords: Science of information, nonlocal information, EPR-experiments, relativity, lightspeed, nonlocality

Introduction

We use the word information so often that we have developed an intuitive understanding of the term, which causes us to use it without thinking. Evidence of this can be seen when we attempt to describe information. When we try, we often use terms such as data, information and knowledge interchangeably. The problem is only made worse by the fact that the various sub-disciplines (computer science, library science, management information systems, etc.) that make up the overarching and general discipline, *information science,* each define the term quite differently. It is understandable given their different histories, and objectives. Furthermore, we often describe phenomena with certain words, concepts and terms in hopes of attaining scientific semblance. For example, the term statistical significance has nothing to do with being significant in the real world. Likewise, social sciences have little to do with being a science that can repeat and predict single events. In physics we have no experimental proof that particles, space, and time exist and the uncertainty principle defies exact measurement. The repetition and prediction of single events, for example the exact time a single radioactive atom decays is elusive. Likewise, physicists in quantum mechanics have been forced to adopt a probabilistic interpretation of results. Exact measurement in physics is as superficial as is our understanding of the human mind both of which are based on a belief system of scientific conventions rather than on a system of non-contradictory experimental findings. Similarly, information theory has nothing to do with information, rather it is a statistical theory of signal transmission that, as Shannon (1948) noted, can be more accurately described as a mathematical theory of communication. Einstein (1954) summarized these dilemmas when he said: "We do not know: we only can guess." The best we can do is to guess on the basis of experiments that reach deeper into a fundamental level of reality beyond the concepts of space, time, and matter and start to shed new light on widely accepted theories and conventions that are blindly followed and are falsely treated as facts (Svozil 2002). For this we need properties that are spacetime independent.

We believe that as a first step in the effort to gain a better understanding of information and how it relates to the other important terms--data and knowledge, we need to step outside the forum in which the discussion has been taking place, and look at the issue from a new perspective with a new and different lens. This is not unlike what Norbert Wiener did when he sought to solve the problems of feedback and control that accompanied his effort to design high-speed computers. He looked to biology and found the answer there (Wiener 1948).

In this paper we propose ways to better understand these terms and the relationship among them not by looking at the problem from an information science perspective but from what might be described as a *modern science* one. We will look at experiments such as the double slit experiment (DSE) (Feynman et al. 1965), the Einstein-Podolsky-Rosen (EPR) experiment (Einstein et al. 1935) and other important ideas derived from special relativity theory (Einstein 1905a; Einstein 1905b) that we believe shed new light on the notion of information. Together these ideas can help us better understand these terms and the relationships among them.

Since information is as noted above, the operative expression we begin with a review of the theoretical literature in which the term is found. We then present a discussion of two high level views of the term that relate information to the other two terms data and knowledge. One presents a conventional view of information and its relationship to data and knowledge, the other an alternative view that turns the conventional view upside down somewhat. These views can be thought of as two extremes of a continuum of ideas concerning the relationship among the three terms. Next we will look at several modern science experiments that we will use to introduce the ideas that we believe are essential to developing a better understanding of theses terms and their relationships. We will discuss the notion of *objectivity*, the concept of *nonlocal information* and the importance of a *reference frame* in developing this new understanding.

Some Views of Information

There are hundreds of different definitions of information found in the literature, e.g. (Losee 1997; Yuexiao 1988). One simple way to differentiate among them is to categorize them according to those that view *information as a product of a mind or a device* and those that view *information as abstract reality* independent of a mind or device.

Information as Product of a Mind or Device

Those information concepts found in the information science literature that view information as a product of the mind or device can be divided into two groups -- those that either totally depend on a human mind or those that partially involve a human mind. While signal transmission does not involve any intervention of a mind, the creation and reception of the message most certainly must involve a human mind.

The dependent school views information as: (a) Process, thing, knowledge (Buckland 1991); (b) informative (Buckland 1991); (c) meaningful (Pratt 1982); (d) data of value in decision making (Yovits 1969); (e) data (Dolby 1984); (f) values within the outcome of any process (Losee 1990); (g) value as a variable's attribute or characteristic and not economic value (Hirshleifer et al. 1992); (h) value replaced by another value (Russell 1937); (i) a small part of knowledge structure, which can modify the knowledge structure (Brookes 1980); (j) contained e.g. in scientific documents (Hoffmann 1982).

