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Abstract

Purpose: The purpose of this paper is to propose an appropriate symbolic representation, as well as its metaphorical interpretation, to illustrate the special role of information in the knowledge acquisition process.

Design/methodology/approach: Besides the literature review, this is a speculative study based on a symbolic and metaphorical point of view.

Findings: The proposed symbolic representation was derived from the conceptual definition of information 'as a flow' and, accordingly, by the corresponding redrawing of the Data-Information-Knowledge-Wisdom (DIKW) hierarchy pyramid. This representation refers to the appropriate image of the 'tree of knowledge.' In the proposed symbolic image, the knowledge acquisition process is recognized as its growth and was metaphorically interpreted by the analogous processes responsible for the growth of an ordinary tree (as interpreted by modern biology). However, our basic finding provides insight by which the overall growth of 'tree of knowledge' is affected by two flows of its core substrate: one is a flow of 'information sap' from the roots, immersed in 'data soil,' to the tree crown; the second is a flow of 'meaning sap,' driven by the rays of the 'mind sun,' from the crown leaves to the roots of the 'tree of knowledge.'

Originality/value: On the basis of specific symbolic-metaphorical representation, this paper provides a relatively new concept of information which may help bridge observed gaps in the understanding of information in various scientific fields, as well as in its understanding as an objective or subjective phenomenon.

1. Introduction

This paper concisely presents the diversity of views on the concept of information and interprets the process of acquiring human scientific knowledge, specifically from a symbolic and metaphorical point of view. In this view, the notion of information takes a central role, in addition to the related concepts of data and knowledge. Indirectly, this paper explores the question of why different perspectives of knowledge acquisition within the scientific fields have different views of information. Two such views, it seems, are directly opposed: one holds information as an objective entity that exists in an 'outside world,' and a second considers it a construct of our mind.

Therefore, this paper has two aspects: a review aspect and a symbolic-metaphorical aspect. In the first part of the paper, we provide a review. As concisely as possible, we attempt to provide insight into the diversity of views on the concept of information by researchers from various fields of science. These views are considered information theories. We focus on the theory of Claude E. Shannon, directions in the development of other information theories, definitions of information and types of information. The second part of this paper will propose an appropriate symbolic representation as a counterpart to the existing representation of the Data-Information-Knowledge-Wisdom (DIKW) hierarchy for the purpose of understanding the relationship between the term 'information' and the related concepts of data and knowledge. Through the symbolic representation, as well as its special metaphorical interpretation, we will try to illustrate the role of information in the process of acquiring knowledge. In this way, we will provide a relatively new understanding of information, which can mitigate, if not completely overcome, the problem of different understandings of this concept in various scientific fields. The symbolic representation and metaphorical interpretation of the role of information in the knowledge acquisition process provides a framework for a new understanding of the observed gap between views of information as an objective or a subjective phenomenon. Such a framework can also be used to overcome this gap.

2. Shannon’s theory... and beyond

2.1 Shannon's theory... for the umpteenth time!

As time goes on, there is growing frustration over inadequate and inconsistent understanding of the phenomenon of information in almost all fields of science (Hjørland, 1998; Saracevic, 1999; Cornellius, 2002). This is especially true because it is widely accepted that this is the information age, characterized by widespread use of information and communication technology (ICT). ICT, in turn, is enabled by machine readable, processed information. From Shannon's ‘information theory,’ which was released in mid-last century, a similarly revolutionary insight that may stand side by side to his theory, in computer and information science, has not yet been developed. Although ‘information theory’ is not, basically, his original idea and other researchers (Nyquist, 1924; Hartley, 1928) can be thanked for its existence, it contains a key generalization that makes it revolutionary (although mainly in circles of telecommunications and computer specialists, as well as mathematicians, interested in this area) [1]. Time has shown that Shannon's theory made exclusive, revolutionary progress in the field of signal transmission, while the attempt of his colleague Warren Weaver to generalize it into a general theory of communication, at least within the social sciences and humanities, ‘famously failed’ (Machulp and Mansfield, 1983; von Foerster, 1984). Shannon’s theory represents a milestone for “...the electronic communications networks that now lace the earth” (IEEE Information Theory Society, 2015), according to the Shannon-friendly IEEE Information Theory Society, and digital traffic is measured by bits—units which were introduced by Shannon [2]. However, it seems there is yet no 'information theory' that would satisfy all researchers, nor an acceptable definition of information that could be used in all scientific fields.

'How much meaning' was included in Shannon's theory? Shannon claimed 'a little.' His famous dictum, ''... the semantic aspects of communication are irrelevant to the engineering aspects" (Shannon and Weaver, 1963, p. 31) could not remove the tension between the two communities. Starting from cybernetics conferences in 1950s [3], it seems that dialogue on the issue of information between researchers from the natural sciences and humanities and researchers from the social sciences to the present day has not achieved significant progress.

To briefly remind ourselves: in Shannon's theory, information is presented by the (logarithmic) coded signals that are managed by the effective probability calculation of their transmission. In short, according to Shannon, information corresponds to *yes-no* answers to simple questions to select one choice (or message) from a predetermined set of choices (or messages). As in many of these choices, the coding process results in larger code, and hence, a greater amount of information (Shannon and Weaver, 1963). Shannon's colleague W. Weaver explained the essence of 'information theory' with the following words: "... word ... information relates not so much to what you do say, as to what you could say ..." (Shannon and Weaver, 1963, p. 8). However, Shannon's true contribution to science, as is well known, was applying probability calculus to the problem of transmission of information. In practice, the choices (messages) from a predetermined set of choices often do not have the same probability value. By example of the letters of the English alphabet as a predetermined set of choices, Shannon showed that the amount of information decreases with the increasing the probability of occurrence of each letter. In this way, he established a strong link between the probability of a certain choice from a set of predetermined choices and the quantity of information generated by that choice (Shannon and Weaver, 1963).

Based on the above consideration, the meaning of the message is not important for 'information theory,' but only the total number of choices on the basis of which a concrete choice (message) can be unequivocally encoded. In other words, it seems that choices between the options are a function of the transmission of internally-coded signals as a carrier of information, not the information itself. Accordingly, the practical value of the inclusion of the probability calculus in 'information theory' lies in a precise calculation of the maximum capacity of a communication channel (the maximum possible amount of encoded signals that can be transmitted through these channels per time unit). Or, as Bates concludes: "Shannon's model of information is dismissed today because he separated information from meaning. What is currently forgotten, however, is that this separation was in fact an achievement" (Bates, 2009, p. 2350).

So, as regards the practical aspect of Shannon's formula for the amount of information, it was only the calculation of the maximum capacity of a communication channel through which the signals are transmitted. Because of that, meaning in Shannon's paper did not play any role. It was always talking about signal transmission (which, strictly, represents information in an internally-coded form), not about the information itself. In his influential book, *Knowledge and Information Flow*, published in 1981, Dretske writes: "It deals with amounts of information—not, except indirectly and by implication, with the information that comes in those amounts" (Dretske, 1981, p. 3), concluding that Shannon's theory may be misnamed. Perhaps it should be called the theory of coding and transmitting information? Similar thinking as this one was offered by other researchers, including Qvortrup (1993) and Bates (2009). However, this opinion is not widely accepted within the scientific community.

2.2 Beyond Shannon's theory… theories, definitions & kinds of information, as well as directions in development of information theory

Many information theories emerged from Shannon's revolutionary paper: Bar-Hillel and Carnap's 'theory of semantic information' (1953), 'an algorithmic information theory' first proposed by Solomonoff (1960) and further developed independently by Kolmogorov (1965) and Chaitin (1966), a pragmatic 'economic theory of information' by Marschak (1959), 'a semantic theory of information' first proposed by Dretske (1981) and further developed by Barwise and Seligman (1997) and Barwise and Perry's situation theory (1983). More recently, additional theories have been developed: Floridi's 'theory of strongly semantic information' (2004), Hofkirchner's framework for 'a unified theory of information' (UTI) (1999) and, most recently, Mark Burgin's 'general theory of information' (GTI) (2010).

In addition to the relatively large number of theories, multiple attempts to more exactly define the phenomenon of information followed. The proposed definitions often included the semantic aspect of information, which is omitted in Shannon's theory. Usually, information was brought into close relationship with another concept; different kinds of conceptual designations/determinations were highlighted in different definitions. The conceptual designations/determinations of the phenomenon of information are:

- difference (…in the sense that makes a difference in the mind) (Bateson, 1969),
- reflected diversity (Ursul, 1971),
- structure (Belkin and Robertson, 1976),
- patterns (…of organization of matter and energy) (Parker, 1972; Bates, 2006),
- thing (Buckland, 1991; Qvortrup, 1993),
- data (well-formed, meaningful and truthful) (Floridi, 2011),
- event (in time and space) (Pratt, 1977),
- process (Buckland, 1991),
- flow (Dretske, 1981; Barwise and Seligman, 1997),
- property (… of things to change other things) (Burgin, 2010),
- difference (…in mind that finds the difference in nature) (Qvortrup, 1993),
- social construction (the product of social practices) (Cornellius, 1996),
- psychic construction (Qvortrup, 1984),
- cognitive differences (Qvortrup, 1993), and finally,
- knowledge (Buckland, 1991).