Also among those who view information as being dependent upon a human mind there are those who describe information as meaning and knowledge that is transmitted to a sentient being. In this sense information is defined as (k) knowledge with the human body taken out of it (Peters 1988); (l) that which occurs within the mind upon the absorption of a message" (Pratt 1982); (m) a complex phenomenon, which exhibits a staggering variety of physical, biological and behavioral properties (Saracevic 1970); (n) what remains after one abstracts from the material aspects of physical reality (Resnikoff 1989).

Those who view information as being at least partially independent of a human mind describe information as: (o) signal transmission (Verdú 1998; Shannon et al. 1949; Shannon 1948); (p) what is expressed by the signal sequences (Barr-Hillel 1955); (q) either related to a human phenomenon or exists in the world of animals and machines (Wiener 1984); (r) neither matter nor energy (Wiener 1984).

Information as Abstract Reality Independent of a Mind or Device

Then there are those who view information more as an *abstract reality* independent of the processing of a mind or a device. (Norton 2000) contends that information is at the center of all sciences; (Saracevic 1999) argues that information is a basic phenomena; (Stonier 1997) contends that information is the underpinning concept of reality and the universe; (Mikhailov 1984) relates information to a number of philosophical categories, such as space, time, motion, and energy, and Yuexiao (1988) sees information "on the same level with 'matter' and 'energy' (Yuexiao 1988)."

Implications of Information as Product of a Mind/Device or as Abstract Reality

Those who view *information as a product of a mind or device* contend that there needs to be something that knows something before information can be observed. For example, a scientist has knowledge about a certain topic, which he or she formulates as a theory and articulates in the form of a written document. The document is information. Unfortunately, we do not know how the scientist arrived at his or her knowledge to begin with. Was knowledge always there, wired in or does it come from random molecular or neuropsychological brain activity. Regardless of how knowledge is acquired those who subscribe to this view argue that there must be a knower with knowledge before information can be created.

On the other hand, there are those who view information as an *abstract intangible reality*. They contend that information must exist before all else, independent of a knower and before a device can be created by a knower to observe "something". This raises the question of where does information come from in the first place. If information exists before everything else then it must have always been there, and it must have the capability to create something out of itself through some dynamic self-processing. A good example of this notion can be found in nature, which is dynamic and constantly changing. For this to happen self-processing must continuously be creating something different out of itself. For example, nature in its self-processing creation process developed dinosaurs, then warm-blooded creatures and even consciousness.

Data, Information, and Knowledge Hierarchies

A reason for the lack of a precise definition of information can be readily seen from the above, limited as it is, literature review. We will in subsequent sections return to the notion of *information as a product of a mind or a device* but for now we believe that it is necessary to be a bit more pragmatic. To do this we will look at data, information and knowledge from two views that represent opposite ends of a continuum that includes many of the notions of information and how it relates to data and knowledge.

Data, Information, and Knowledge: A Conventional View

A commonly held view is that data are raw numbers and facts, information is processed data, and knowledge is authenticated information. This conventional view posits that first there is data that can be processed to form information, and from information comes insights that contribute to knowledge. This view assumes that summarizing, interpreting, and analyzing data create information. But who decides what data are to be collected and observed in the first place. We don't collect data without first having some idea as to how it might be used. Furthermore, how can we be certain that the same data and/or information given to two different people will produce similar knowledge? Give the same book to two different people and what they learn will most certainly be different. Alavi et al. (2001) contend that such a hierarchy from data to information to knowledge (see figure 1) with each varying along some dimension such as context, usefulness, or interpretation rarely survives scrupulous evaluation.

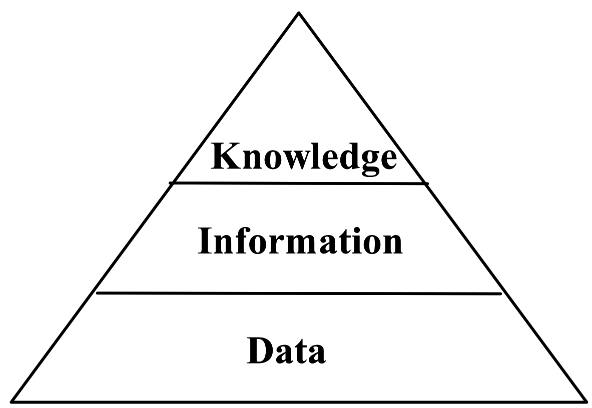


Figure 1. The Conventional View

Data, Information, and Knowledge: An Iconoclastic View

Tuomi (1999) proposes a hierarchy that begins not with data but with knowledge. Knowledge according to this view must exist before information can be formulated and before data can be measured to form information (see figure 2). This view posits that raw data do not exist without a knowledge process that must identify what is to be observed, measured and collected. Tuomi's argument is based on the assumption that knowledge does not exist outside of an agent, a knower if you will. Likewise, Alavi et al. (2001) contend that information is converted to knowledge once it is processed in the mind of individuals and knowledge becomes information once it is articulated and presented in symbolic form. Knowledge is information processed in one's mind that becomes personalized information.

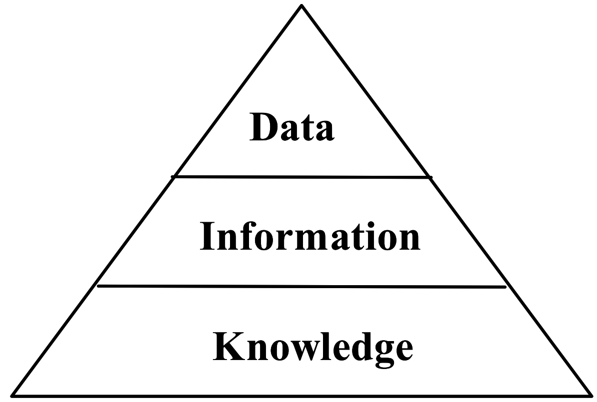


Figure 2. The Iconoclastic View

The problem with the conventional view is that data can only be derived from an outside "objective reality" that is completely separate from an observer. This requires a reality that is entirely sensible and logical. Entirely sensible means that when the "objective reality" is observed all information can be or is accessible and observable, and is ultimately perceived. For example, in physics it is assumed that an electron has attributes such as location and momentum and that it is a particle or a wave with certain mass and so on and this set of attributes is the information that forms a *complete description* of an electron. But in fact nobody knows what an electron is or how much information it contains. Is the information content limited or unlimited. How many attributes an electron consist of does not depend on how many attributes are observed by an observer or device. An electron always consists of an unlimited; some might say infinite number of attributes, of which most are neither accessible nor observable by an observer or a device. The number of attributes an observer or device can observe or measure depends on his or its specific reference frame. It is the reference frame that limits reality or the information content of observed "things". Consequently, any reality that is the product of an act of observation or measurement is different then when unobserved. Reality only exists in the confines of a limiting reference frame that is unique for each individual.

Since reality as a whole is not entirely sensible and, since, there is no "objective reality" that can be observed, an alternative definition of data is necessary. Rather than objective data there is subjective data, however, in order to be data it must be reproducible under identical conditions, which requires identical reference frames. Humans cannot produce such identical conditions, because not two human mind-sets are identical. Different mind-sets create different reference frames. Furthermore, a particular human's mind set, hence, his or her reference frame varies with each new experience, thereby increasing the level of acquired knowledge. Consequently, the dynamic reference frames of humans cannot generate reproducible data. In contrast, identical devices have identical static reference frames and thus can generate and reproduce data. For example, identical IR spectrometers record exactly the same IR-wavelength, because they have identical reference frames that do not change.

Modern Science Experiments: A New Lens with which to View These Terms

Experiments and thinking in modern sciences, in particular the double slit experiment (DSE) (Feynman et al. 1965) and the EPR experiment (Einstein et al. 1935) as well as works of Bell and Aspect (Bell 1964; Aspect et al. 1982; Aspect 1999; Weihs et al. 1998) challenge the notion of the classical assumption that information is objective and raises the possibility of an important and heretofore unrecognized component of information that we believe should be titled "nonlocal information".

The Double Slit Experiment: The Notion of Objectivity

The essential conclusion of the double slit experiment is that to observe or measure reality an interaction is needed which changes unpredictably the observed reality (Feynman et al. 1965). For example, in order to see something with our eyes photons must interact with an object. This interaction unpredictably changes the object and thus the reality observed is not the same as it was before it was observed.

Furthermore, every individual has a unique mind-set, which creates different realities. Hence, the reality an individual mind creates is always biased, colored and constantly changing with life experience and worldview.

The EPR Experiment: Nonlocality

The term nonlocality is also used in physics (Grib et al. 1999) but as we will show, significantly differs from our notion of nonlocal information. To avoid confusing the two terms we believe it is necessary to first explain the physics notion of nonlocality. The notion of nonlocality discovered as part of the EPR experiment suggests that information transfer must occur faster than lightspeed *in spacetime.* This is in direct violation of special relativity theory, which contends that nothing can travel faster than the speed of light (Davies 1977). Spacetime refers to the time it takes something to travel between two points separated by some distance. If nothing can travel faster than the speed of light how is it possible that in the EPR experiment and related theoretical experiments, information appears to travel faster than the speed of light, in fact, infinitely fast. In order to explain this violation of special relativity theory we introduce the ideas of *no spacetime* and *nonlocal information*.