In this tentative listing of designations/determinations of information by different authors, of course, a few important things were probably omitted. This applies to what these authors had wanted to point out when they suggested that it would be a good idea for the notion of information to be associated with a particular term. Their ideas, thoroughly reasoned in their papers, require a discussion separate from this paper. After all, at this point of consideration, it seems a good idea to ask the question: how important is it to give a precise definition of a particular term? Capurro and Hjørland (2003) note that it does not matter whether the definitions of terms are true or false (in fact, they cannot be either or both), but whether the theory they support is more or less fruitful. Somehow, researchers are always free to define the theoretical terms as they want, if and only if their theories, in which they would be incorporated, find confirmation in reality.

A solid overview of the definition of information phenomenon was also provided by Bates (2009). We referred to some of them in the previous paragraph.

It is clear that the aim of this brief review of previous papers about information is only to provide insight into the diversity of views and understandings of this phenomenon, not to serve as a reference for a much more extensive review by other authors like Cornellius (2002), Capurro and Hjørland (2003), Robinson and Bawden (2012, 2014) and other authors. Nevertheless, it seems that the time has come for the meta-analysis of contributions through the study of the phenomenon of information. One such a paper by Furner (2014), declared as a meta-review paper, observed that papers about information can be divided into three types, based on their objectives (Furner, 2014, p. 144):

> "...to present and/or to advocate for a single conception of information that was first formulated elsewhere;
> - to review and/or to classify a range of existing conceptions of information; and
> - to present and/or to advocate for a new conception of information."

Furthermore, each paper may be further categorized depending on whether it is offering "a discipline-independent conception capable of universal application" or "discipline dependent conception intended for application in a context with specifiable boundaries." In addition, Furner proposes that reviews of the concept of information can be distinguished by considering the disciplinary affiliation(s) of their authors. Furner offers his own meta-analysis of papers about information phenomenon largely based on an ontological view of the information, whose exposure exceeds the limits of this paper (Furner, 2014, p. 144).

In addition to the relatively large number of papers which contain new or supplement existing information theories, or offer a new or a modified definition of information, a large number of papers were written to categorize the information phenomenon. Floridi (2010), for example, distinguishes mathematical, semantic, physical, biological and economic information. He connects these kinds of information with language and ethics issues. In turn, Burgin (2010) distinguishes information in nature, information in society and technological aspects of information. In this sense, one can speak about objective and subjective information. On the other hand, information can vary according to its use in a variety of disciplines—information in physics, information in psychology, information in biology etc. (Robinson and Bawden, 2014).

Organizing these papers in an original way, a few prevailing directions of the development of information theory can be seen. Some authors, such as Cornellius (2002) and Wersig (1997), also write of information in this manner. For example, Wersig (1997) considers that one approach to the development of information theory dominated till the 1970s. Wersig characterizes the published review papers on proposed 'information theory' and the communication model by Shannon and Weaver. That is the reason why Wersig called this period in the development of information theory the 'Shannon and Weaver phase'. This phase included, for example, the works of Rapport (1956) and Brillouin (1956).

In the mid-1970s, in light of the foundation of cognitive science, the information science literature began developing its own approach to the problem of information, known as the *cognitive turn* or *viewpoint*. This approach is recognized in papers of Belkin (1976), De Mey (1977), Brookes (1980) and other authors. Cornellius explained this view of information thus: "The critical component in this cognitive viewpoint is that information is mediated by a potential recipient's state of knowledge." (Cornellius, 2002, p. 406).

About the same time, the philosopher Fred Dretske claimed that information is relative to what one already knows in general and depends on what one already knows about the alternative possibilities that exist at the source of information. For Dretske, information is just "something that is required for knowledge" (Dretske, 1981, p. 82). However, the author considers information as an objective entity, unlike most information scientists, who claim that information is exclusively a subjective phenomenon.

During the 1980s, the open *objectivist approach to information* entered the stage and found one of its biggest advocates in biologist Tom Stonier. According to Stonier (1990, p. 21): "Information exists. It does not need to be perceived to exist. It does not need to be understood to exist. It requires no intelligence to interpret it. It does not have to have meaning to exist. It exists." The attitudes of most physicists can surely be counted among an objectivist approach to information. According to physicist John Archibald Wheeler, author of the aphoristic expression *'It from bit,'* matter and energy are carriers of much more abstract and profound entities: information (Greene, 2011).

In response to the objectivist approach to information by researchers who came from the natural sciences, the 1990s saw development of a *constructivist approach to information*, mainly in the humanities and social sciences. This point of view takes its starting point from several areas of human knowledge (for example, biology, psychology and sociology). Based on the proposed concept of *autopoeises* by Chilean biologist's Humberto Maturana and Francisco Varela (1980, 1986) [4], it is reflected, more or less, in the works of N. Luhmann (1989), S. Brier (1992), I. Cornellius (1996) and other authors. Constructivists do not consider information as an objective entity. "Information is an internal change of state, a self-produced aspect of communicative events and not something that exists in the environment of the system and has to be exploited for adaptive or similar purposes", argues Luhmann (1990, p. 10).

The paradox in the development of the objectivist and constructivist approaches to information may reflected by the following fact: the initial trigger for the objectivist approach to information was found in the works of researchers came from the social sciences (Bateson, 1972). On the other hand, the constructivists were inspired by an idea of biologists, researchers who came from the natural sciences (Maturana and Varela, 1980).

As opposed to the constructivist approach to information, pancomputational and paninformational approaches are emerging. According to them, all processes in the world can be reduced to those which have information and a computational nature. Pancomputationalists, like Gregory Chaitin and Gordana Dodig-Crnkovic, believe that nature, in principle, can be understood as a large computer (Chaitin, 2010; Dodig-Crnkovic 2010). Consideration of information as a purely objective entity seems to culminate in 'the world as a hologram' idea by Leonard Susskind (1995). However, this idea is based on the idea of 'the holographic principle' by Gerard't Hooft (1993). According to this theoretical hypothesis only, the whole universe and all events within it are a representation of written information on remote, two-dimensional sheets which light projected into space (Bousso, 2002). The latest research goes so far as some scientists trying to prove the holographic nature of universe experimentally, over the digital nature of space and time [5]. However, no matter how attractive and mathematically consistent this idea is, 'the world as a hologram' remains controversial. In this case, the aim was to highlight the role of information in the field outside its usual discussion domain—and not just any field, but physics, perhaps the most fundamental science of all, which, it seems, information wants to crown as 'the new queen of reality'!

An effort by philosopher Luciano Floridi to establish a new philosophical discipline, Philosophy of Information, in the 2000s can be viewed as a separate line in the development of information theory. In his book, "The Information: A Very Short Introduction" (2010, p. 9), Floridi writes: "... we are not standalone entities, but rather interconnected informational organisms or *inforgs*, sharing with biological agents and engineered artefacts and global environment ultimately made of information, the *infosphere*." Floridi is also one of the researchers who believe that the information is made up of data. According to his Theory of Strongly Semantic Information (TSSI), information is nothing else than well-formed, meaningful and truthful data (Floridi, 2011).

Recently, attempts to shed light on this phenomenon seem to have significantly increased. The World Scientific Series in Information Studies may especially boast of these efforts, announcing in a short time, between 2010 and 2013, three books that follow modern research trends in the field of information theory [6]. It only requires mention of the titles of theories which they are considered to realize the persistence, and perhaps, patience of researchers from different scientific fields to attempt to define information are at their highest point, for example: General Theory of Information (GDI) by mathematician Mark Burgin (2010) or Unified Theory of Information (UTI) by sociologist Wolfgang Hofkirchner (2013). A little earlier, in 2007, as a part of the edition of the "Handbook of the Philosophy of Science", proceedings of Philosophy of Information were published by the editors Johan van Benthem and Pieter Adriaans. The proceedings brought into one place eminent authors from different scientific fields, among others, L. Floridi, F. Dretske, K. Devlin and J. MacCarthy (Benthem, J. V. and Adriaans, P. (Eds.), 2007).