We define *nonlocal information* as something that occurs or exists in *no spacetime*. By no spacetime we mean that time and space from the past, present and future collapses into a single "nonlocal" point at lightspeed, thus, creating *no spacetime*. Coercively, all information from the past, present and future collapse into a single *nonlocal information* point. The direct consequence of this assertion is that information does not have to travel faster than lightspeed because it is always present, in other words it is already there. Subsequently, at no spacetime no transfer of information is needed so that the principle that nothing travels faster than lightspeed is not violated. No spacetime, in principle, means that all information about everything is everywhere at anytime. Consequently, we have to modify the expression "Nothing can travel faster than light" and more accurately conclude, "Nothing with mass can travel faster than light." Photons and information do not have mass and can exist at and beyond lightspeed.

Special Relativity Theory: Nonlocal Information and the Collapse of Information at Lightspeed into a Single Nonlocal Information Point

The following figure illustrates the idea of nonlocal information. As can be seen, information collapses at lightspeed into a single nonlocal information point.

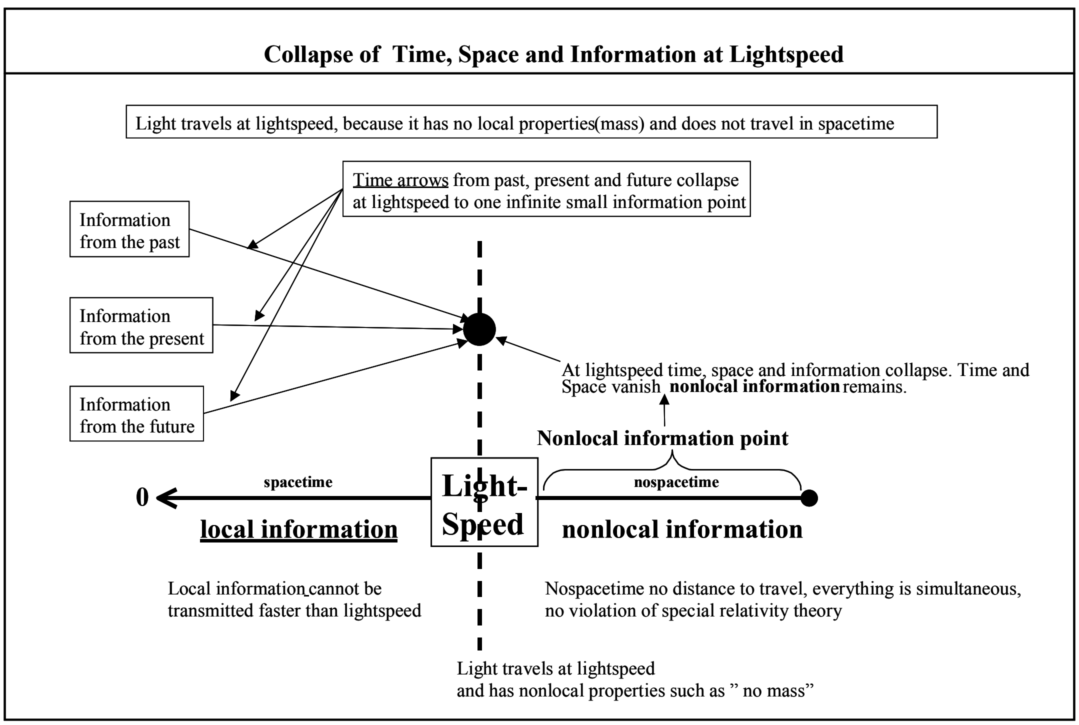


Figure 3. The fact that time is relative incorporates some consequences at lightspeed. First it causes the creation of something called *no spacetime*, which means that at light-speed space and time of the past, present and future collapse and cease to exist. Second it marks the creation of something called *nonlocal information*, which means that at light-speed all information of the past, present and future collapse into a single nonlocal information point that exists in no spacetime.

Nonlocal information is a result of the extraordinary behavior of time, space and information at lightspeed. Nonlocal information is defined as something that occurs or exists in what we call no spacetime. To understand no spacetime we take the fact that at lightspeed, time is zero, e.g. (Renshaw 1996; Hafele et al. 1972) and together with space collapse into *no spacetime,* e.g. (Davies 1977; Kennedy et al. 1932). In other words, at lightspeed time, space and information collapse into a single point and spacetime ceases to exist creating something called no spacetime and nonlocal information. In no spacetime no local tangible properties exist, with the exception of information. Since all the information about everything exists in no spacetime it is termed *nonlocal information*. This is possible, because in contrast to time and space which vanish at lightspeed, information of the past, present, and future collapse into a single nonlocal information point at no spacetime concentrating all information and creating an infinite amount of information in a single point. The direct consequence of this assertion is that information is omnipresent from which it follows that no spacetime, in principle, means that all information about everything exists everywhere at anytime.

Nonlocal Information and the Big Bang Theory

Another way to conceptualize or explain the implications of nonlocal information is by using the big bang theory and by defining the reality or existence of a "thing" before and after the big bang or, we can look at the difference between information content of an unobserved and observed "thing". As can be seen in figure 4, reality or the information content of an unobserved "thing" before and after a big bang is the same. In both cases, the information content is infinite whereas the information content of an observed "thing" is finite within the confines of a reference frame.

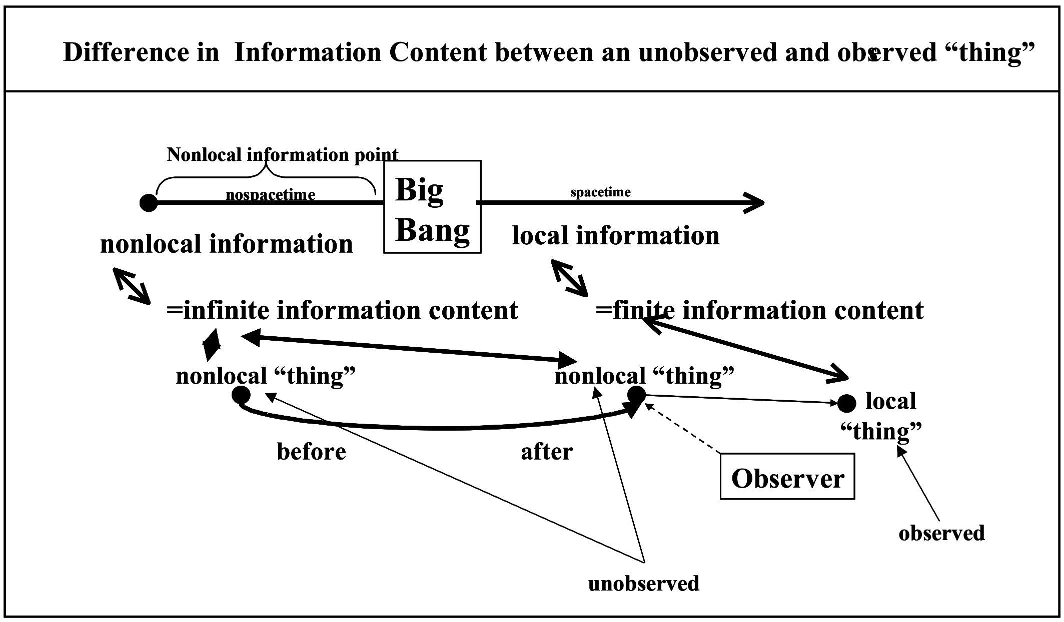


Figure 4. The information content of both nonlocal "things" before and after the big bang is infinite. Consequently this suggests that the big bang is not necessary for the creation of the sensible local universe. Reality before the big bang is a single non-local information point with infinite information content. All information is concentrated in a single nonlocal point. Consequently, the information content of a nonlocal "thing" before and after the big bang is the same as long as it remains unobserved, which means that nonlocal information has not been confined within a limiting reference frame. As soon as an act of observation or measurement is inflicted on the infinite nonlocal amount of information, and hence, confined into a specific reference frame the amount of information is limited to that of the reference frame. For example, the scope of the reference frame for an IR-spectrometer is to detect and record infrared light. Consequently, the IR-spectrometer only measures and records the wavelength of infrared light, despite the fact that an infinite amount of information is there in unobserved reality.

The crucial argument here is that reality is an information phenomenon and not a space/time/matter phenomenon that needs a point of origin. The problem with the big bang theory is that it cannot sufficiently be explained other than it just happened. Nevertheless, the big bang principle should not be disregarded, because every observation is a little big bang creating space, time and matter in the confines of a reference frame.