In library and information science, there has also been illumination of this phenomenon. Under the editorship of researchers from library and information science, Fidelia Ibekwe-Sanjuan and Thomas M. Dousa, within the Studies in History and Philosophy of Science series, proceedings entitled "Theories of information, communication and knowledge: a multidisciplinary approach" was published (Ibekwe-Sanjuan, F. and Dousa, T. M. (Eds.), 2014). Moreover, mentioning Floridi's General Definition of Information (GDI), presented in his book Philosophy of Information (Floridi, 2011) (in this book the author summarized the ten-year work on the issue of this phenomenon), as well as a book by James Gleick "The Information: A History, a Theory, a Flood" (Gleick, 2011) by the popular-scientific provenance, it becomes clear that information has become a passion of not a small number of researchers today.

Some authors, such as R. Cappuro, came to the conclusion in the 1990s that it might not be possible to build a unified theory of information (Cappuro et al., 1999) [7]. Ignorance of information becomes critical, as M. Burgin (2010) said, the more dependent society is on so-called computer processing of information. Is the term information really an elusive concept for any theory? Is it even possible to shed light on it? Or is information simply the sort of thing that one can truly define only ambiguously? However, with due respect to previously proposed theories and definitions of information, a concept of information that adheres to any information theory, from any field of human knowledge, is still lacking. And this work is also a contribution to this effort.

3. The knowledge acquisition process

3.1 "A science is defined by its problem"

By the example of Shannon's theory, it is easy to establish a link between a scientific discovery and its appropriate practical application. A scientific discovery, in this case, the formula for the transmission of 'internally coded' information, addresses the problem of its age—the problem of optimal signal transmission. Its solution led to definitions of several closely-related terms (information sources, information channels and noise), but not, according to most researchers, to an acceptable definition of information (including C. E. Shannon himself).

If "science is defined by its problems," as claimed by C. S. Peirce (Philosophical Writings of Peirce, 1955, p. 66), it might be appropriate to ask ourselves if there is such a problem for information science whose solution, in addition, offers an acceptable definition of information? In theoretical discussions, several problems of information science have been recognized. One of the most important problems of information science recognized by some researchers is the idea of information retrieval (e.g. K. van

Rijsbergen, P. Ingeversen, P. Vakkari etc.). Others have found it in the study of the phenomenon of relevant information (e.g. T. Saračević). For many researchers, the initial problem of information science is information explosion, the phenomenon of an enormous increase of printed publications that began in the nineteenth, but which definitely culminated in the mid-twentieth century.

According to V. Bush (1945), applying information and communication technology (ICT) was one solution to that problem. However, in the history of science, it is often the case that the solution of one problem in one era becomes a trigger for new problems in a following era. For many, massive ICT use has created a new problem—information flood (Gleick, 2011), characterized by the excessively publication of all types of content in digital form.

3.2 Knowledge acquisition as a problem of information science

However, if attention is drawn to the part of information science where there is a need to define the phenomenon of information 'bundled' with the related concepts of data and knowledge, one problem, according to the author of this article, particularly arises. This is the problem of human knowledge acquisition. In doing so, it should be noted that this paper does not intend to treat this problem from philosophical positions and, for example, wondering if any knowledge is possible at all. In addition, our intention is not to consider the problem from a pedagogical point of view, nor from the psychological background of the process. On the contrary, the focus here is on the knowledge acquisition process about the world in general, without having to know if this world really exists or if it is really accessible by our senses. Talk is always about the acquisition of human 'scientific knowledge,' whether it is a subjective or objective phenomenon [8].

It is important to point out that the knowledge acquisition process, as understood in this paper, has nothing to do with any scientific method yet, because it takes place *a priori*, before conducting any of scientific methods (such as induction or deduction, analysis or synthesis), at a fundamental level of the human relationship to reality. Therefore, this process is necessarily independent of conducting any scientific method at all. We believe that its basis lies in the interaction of related terms—data, information and knowledge—and expect that analysis of this process will discover the acceptable definitions of these terms in all scientific fields. In this way, all sciences are addressed, because, all scientists base their research on scientific data, which depends on their knowledge.

Besides Dretske's approach, in which information is viewed as "something that is required for knowledge" (Dretske, 1981, p. 82), a surprisingly small number of researchers write about this problem. It is worth mentioning the papers by M. MacKay (1969), E. Oeser (1976) according to Capurro and Hjørland (2003) and some Soviet information scientists, for whom only scientific information made sense and whose efforts were summarized by Belkin (1975). In her book, "Big Data, Little Data, No Data", C. Borgman (2015) approached data exclusively from a scientific point of view.

Borgman's definition of data addresses only scientific data, rejecting any notion of generalization that would be valid for other types of data (Borgman, 2015).

It is also important to point out that in the literature, there are two understandings of information that, at first glance, are incompatible with these proposed definitions. The first is information treated as a physical, objective thing in the world that exists independent of an observer (e.g. Stonier, 1990). The second, information seen as a subjective phenomenon, is dependent on the observer, often attributed the property of 'giving a meaning' (e.g. MacKay, 1969). In contrast, the concept of information that is considered here is inseparable from the related concepts of data and knowledge. Hence, in many cases, the terms data and knowledge seem more suitable to those parts of reality which are taken as objective or subjective information first. It is clear that this means that the 'objective aspect of information' is somehow correlated with data, and the 'subjective aspect', to knowledge.

Ordinary social situations, in which people transmit, receive and generally share information in a broader context, remain aside from this consideration. Therefore, the following considerations are special cases of a broader framework of acquiring not only scientific, but also practical knowledge that humans are ready to forget. They also handle human memory and experience. Generalization of the proposed framework to all situations should harmonize the notion of information in a broader context.

4. Bridging the gap in understanding the concept of information: information as a flow

4.1 Is information a subjective or objective phenomenon?

In a paper, "Mind the Gap: Transitions Between Concepts of Information and Varied Domains", L. Robinson and D. Bawden (2014) identify a crucial gap in the understanding of information in various fields of human knowledge by two thoroughly different approaches: on the one hand, information is taken "...as something objective, quantitative, and mainly associated with data," and the other "... as subjective, qualitative, and mainly associated with knowledge, meaning, and understanding" (Robinson and Bawden, 2014, p. 131). Qvortrup (1993) expressed a similar observation: "At the one end, information may be defined as a thing. At the other end, information may be defined as a psychic construction" (Qvortrup, 1993, p. 3). According to Qvortrup (1993), this dichotomy in the definition of the phenomenon of information leads to the problem of meaning in information theory. On the other hand, Cornelius (2002), on Qvortrup's trail, notes: "It seems accepted that at some point the data by perception, or selection, become information, which feeds and alters knowledge structures in a human recipient" (Cornelius, 2002 p. 394). Cornelius explicitly states that the difference between data and information will not be considered in his paper, because it seems that the relationship between information and knowledge is much more problematic. Qvortrup opposes this position; he drew attention to differentiation and establishing the relationship between data and information. Therefore, it seems that the mentioned review papers on information extraordinarily supplement each other.

One of the most comprehensive reviews of the concept of information was published in ARIST in 2003 by R. Capurro and B. Hjørland. Among other things, these authors distinguish between the objective and subjective aspects of information: "In our view, the most important distinction is that between information as an object or a thing (e.g., number of bits) and information as a subjective concept, information as a sign; that is, as depending on the interpretation of a cognitive agent" (Capurro and Hjørland, 2003, p. 396). According to Cappuro and Hjørland, "...almost every scientific discipline uses the concept of information within its own context and with regard to specific phenomena" (Capurro and Hjørland, 2003, p. 356). S. Brier (2014) supplements this view by claiming that some of them are rooted in the sciences—some in life sciences, some in the social sciences—and some in the humanities; therefore, they are often incommensurable [9].

However, most researchers managed to establish a consensus on some fundamental properties of information, although it appears that they have not explicitly elaborated within any theory. It was found that information has to be new to the recipient (informative), usually has to be encoded (whether or not this is necessary remains a question), is necessary for knowledge growth, has to be transmitted, and finally, is closely linked to data and knowledge. The last basic property of information will be examined in more detail in the following section.

4.2 Information as a flow ... (and previously, as a process)

As a result of the conceptual vagueness that fluctuates between two opposing poles of a fundamental understanding of information—as a thing and as a mental structure—it seems that conceptual-metaphorical designations of information 'as a process' (G. Bateson, R. Capurro and M. Buckland) and 'as a flow' (F. Dretske, J. Barwise and J. Seligmann) do not belong to any of these mentioned. Moreover, it seems that they can be placed 'somewhere' between an objective and a subjective understanding of information. It is hoped that this paper will show that these are concepts can help bridge perceived gaps in understanding information as an objective or a subjective phenomenon [10].