Special Relativity Theory: Reference Frame

One way to think of relationships among data, information and knowledge is by thinking about different reference frames. Information that we take from an observation of a symbol is a function of our reference frame. For example, a red dot--a symbol, if you will, will be interpreted differently by individuals because of their different experiences, cognitions and perceptions. These are the things that form our unique frame of reference. An Indian sees something quite different in a red dot, than does someone from Japan or a Taxi driver in Honolulu.

Reference Frame of Humans

Every person has his or her own reference frame. Nobody would doubt the fact that individuals have their own point of view and that there are no two identical individuals with the same identical opinions or mind-set. Why then would we expect individuals to have the same reference frame.

Because time is relative individuals also live in separate reference frames of time. According to special relativity theory, everything exists in different time frames depending on the history of travel or movements (Wheeler et al. 1998). For example, when a photon was emitted from a quasar four billion lightyears away from earth and hits an observer's eye on earth the time that had past for the photon and the observer on earth depends on their particular reference frame. For the observer on earth the photon needed four billion years. For the photon in its nonlocal reference frame at no spacetime beyond lightspeed no time had past at all. At no spacetime no distances exists at all. Consequently, for the photon traveling beyond or at lightspeed where no spacetime exists there is no distance to overcome, whereas the distance in the reference frame of the observer on earth appears to be four billion lightyears. The distance of four billion lightyears only exists in the mind of the observer on earth, but not in the nonlocal reality of the photon. Therefore, every reference frame constitutes a different reality relative to a particular observer's reference frame of time and motion.

We come back to the important reference frame of the mind and consider certain presuppositions. First no two persons have identical reference frames. Second the reference frame of a person is constantly changing with time and life experience. The fact that humans never have identical reference frames is important in formulating the relationships among data, information and knowledge.

Reference Frame of Devices

In contrast to the human reference frame that is dynamic and constantly changing it is possible for identical devices to have identical and unchanging reference frames. Thus devices are able to reproduce identical results at any time and any place of equal conditions. The psychological reference frame created by the mind is what causes the difference between a knower and a device and finally between data and knowledge.

Definition of DATA, KNOWLEDGE and INFORMATION According to this New Lens

Given the above discussion we now begin to define and distinguish among data, information and knowledge.

Data are reproducible results generated by devices with identical reference frames, and can be expressed by the following formula: *data = static reference frame + result of measurement*.

Local information is data processed and formulated by a mind or it is knowledge detached from a human reference frame. When a scientist writes a paper, the information in the paper is detached from his or her reference frame. This means that local information can be described in one of two ways: *local information = dynamic reference frame + data,* or *local information = knowledge – dynamic reference frame*

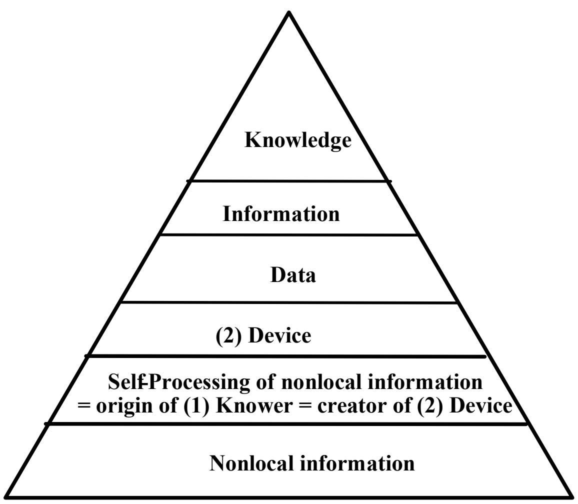
Knowledge on the other hand is the unique irreproducible product of a mind. No two minds are identical and thus no two human reference frames can produce identical results. Results are always colored and do not represent an "objective reality." No two individuals will ever have the same reference frame. Therefore results are not reproducible. Knowledge can be thought of as: *knowledge = dynamic reference frame + local information*.