The definition of information as the 'difference that makes a difference' (Bateson, 1972) represents a typical example of a definition in which information is realized 'as a process.' Although 'difference' takes causal and consequential roles in this definition—a causal role as a 'difference' that occurs in the external world and consequential role as a difference observed by the observing system—the verb 'to make' still plays a key role, embodying the procedural nature of information.

Besides Bateson, Cappuro (1991, pp. 82) takes information "...as a more or less adequate metaphor, to every kind of process through which something is being changed or in-formed."

In the literature, a view of information by Michael Buckland (1991) is very often cited, in line with an increasingly frequent understanding of that term 'as a process.'

Buckland notes "three principal uses of the word 'information'": in addition to information-as-process, which he seems to be closest, information has been identified as a thing (information-as-thing) and as knowledge (information-as-knowledge) (Buckland, 1991). A correct understanding of the concept of information-as-process arises from understanding the specific information action. Buckland thinks that information, by itself, may not even exist; what exists is a process of transmitting it from one place to another, from one individual to another. The literature often cites his statement: "Since information has to do with becoming informed, with the reduction of ignorance and of uncertainty, it is ironic that the term "information" is itself ambiguous and used in different ways." (Buckland, 1991, p. 351)

On the other hand, one of the biggest advocates of the idea of 'information flow' was a philosopher, Fred Dretske. He elaborated this idea in his book "Knowledge and information flow" in 1981. According to Brier, "Dretske defines information as the content of new, true, meaningful, and understandable knowledge" (Brier, 2014, p. 29). For Dretske, it seems that information as a flow simply merges into the pool of individual knowledge. However, unlike the point of view by the researchers from Library and Information Science, Dretske holds information as an objective, but at the same time, relative phenomenon in relation to the recipient's knowledge (Dretske, 1981). Relativity of information in this case arises from the recipient's knowledge of the situation in which they receive information, not from the knowledge sources or by the information channel through the information arrives to them.

Based on Dretske's idea, Barwise and Perry have developed a situational information theory (Barwise and Perry, 1983). According to this theory, the flow of information is formed depending on the particular type of situation and leads to knowledge growth.

The phrase 'information flow' can be found in a book by Jonah Barwise and Jerry Seligman, "Information Flow: The Logic of Distributed Systems", from 1997 that is concerned with the logical formalization of Dretske's approach to information (Burgin, 2010). By all proposed theorems in this book, Barwise and Seligman have dealt with one issue that had been also troubling Albert Einstein, mostly by the philosophical provenance: "...how is it that science, with its use of abstract mathematical models, carries any information at all about the real world?" (Barwise and Seligman, 1997, p. 174). In an attempt to respond to this question, Barwise and Seligman reached the phrase of 'information flow,' which they define as a stream of a binary information channel (C) which connects reality (D) and its idealization in our mind (Q) (Barwise and Seligman, 1997). We think this is an important finding that made an impact on other theories in various fields of human knowledge.

If the specific information action of a specific process is examined, one may ask: what is the 'tangible' substance of this process? We believe that the answer to this question can only be: the flow of information. This provides sufficient grounds to reject the conceptual-metaphorical designation of information 'as a process' in favour of 'flow.' Information taken 'as a flow' can find a place in almost any of the above-mentioned information theories and trends, with the exception of those in which it has been taken to the extreme, as a purely objective or a subjective phenomenon. Therefore, within the Shannon's theory, the amount of information conveyed through the information channel from the sender to the recipient bears the clear allusions to information understood 'as a flow.' In the same manner, Qvortrup (1993, p. 5) has talked about information as *'water in the water pipe'*. In cognitive terms, the information is also something which merges into knowledge, allowing its growth. Ultimately, Brookes' *'fundamental equation of information science,'* although expressed in pseudo-mathematical form, at a conceptual level clearly demonstrates the same thing, including the expression of information as a ΔI (information increment/inflow) in his equation (Brookes, 1980, p. 131) [11].

It is clear that this paper stays close to Shannon's theory. With that choice, the border which separates the objective from the subjective understanding of information is at hand.

4.3. Information as a flow ... between data and knowledge!

4.3.1 Information and related concepts of data and knowledge: the unsustainability of DIKW hierarchy. Despite the gap in understanding information in a various fields of human knowledge, it seems that differences in its use are crystallized in common speech in relation to data and knowledge. As in the case of the fundamental properties of information, a consensus on this issue has more or less been achieved, although it appears not to be explicitly elaborated in any theory. For data, colloquial speech says that may be damaged or deleted. That claim will never be made for information; rather, information is vague, ambiguous, or can (not) be accessed. In the same sense, one speaks of having or not having sufficient knowledge to do something. Belkin claims that knowledge, in its initial form or stage, is always insufficient, as the 'anomalous state of knowledge' generates our need for information (Belkin, 1980).

This chapter will examine more closely an intuitive understanding of information that has recently been unavoidable in Library and information science (LIS) and information connected with the two, related phenomena of data and knowledge. Understanding of the relationship between these terms found expression in the symbolic figure of the pyramid (or triangle), known in the literature as the Data-Information-Knowledge-Wisdom (DIKW) hierarchy. The lower layer is data (largest surface area and volume of the pyramid). The first intermediate layer, above data, is information. The knowledge layer is located above the information layer, while the wisdom layer is located at the top of the pyramid (the minimum area/volume of the pyramid), as shown in Figure 1.

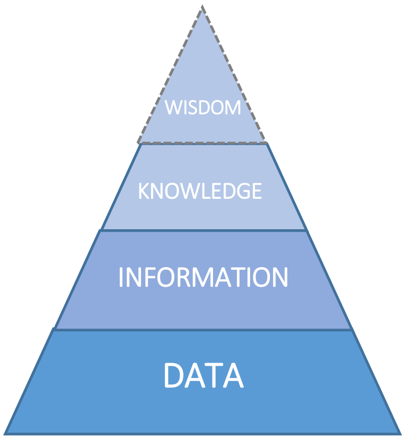

Figure 1 - DIKW hierarchy in its simplest form.

The conceptual model (although, it seems that is only a symbolic representation) was described in the literature by J. Rowley (2007), C. Zins (2007) and M. Fricke (2009) in LIS and M. Green (1987), R. Acoff (1989) and A. Liew (2007) in the field of knowledge management (KM). Focusing on the concise, figurative interpretation of DIKW hierarchy, more or less, a consensus is reached. This consensus is presented in a paper, "The wisdom hierarchy: representations of the DIKW hierarchy" by J. Rowley: "There is more data than information, than knowledge, than wisdom. ... The hierarchy with its broad base of data is safe, secure and stable. Wisdom is only attained after much processing of data, information and knowledge, and the process starts with data" (Rowley, 2007, p. 175).

Based on the above considerations, M. Alavi and Leidner (2001) conclude that information is transformed into knowledge when it is processed by the human mind, and knowledge into information when it is presented in the form of text, images etc. The key implications of their interpretation reflect the fact that individuals who want to have the same understanding of specific data and information must have identical structure and knowledge of the world around them.

However, Zins (2007) asks whether or not such a viewpoint of the relationship of data, information and knowledge is sustainable in his study "Knowledge Map of Information Science". In this study Zins, through the Delphi method, succeeds in documenting 130 definitions of data, information and knowledge by 45 experts from the field of Library and Information Science. Zins notes that all three phenomena and concepts undoubtedly correlated with each other, but at the same time concludes that the nature of their relationship is disputed, as is, after all, their meaning. In other words, in many fundamental issues concerning the fundamental concepts of information science, DIKW hierarchy is not helpful in this form (Zins, 2007). The same opinion quotes Cappuro, as a participant of Zins' research; he considered the concepts of data, information, knowledge and wisdom to be irreducible, proclaiming the DIKW hierarchy as a fairy tale (Zins, 2007, p. 481). Finally, Fricke (2009) proposes abandoning the DIKW hierarchy because of the key logical error at its core, reflected in the pre-assumed truth of all DIKW's constituents.

In other words, despite that is really only a purely symbolic view, the concept of the DIKW hierarchy in this form has proved to be insufficient to describe the many complex relationships of its concepts. We believe that this viewpoint has to be extended, or, more specifically, tailored. This will be done in the next section, in accordance with the pre-selected conceptual and metaphorical designation of information as flow.

4.3.2 Redrawing of DIKW hierarchy. According to Capurro and Hjørland, theoretical concepts in scientific discourse "… are not true or false elements or glimpses of some element of reality; rather, they are constructions designed to do a job in the best possible way" (Capurro and Hjørland, 2003, p. 344). The same authors also refer to Chalmers (1999), who has noted that Isaac Newton could not give a definition of weight and force in the terms of old scientific vocabulary and was forced to develop new concepts. For Galileo, in turn, Chalmers said: "It is hardly surprising that—contrary to popular myth—his [Galileo's] efforts involved thought experiments, analogies and illustrative metaphors rather than detailed experimentation. This situation is understandable if it is accepted that experimentation can only be carried out if one has a theory capable of yielding predictions in the form of precise observations" (Capurro and Hjørland, 2003, p. 348). Based on Chalmers' considerations, Capurro and Hjørland proposed "that the scientific definitions of terms like information depend on the roles we give them in our theories" (Capurro and Hjørland, 2003, p. 348).