Nonlocal information is all data, information and knowledge in one information point in no spacetime, which can be expressed as: *nonlocal information = infinite reference frame*. The human mind, but not mechanical devices can, in a limited way, access and utilize nonlocal information. Therefore we conclude that: *knowledge = dynamic reference frame + link to nonlocal information = overlap of dynamic reference frame with infinite reference frame.*

Implication of Nonlocal Information on the Conventional and Iconoclastic View

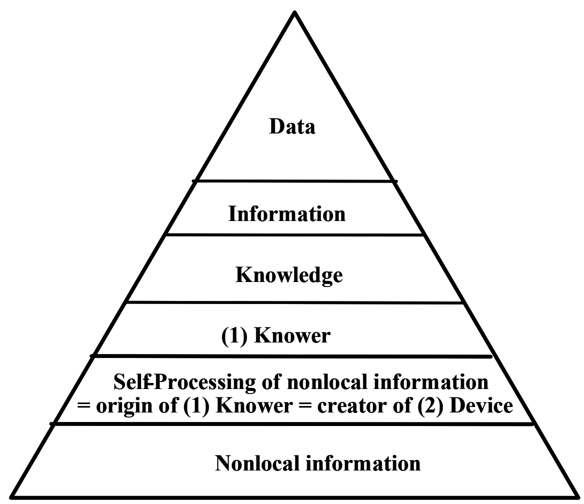
In the conventional view data must be generated through an act of observation. According to the iconoclastic view, there needs to be a knower to create knowledge that exists only in his or her mind (Alavi et al. 2001). A critical yet unresolved question is how a knower is created or how a knower comes into existence in the first place. As previously discussed, nonlocal information constitutes an *abstract reality* on an ontological level. The critical argument here is that nonlocal information is not a mindless reality as are particles, energy, time, and space. Nonlocal information contains all information and knowledge, past present and future, and thus must be as conscious as any being. Subsequently, it is not only an infinite library, but also infinite knowledge creating an infinite reference frame capable of executing any action in a highly organized and planned manner. Logically, nonlocal information is ultimately able to create the first knower in a sense that a knower is created through the self-processing of dynamic nonlocal information. Processing of nonlocal information is able to limit infinite nonlocal information and thus inflicts or produces the creation of local realities with limited finite information. This dynamic behavior of nature can be observed and constitutes our common sense reality in a confined reference frame.

Subsequently at the beginning of both of the data, information, and knowledge pyramids there is nonlocal information, which is the creator of a knower who always is the creator of a device. What this all means, is that depending upon which view one subscribes to will determine whether a knower or a device results from the self-processing of nonlocal information. For the conventional view we contend that a device begins the process of generating data with a static reference frame (see figure 5). According to the iconoclastic view a knower creates knowledge within a dynamic reference frame (see figure 6).



Conventional Model with Device generating DATA

Figure 5. Resulting Conventional View



Iconoclastic Model with Knower creating KNOWLEDGE

Figure 6. Resulting Iconoclastic View

In either case, the creation of information from data or from knowledge, naturally involves a knower. In the data to information case, data first has to be processed by a mind in a human reference frame before it can be formalized as information (e.g., into electronic form). In the case of the iconoclastic view the step from information to data involves a device with static reference frame.

While we have augmented both views we nevertheless believe that the self-processing of nonlocal information can only create a knower, not a device. Because a knower always creates a device the iconoclastic model is, we contend, more accurate and closer to reality. Nevertheless, each model has value and neither should be disregarded. We can think of the two models in the following way. The iconoclastic view is on a more ontological and fundamental level, whereas the conventional view is a more epistemological or practical one.

Knowledge Management, Organizational Memory and Organizational Learning

Figure 7 distinguishes between data and information that can be managed by IT, and knowledge that is the result of the management of people. Firms are seen as dynamic repositories of different sets of knowledge that are critically dependent upon the individual and collective human capital in an organization (Ranft et al. 2000). As such, substantially more resources should be allocated to manage people than to IT. The recommendation to invest substantially more into human capital correlates with what is well documented in the knowledge-based view of the firm literature.

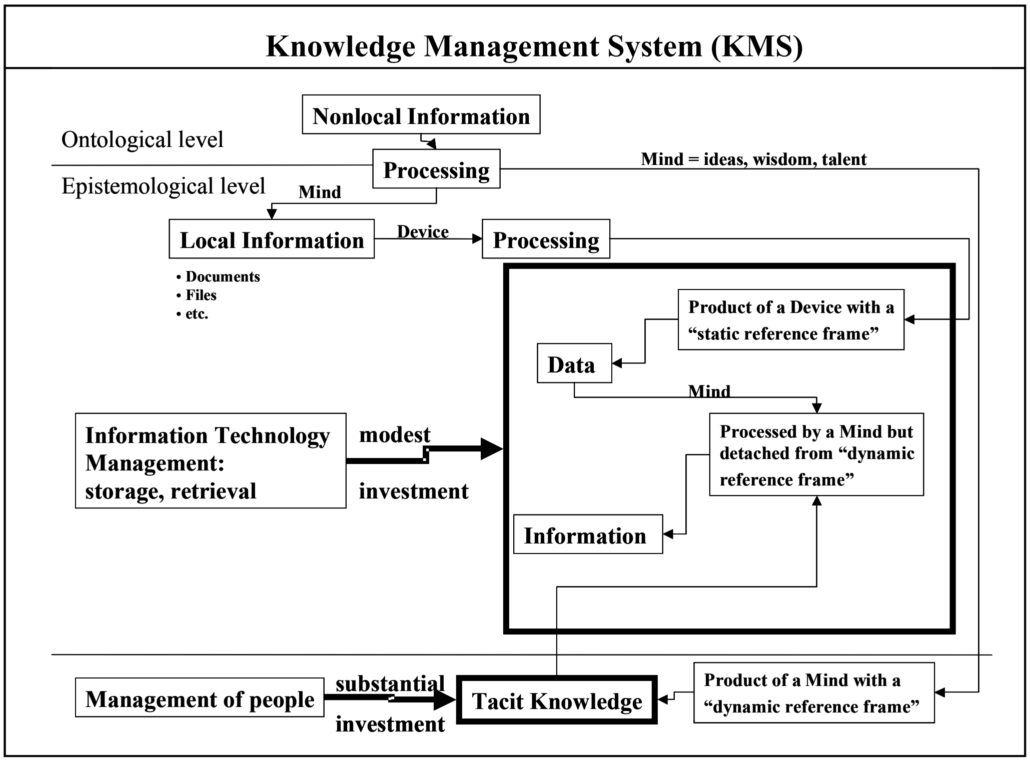


Figure 7. The diagram shows that data and information can be managed by IT, but not knowledge. The conclusion is that investments should be substantially allocated to the management of people and into the development of an internal marketing structure, because without people the IT infrastructure cannot be properly utilized.

Critical to this model is the fact that nonlocal information can only be accessed and processed by a mind within a dynamic reference frame that has ideas, thoughts, knowledge, wisdom, talent, insights, awareness, consciousness, thinking, and all the intangible properties and processes of life. Processing of nonlocal information actually creates and defines the mind and with it a specific reference frame for an observer.

Information technology, in contrast, has a static reference frame and consequently, cannot be the focal point of knowledge management and organizational learning since the management of knowledge is the management of dynamic reference frames. This involves the management of people. The management of people requires management tools such as those developed in the field of internal marketing, (Varey et al. 2000; Ballantyne 1997; Gupta et al. 1991). What is important here is to build and maintain an environment of trust (Morgan et al. 1994; Winter 1985). Organizational memory, however, could be seen as a huge database or data-warehouse with a static reference frame. Consequently, organizational learning results from the interaction between people, which is the interaction between dynamic reference frames or it is the interaction between people and IT-based systems, which is the interaction between dynamic and static reference frames.

Because only a mind can process nonlocal information through the use of a dynamic reference frame, knowledge is always tacit (Stenmark 2002) and when detached from the dynamic reference frame it becomes information. Information is either created through formalized knowledge or mind-processed data, and is set and stored into a static reference frame, e.g., a computer. Conclusively, this suggests that investment in technology does not generate all that much value. At most, IT is an enabler and a facilitator in the value creation process providing the technology has been adapted and designed according to user needs and requirements. Nowadays, users are supposed to adapt to the technology rather than technology to the user and organizations end up paying a lot of money for poor results.

Towards a General Theory of Information

In order to better understand the relationships between data, information, and knowledge we believe a general theory of information is needed. To help construct such a theory we call upon the notion of information posited by John Archibald Wheeler (1991, 1998) that "information is everything" and attempt to shed new light on the notion that information is the primary matter of reality. We believe that as a beginning a general theory of information should be based on the notions of *nonlocal information*, *no spacetime* and the *limitation of nonlocal information through the act of observation*. The following points should be considered in such an attempt: (1) Time, space and information collapse at lightspeed, (2) Time and space vanish at lightspeed, (3) Nonlocal information has absolute properties unlike time and space, (4) Information of the past, present and future are inseparable and follow the first law of thermodynamics which says that information cannot be created out of nothing or destroyed to nothing, (5) Nonlocal information is the collapse of past, present and future information when all information collapses into one single nonlocal information point at no spacetime, (6) The information content of nonlocal information is infinite, (7) Nonlocal information constitutes an *abstract reality* and the information content is infinite, (8) The act of observation or measurement inflicted on nonlocal information limits the information content in a specific reference frame and hence creates the reality confined to specific reference frames.

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