Bearing that in mind, attention now turns to the design of a new symbolic representation of information 'as a flow' at the conceptual level. The information layer of the DIKW pyramid took the form of the channel through which information 'flows' from the 'data layer' towards the 'knowledge layer,' and vice versa. This yields a new symbolic representation of the DIKW hierarchy, shown in Figure 2.

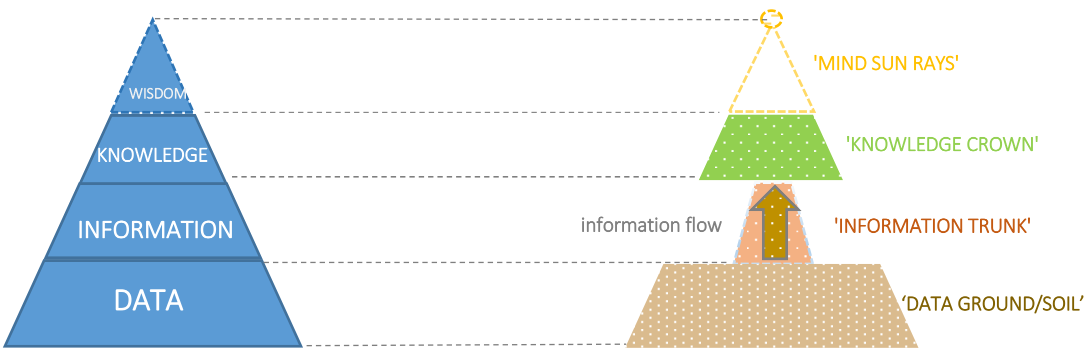

Figure 2 - 'The DIKW Tree'—a new symbol of data, information, knowledge and wisdom relations, developed by the simple redrawing of the DIKW pyramid.

In a figurative sense, it is obvious that this is not a pyramid anymore, other than the glimpse that rather reminds one of a tree, with a 'knowledge crown' and 'information trunk,' which relies on a 'data ground/soil.' For simplicity, this picture is, temporarily, called the 'DIKW Tree.'

As it is immediately evident, the 'wisdom layer' lost its 'material embodiment'; it is represented only by the 'mind sun rays,' which is a new element of the symbolic representation of DIKW relations. In this sense, it is easy to establish an analogy between the light of the sun and the growth of an ordinary tree, on the one hand, with the 'mind sun rays' and growth of the 'crown of the DIKW Tree,' on the other. Accordingly, it can be said that 'mind sun rays' symbolize man's faculty for abstract thought, which is necessary for the adoption and organization of knowledge.

Furthermore, if the DIKW pyramid equally emphasized the structural and functional aspects of DIKW relations by interpreting the key concepts contained in it, this picture of the 'DIKW Tree' particularly emphasizes the functional aspect. This is logical, because of the information flow it includes. If information, in accordance with its designation of 'flow,' is understood as some sort of *sap* which runs throughout the tree, from the roots to the crown and back, it is clear that trunk of the 'DIKW Tree' no longer has an informational character. By its composition, it seems that is far closer to the crown or roots of the 'DIKW Tree' than to the 'information sap' or 'data ground/soil.' In other words, no obstacle is seen in the fact that all tangible, solid parts of the tree (a crown, a trunk and roots) are understood as a whole of actual, controlled, comprehensive knowledge which was previously grown. On the basis of this conclusion, a new name is suggested for the symbolic image of the 'DIKW tree' in the context of 'data ground/soil,' where it is growing, and 'information sap,' with which it is filled; it is a 'tree of knowledge.'

The 'knowledge tree' also has this meaning only as a purely symbolic representation of the relations between information, data and knowledge. However, because of its evident functional character, this representation can also symbolize the knowledge acquisition process. Therefore, it does not seem excessive if, given the functional character of the 'tree of knowledge,' the analogy of an ordinary tree is suggested. In other words, considering the information that really flows through the parts of the 'tree of knowledge,' then it seems there is no problem interpreting this phenomenon by an analogue of biological processes that occur in ordinary trees. If this is successful, the contours of an area may be drawn for a complete and consistent information theory, although only from a symbolic-metaphorical standpoint.

5. 'Tree of knowledge': a symbolic representation and metaphorical interpretation of the knowledge acquisition process

5.1 Introduction

5.1.1 Previous meaning of the term 'tree of knowledge.' Colloquial speech also often represents the knowledge concept by the tree symbol. In Croatia, to all school children, 'lovers of science,' there is a well-known magazine named 'Knowledge Tree.' On Wikipedia, the phrase 'Tree of Knowledge' refers to several meanings. Undoubtedly, the most famous is the one that refers to the 'Tree of Knowledge of Good and Evil.' In addition to Biblical references, other uses of that phrase, including mention of the

Croatian magazine, are related mainly to published books and films [12]. Indeed, in countless cases, knowledge is 'something that has grown,' and which can be renewed, but also which can 'dry up'. 'The ground' in which the 'tree of knowledge' is planted, in an appropriate analogy, could be seen as 'data ground/soil.' And, what largely nourishes the 'tree of knowledge' that grows on the 'data ground/soil,' is 'information sap,' which simply rises from its roots to the top! This is, of course, too simplistic an image, but it will serve as the basis for making the image of the 'tree of knowledge' more explicit below.

5.1.2 Description of growth of an ordinary tree (a small reminder of biology). First, briefly, the growth of an ordinary tree will be discussed, as interpreted by modern biology. As every child in school knows, a tree consists of roots, trunk and tree crown. Through the roots, it receives (or takes?) water and nutrients from the soil. Turned into sap, water and nutrients begin to settle, already at the root branches enabling their growth in length (primary or extension growth), or their thickening (secondary growth). In addition to these options, they can funnel to the trunk, and from there, to the tree crown, through the xylems (the specific cells in the form of tubes). Via the xylems, sap rises rapidly over longer distances, usually when it 'travels' to the tree crown. Biology has no clear answer to which way the water and nutrients reach the tree crown. According to some opinions, the osmotic pressure by the process of osmosis, which comes from the soil, allows the transmission of water and nutrients through the cell's membrane in height. According to others, the process of transpiration or water evaporation from the leaves is responsible for this. The process of transpiration can be described as a process in which solar energy creates a vacuum in the cells closest to the sun, leading to water evaporation. The sap, which is located in the neighbouring cells below, is simply sucked by the vacuum cells, and the process is repeated. In other concepts used in biology, and for the purposes of this analogy, the phloem, some sort of xylem with inverse function, is emphasized. By the phloems, the products of the process of photosynthesis, which takes place in the leaves of trees, are forwarded to other parts of the tree, including the trunk and roots. Finally, the important role of our sun as a source of light and heat must be emphasized for the smooth conduct of the photosynthesis and transpiration processes in the leaves of the tree.

5.2 'Tree of Knowledge' as a symbolic representation

5.2.1 The symbolic description of the 'tree of knowledge.' Figure 3 shows the deployment of scientific fields in the 'knowledge tree crown,' accentuating their position on the boundary constituents of this symbolic representation—'data ground/soil' and 'mind sun.' Thus, natural and technical sciences are deployed at the bottom of the knowledge crown, nearest to the 'data ground/soil,' symbolizing their relatively straightforward access to data from the 'outside world,' as opposed to other sciences. They are not interested much in what is going on above them. You can imagine that each branch of the tree crown in 'the area of natural and technical sciences' belongs to one discipline which further forks into other branches, its subdisciplines etc. For example, the central branch of the tree, which comes out of the trunk, may belong to physics; the lateral branches of first-order may belong to chemistry and biology. The lateral branches of second-order are their subdisciplines; in the case of physics: astrophysics, nuclear physics and particle physics. In the case of chemistry, it would be organic and inorganic chemistry etc. In the middle of the tree the social sciences are settled, in a very different environment than that of the natural and technical sciences. The branch of sociology is located in its middle. It interprets all relations in the world on the basis of the 'information sap' running throughout the tree crown. This situation cannot be different, because of sociology's position; it can only 'feel' the other branches and leaves.

In the case of natural sciences and engineering, one can imagine that each branch of the tree crown represents a social discipline and every twig its subdisciplines. Going even further, each leaf on the branch may represent, in a metaphorical sense, a scientific theory. Along the edge of the 'tree of knowledge' crown, the humanities are deployed. Each branch might represent a humanistic discipline, and every leaf on a branch represents a humanistic scientific theory. The sun sends most of its rays to philosophy, which is placed on the tree top, then to the other humanities disciplines. This is an important conclusion: beside by the 'information sap' which is coming from 'data ground/soil,' the growth of the 'tree of knowledge' crown is also undeniably affected by the 'rays' of our 'mind sun' above it.

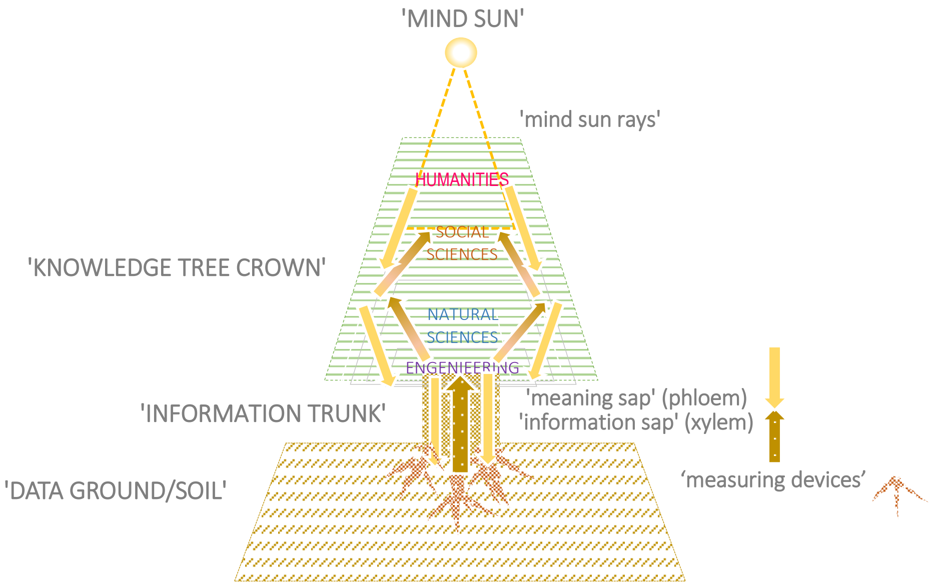

Figure 3 - 'Tree of knowledge' - a symbolic representation of the different perspectives (scientific fields) of knowledge acquisition.

The 'tree of knowledge' trunk can be viewed as a major information conductor. One might think that its growth could symbolize the growth of ICT development, which is common, and that, accordingly, may fall to engineering. In terms of natural and technical sciences, nothing prevents that, except the tree crown, other parts of the tree, such as tree trunk and even roots also proclaim their knowledge. Surely, a strict distinction here is not necessary in this paper, as long as one points out only the differences between the positions of natural and technical sciences and that of social sciences and humanities in the context of the tree of knowledge.

Below the tree trunk, and already immersed in 'data ground/soil,' lies the 'tree of knowledge' roots, which mainly symbolize the measuring devices and other tools used to retrieve data in each field of science. Of course, the most common devices belong to the researchers from the natural sciences. In addition, the roots of the 'tree of knowledge' can symbolize knowledge about particular methods and techniques that are used to retrieve data in each field of science.

5.2.2 Some objections to symbolic description of 'tree of knowledge.' However, at this point, at least two objections can be already made to our symbolic description of the 'tree of knowledge.' The first objection concerns the apparent discrepancies between an unquestionable information property that it has no effects on the data structure from which it is extracted and the analogue property of 'information sap' required to really take 'data ingredients' from the 'data ground/soil.' The second objection is related to the vague way in which researchers from the social sciences and humanities access data; for example, how could one present a book as a source of information by such a conception?

Regarding the first objection, it is clear that 'information sap' has to be such that its extraction from the 'data ground/soil' does not violate the data structures. It is obvious that the letters remain in a book and after they are read. Hence, it is clear that 'information sap' is not and cannot be a 'sap' in the normal sense of that word, as found in an ordinary tree (such a 'tree of knowledge' is not usually a tree that can be found in nature). By all means, its composition and, thus, nature are specific. If it is nothing taken by the process of extraction from 'data ground/soil,' the only acceptable solution is to imagine that 'information sap' is created by mapping 'data components' from 'data ground/soil,' which at a given moment, had been lying on the tops of the 'tree of knowledge' roots. In this way, one can think about 'information sap' as some sort of electromagnetic phenomenon (nonetheless, in a real or figurative sense) [13].

Regarding the second objection, it appears that neither the retrieval method nor the data storage location of the data is understandable by social sciences and humanities researchers, at first glance. Perhaps it is 'buried' in the 'data ground/soil,' together with natural sciences researchers' data? Perhaps it is coming from root branches or tree branches of another 'tree of knowledge' close by?

Apart from these possibilities, the image of the 'tree of knowledge' offers still another possibility: the research data of the social sciences and humanities can be easily taken as knowledge of other researchers which flows from other branches via the 'information sap.' This paper insists precisely on this last meaning. However, to understand this point of view, the reader must use great power of abstraction in imagining. You can imagine that 'information sap,' immediately after its creation, comes into contact with the existing 'solidified knowledge' of the 'tree of knowledge,' which symbolizes the 'xylem walls.' Because the process of mapping must continue to take place within the xylems, there is some sort of 'infecting' of 'information sap' by existing knowledge. This 'infection' already takes place in the root of the tree. We can easily say that existing knowledge of methods and techniques, via which 'data ingredients' are retrieved from 'data ground/soil,' is also mapped into 'information sap,' together with the source 'data ingredients.' In some respects, the 'ingredients of existing knowledge,' on which the scientific research data greatly depend, offer the metaphor of Kuhn's concept of scientific paradigm, which he mentioned in his influential book, "The Structure of Scientific Revolution" (Kuhn, 1962). In general terms, existing knowledge can simply be realized as the literal knowledge of previous researchers. This means that the 'infection' of 'information sap' by the existing knowledge happens 'even' to researchers from the natural sciences. This is logical, because the context of their own research forces them to rely on the knowledge of their predecessors. However, the effect of 'infection,' definitely, is the most intense in the knowledge tree crown, where 'information sap' is exposed to far more influence by the surrounding knowledge. In an extreme case, one can imagine that the 'information sap' is composed almost entirely of mapped 'knowledge ingredients.' The remaining source 'data ingredients' could be applied only to the storage medium of that knowledge. (This could be a book, but also a computer screen.) That is exactly the case; research data from the social sciences and humanities can be recognized in the existing knowledge of their predecessors [14].

It would be very interesting how this understanding of the nature of data, information and knowledge could be applied to realizing the process of receiving information from the computer. Here, it is extremely important to realize how all content stored on computer memory units is, in fact, its 'knowledge,' although it is pure data. In this case, a memory unit is a 'computer head.' A computer also retrieves its source data exclusively from the 'outside world.' However, what a computer is missing in the knowledge acquisition process is the much wiser 'mind sun.' In other words, it is missing artificial intelligence, which is more effective in organizing knowledge intelligently; among other things, this is the main reason why computer 'knowledge' is 'seen' today as only data [15].

By this symbolic picture, it is also necessary to clarify and try to imagine the case of representation and data access from questionnaires. It is important to emphasize that it is obviously 'source data,' and not some sort of existing knowledge. Accordingly, a 'tree of knowledge' picture suggests that they must be located in the 'data ground/soil.' However, it is obvious that you cannot find them there, because the 'data ground/soil' represents only data from the 'outside world.' When you think about it, you may only come to the conclusion that their source must lie somewhere above 'data ground/soil' in an area on which the 'mind sun' shines. That is it because filling out the questionnaire puts actual human consciousness out of action, which produces pure data about itself and its views about the 'outside world.' That is a reason why the origin of this kind of data must lie somewhere above the 'data ground/soil.' In addition, the impact of our current mood in the process of filling out the questionnaire should not be forgotten. One may recognize the symbol of this impact in an atmosphere that reigns above the 'data ground/soil.'

In a broader sense, the ingredients of the atmosphere that surrounds the 'tree of knowledge' represent, as a whole, human consciousness. Many of those 'atmospheric ingredients' set down to the ground; some of them can be recognized as source data from questionnaires. In the form of 'air pockets,' they could penetrate deep into the soil, where a root branch of the tree could extract them and convert into 'information sap.' These are, perhaps, fragments of human consciousness that produce data on the basis of what they 'know' in a particular moment. But they can also be bits of consciousness not directly linked with personal knowledge, referring to data based on what one fragment of consciousness feels or has experienced. In both cases, one consciousness can give answers to the questionnaire, which can be regarded as sufficient research data for the social sciences.

In this way, one may conclude that a new symbolic representation of DIKW relations, at this level of interpretation, can differentiate at least three types of data: *source data*, which was retrieved at the tips of the tree roots (and which belong exclusively to the 'outside world'), '*data of existing knowledge*,' mainly stored in the tree branches, and '*data of atmospheric ingredients*,' which may be set down to the ground and extracted to 'information sap' by the appropriate root branches of the 'tree of knowledge.'

This way of understanding data agrees very much with our experience in the real world! Knowledge of an individual, informed by conversation with them, before it establishes itself as personal knowledge of our own and not necessarily equally (because of the noise of the information channel), at least, at the beginning of the conversation, in a short period of time and in its original form, represents only data [16].

5.2.3 The symbolic interpretation of the reason for different views on information from scientific fields. To determine, in a given symbolic sense, the possible reason for a different view of information from various scientific fields, it will be considered how the scientific fields from their position or perspective in the 'tree of knowledge' image experience 'information sap' or information. As an example, the growth of knowledge of researchers from the natural and social sciences will be compared. Symbolized by position immediately at the bottom of the 'tree of knowledge' crown, natural sciences (and engineering) researchers' knowledge is built on the basis of what it has taken directly from the 'data ground/soil' by experimental observation. For researchers from the natural sciences, 'data ground/soil' is the 'outside world.' From this perspective, 'information sap' or information itself must appear objective, as something that is literally taken from reality and has changed its form only inside the 'tree of knowledge.' To know more about the 'information sap,' for example, something about its quantity or flow rate, a natural sciences researcher will credit mainly factors prevailing at the root and the trunk of the tree. This will be achieved by 'looking' from the bottom of the crown. The researcher will do this, after all, because these factors are the most accessible to them. In addition, insights may be drawn that the angles of the twig roots are very different compared to those prevailing in the crown; perhaps they thought that 'information sap,' in its straight-line movement through the trunk, tends to accelerate or decelerate. There are other factors that a researcher from the natural sciences should include in the calculation, such as the composition of the sap, its degree of transparency or the effect of its 'infection' by existing 'solidified knowledge' (mentioned in the previous section).

On the other hand, the knowledge of researchers from the social sciences, symbolized by the branches and twigs in the crown of the tree, is primarily based on information that comes from the local branch and was reduced to a reinterpretation of the knowledge of other researchers in their scientific fields. Some of the source data flows from the 'data ground/soil,' but following the discussion in the previous section, most of it originates from other branches. If a researcher from the social sciences would like to establish their own 'information sap law' of some sort, the calculation will not coincide with that by a researcher from the natural sciences. In his 'formula' (or only definition), a hundred 'different' forks must be included that dominate the interior of the crown. From his point of view, the law of 'information sap' flow largely depends on the structure of the tree crown, rather than on what he originally carried—some sort of space-time message from the ground or the surrounding atmosphere. We can assume that the 'information sap' is 'infected' by passing through other parts of the tree, on its way to the crown of the tree. Consequently, inside the tree crown, it necessarily has a different composition compared to that in the trunk. However, it cannot be said that a branch of sociology, located in the middle of the 'tree of knowledge' crown, has not the best view on the structure of the tree crown as a whole. This leads to the conclusion that the 'information sap,' or the information itself, is only a communication tool, a 'social construct' of all branches in the region—in other words, something that is subjective.

Of course, it does not matter which factors enter into the so-called 'calculation' of researchers from the natural and social sciences. All of these are only metaphors, symbols. It is only important to note that, whatever they may be, in the context of the 'tree of knowledge,' they must vary considerably, relative to one another, with respect *to the position* they occupy in the given picture. In other words, differences in the interpretation of the nature of 'information sap' that circulates through the 'tree of knowledge' are in a function of the position of the individual branch or another part of the 'tree of knowledge,' which measure and interpret. As it will now be shown, this interpretation will help bridge the gap in the perception of information as a purely objective or subjective phenomenon.

5.3 Metaphorical interpretation of the knowledge acquisition process

5.3.1 Functional character of the 'tree of knowledge.' So far, this paper has dealt with only static aspects of the 'tree of knowledge' by exposing them, more or less, through the intuitive symbolic description. It is time to consider its dynamic nature, which is reflected by its functional character. The interpretation of the functional character of the 'tree of knowledge' will be based on the analogue interpretation of the functional character of ordinary trees, as interpreted by modern biology. The functional character of an ordinary tree is primarily associated with three processes: osmosis, transpiration and photosynthesis. In an appropriate analogy, views on the interpretation of the processes of 'osmosis,' 'transpiration' and 'photosynthesis' within the 'tree of knowledge' are given.

5.3.2 Interpretation of 'osmosis' and 'transpiration' in the 'tree of knowledge.' To find the answer to the question of how 'information sap' rises in the 'tree of knowledge,' the processes of 'osmosis' and 'transpiration' must be investigated. On this issue, modern biology does not provide a clear answer. According to some, an osmotic pressure (by process of osmosis) is responsible for the sap rising in a tree; the soil itself produces that pressure on the tips of the tree roots, forcing them to receive water and nutrients into a tree. For others, the sap rising is caused by the transpiration process, which uses heat energy from the sun; this energy further leads to sap evaporation from the leaf of the tree. The analogue interpretation of both processes will be examined in the context of the 'tree of knowledge.'

'Osmotic pressure,' through which 'data ground/soil' 'presses' and induces the tops of the 'tree of knowledge' roots is identified as the main cause of the process of 'osmosis' in the 'tree of knowledge.' By 'osmotic pressure,' the 'ingredients' from the 'outside world' did not only pass through the 'xylem' of the 'tree of knowledge,' as already mapped 'data ingredients,' but can move to the top via the 'information sap.' Of course, the osmotic pressure does not explain anything about the conversion of 'outside world ingredients' to 'data ingredients' and, therefore, 'data ingredients' into 'information sap.' It only suggests the way in which information is eventually perceived. If 'pressure' or impulse is coming from the 'data ground/soil,' which has been demonstrated in countless biology experiments in an ordinary tree, then information can be viewed as a 'difference that makes a difference,' according to Bateson (1972). In other words, it can be considered as something objective. In this case, the phenomenon of 'osmotic pressure' can be taken as a metaphor of 'objectivity of the world.'

On the other hand, there is no doubt that 'mind sun heat' is a key factor for the transpiration process of the 'tree of knowledge.' Thence, this 'energy' is responsible for the creation of some sort of 'vacuum,' the gaps in our knowledge, in the cells of the tree closer to the 'mind sun.' Consequently, these gaps are a metaphor for information needs. Because a 'vacuum' exists in 'knowledge cells,' 'information sap' located in the lower cells may simply be sucked into them. In this way, the 'heat' of the 'mind sun' encourages the movement of the 'information sap' from the lower to the higher parts of the 'tree of knowledge.' In this sense, the information is regarded as a 'difference in mind (movement of 'mind sun heat') which finds the difference (movement of 'information sap') from the outside world' (Qvortrup, 1993; Luhmann, 1990). Nonetheless, considering that part of the 'information sap' may even evaporate from the leaves of the tree, the information might seem subjective (although, the process of 'transpiration' primary does not refer to this conclusion). The most important conclusion is reflected in the fact that the 'heat' of the 'mind sun' can be taken as a metaphor for 'human curiosity.'

As already mentioned, except for movements of 'information sap' through the tree, 'heat' from the 'mind sun' encourages its evaporation from the leaves of the 'knowledge crown.' It is easy to imagine an evaporation of all types of information that, for some reason, could not be retained in 'branches' of the 'tree of knowledge.' Think about your daily experience, how much you have heard about many things and do not remember: How much information did you receive, and how much only ''passes through'? This experience can lead to the conclusion that, according to this view, even misinformation is a kind of information (contrary to the opinion of the philosopher Dretske). Due to its inability to establish knowledge, this kind of information is permanently forced to evaporate from the leaves of the 'tree of knowledge' [17].

In the big picture of things, the circulation of 'information sap' within the 'tree of knowledge' can be seen as a general metaphor for perceiving information in the knowledge acquisition process.

5.3.3 The interpretation of the process of 'photosynthesis' within 'tree of knowledge.' To answer the question on how the 'mind sun' affects the growth of 'tree of knowledge,' one must turn to the interpretation of the 'photosynthesis' process that takes place in its leaves.

If sunlight is the primary source of energy in the process of photosynthesis within an ordinary tree, then the 'light' of the 'mind sun' can be seen as the primary source of energy for the 'photosynthesis' process of the 'tree of knowledge.' Various organic nutrients originate as products of this process in an ordinary tree. By analogy, specific ingredients closely related to 'knowledge ingredients' in the 'knowledge crown' are also generated in the leaves of 'tree of knowledge' by the 'photosynthesis' process. These ingredients, 'conceptual ingredients,' metaphorically represent our ability to adopt and organize knowledge in general. In particular and above all, the 'conceptual ingredients' are the metaphor of the inherent capabilities of our mind that attaches meaning to everything that can be distinguished. As 'data ingredients' get through the tree as a part of 'information sap' by 'xylems,' the 'conceptual ingredients' do the same thing as part of its kind of sap, but by 'phloems,' in the opposite direction of the 'information sap.' Bearing in mind that these processes take place within the 'tree of knowledge,' and it is not an exaggeration if the 'sap,' which contains these 'conceptual ingredients' is called 'meaning sap.' Based on the fact that it can reach even the tree roots, the importance of 'meaning sap' in the 'tree of knowledge' growth processes is evident.

In a general sense, the circulation of 'meaning sap' through the 'tree of knowledge' can be taken as a metaphor of *'process of attaching meaning to information'* in the knowledge acquisition process.

5.3.4 'Information' and 'meaning sap' within 'tree of knowledge' as a metaphor of information flow and the 'flow' of attaching meaning in the knowledge acquisition process. Of course, many questions, even from this symbolic-metaphorical perspective, still remain unanswered. For example, one may ask how 'data ingredients' are created, or how 'information sap' is created. And how is 'information sap' mixed with 'meaning sap' and cured into 'ingredients of knowledge'? Unfortunately, the proposed symbolic representation and metaphorical interpretation of the functional character of the 'tree of knowledge' cannot provide answers to these questions. However, they do detect the existence of not one, but two flows which are mainly responsible for the growth of this 'tree.' In addition to 'information flow,' there is also a 'flow,' in the reverse direction, tentatively titled 'a flow of attaching meaning.' This flow is claimed to arise as a pure result of human abilities for abstract thinking; among other things, to things in the world—attach a meaning.

Accordingly, our basic idea concerns the attitude that the two flows are responsible for the overall growth of the 'tree of knowledge,' and hence overall knowledge. One is related to the flow of 'information sap' from the roots to the tree top, partly caused by 'osmotic pressure' by the 'data ground/soil,' and partly by 'heat' from the 'mind sun' in the process of 'transpiration.' Others, 'meaning sap,' are created as a direct result of 'mind sun rays' in the 'tree of knowledge' leaves, which can be lowered even to the roots. One moves via the 'xylems' of the 'tree of knowledge,' and the other by the 'phloems.' Though how specifically these two flows cause the creation of 'solid' 'knowledge ingredients,' enabling the growth of 'tree of knowledge,' cannot be described, this symbolism is powerful enough to conclude that these two flows within the 'tree of knowledge' carry most of the key components of which the 'tree' is ultimately built.

In a much smaller but not insignificant effect, part of the components and energy required for the growth of the 'knowledge tree' is concerned with what it receives from the atmosphere in which it is growing. In this regard, atmospheric effects ('rain clouds,' 'strong wind') to which the 'tree of knowledge' is exposed can be the occasion for a new metaphorical interpretation; but that one, this paper does not address here [18].

5.3.5 Bridging the gap in understanding information as an objective and subjective phenomenon. Does a metaphorical interpretation of the knowledge acquisition process help bridge the gap in understanding information as an objective and subjective phenomenon?

With a focus solely on information in a metaphorical interpretation, the flow of 'information sap,' can be viewed as occurring only within the 'tree of knowledge.' As such, the 'information sap,' or information itself, is a completely subjective phenomenon, since the 'tree of knowledge is entirely 'stretched' in our mind. On the other hand, it is evident that 'information sap' contains the mapping 'data ingredients' from the 'external reality.' It still cannot be said how those ingredients are incurred. Thus, in the proposed symbolism, information is subjective, because it is 'visible' within the 'tree of knowledge.' But at the same time, the information is objective, because it contains 'data ingredients,' which have an objective origin! They originate from the 'data ground/soil,' which undoubtedly belongs to the 'outside world.'

Another way of looking for possible causes of the gap in understanding information is interpreting the processes that are responsible for movement of the 'information sap' in the 'tree of knowledge.' If our image of the 'outside world' is influenced by 'osmotic pressure' from 'data ground/soil,' then our position closely relates to the objectivist approach to information, such as Stonier's approach. This means that 'osmotic pressure' from 'data ground/soil' appears as a 'pressure' to the senses from an unknowable but objective 'outside world,' to become recognizable. According to this understanding, the ability of distinguishing things in the 'outside world' cannot be attached to the inherent power of our mind. However, this feature is fully ascribed to the objective reality that surrounds us all. On the contrary, if 'heat' from the 'mind sun' is mainly responsible for the 'information sap' rising in the 'tree of knowledge,' then, this position is relatively close to the constructivist approach to information, like Luhmann's approach to information. Sucking unknowable reality within one's being on desire deformed by reality, one encodes it by codes only known to them, raising 'knowledge building' exclusively on its own measure.

However, it is quite possible that the processes of 'transpiration' and 'osmosis' take place in parallel in the 'tree of knowledge,' as is the case in an ordinary tree. That means that their effects are more pronounced in areas closer to their cause—osmosis in the roots and trunk, as well as in the lower parts of the tree crown, and transpiration in the middle and upper parts of the tree crown. In these cases, to observers of the process of 'osmosis,' information must seem to be an objective phenomenon (largely researchers from the natural sciences and engineering), and vice versa. To observers of the process of 'transpiration' (researchers from the social sciences and humanities), information must seem to be a completely subjective phenomenon that occurs and disappears by the human perception of reality.

6. Conclusion

The purpose of this speculative conceptual study was to examine the role of information in the context of the knowledge acquisition process, as well as the role of related terms, data and knowledge. To approach this problem, a particular symbolic perspective was opened to further metaphorical interpretation. The knowledge acquisition process is symbolized by the image of the 'tree of knowledge'. In addition, it was metaphorically interpreted by the analogous processes responsible for the growth of an ordinary tree (as interpreted by modern biology). In doing so, the symbolic representation of the 'tree of knowledge' itself was obtained from the conceptual definition of information 'as a flow.' Accordingly, the DIKW hierarchy pyramid is redrawn. These considerations enable understanding the diversity of views on information within the scientific fields. They also throw new light on the observed gap in the perception of information as an objective and subjective phenomenon, in the direction to overcome it.

The symbolic figure of the 'tree of knowledge' recognizes information as sap and identifies one of two key substrates that enable its growth. The 'data ground/soil,' in which the 'tree of knowledge' has grown, represents a symbol of retrieval and measurable 'outside world' (only that one that can excrete measurable data). Meanwhile, the tree crown may represent a symbol of man's explicit knowledge about the 'outside world.' We have also proposed that the trunk of the 'tree of knowledge' can symbolize a great conductor, a communication channel by which information is transmitted. In addition, its roots can represent the symbols of measuring instruments, devices, tools and different methods and techniques for retrieving data from the 'outside world.' Further, the possibility remains that any 'solid' part of the tree may symbolize certain knowledge, including those belonging to the trunk and roots.

However, our basic idea concerns the following proposal: the overall growth of the 'tree of knowledge,' and hence our knowledge, is affected by two—not one—flows of its core substrate. One is a flow of 'information sap' from the roots to the top of the tree. The second is a flow of 'meaning sap' driven by the 'mind sun rays' in the 'tree of knowledge' leaves. This 'sap' moves in the opposite direction to 'information sap,' which means that it may set down to the roots of the tree.

According to the proposed metaphorical interpretation of the knowledge acquisition process, based on the image of 'tree of knowledge' growth, information is recognized as a subjective but impersonal (meaningless), encrypted (mapped) flow (because it always transmits somewhere), an invisible 'communication tool' between data and knowledge. The role of information as an invisible link between two worlds, the 'world of data' and the 'world of knowledge,' might be not an original idea, but this paper holds that the idea is significantly deepened.

On the other hand, both of the processes—the process of 'data ingredients' excretion and the process of 'information sap' creation—inevitably remind one to the processes of coding and selection of one choice (message) from a given set of choices (messages) in Shannon's theory. But is it really possible to take these processes as a metaphor of processes which are the backbone of 'information theory'? This remains for discussion. If these opportunities are accepted in the context of this particular symbolic image, Shannon's theory would be then located at the very tips of the 'tree of knowledge' roots. However, these considerations produce a dramatic 'insight.' The knowledge acquisition process in this way is based on some kind of *'(en)coded reality'* (the process of 'data ingredients' excretion), and then on its perception/transmission (the process of 'information sap' creation)—and all because in order to increase human knowledge [19].

This image undoubtedly indicates that the ability to obtain 'data extraction' from the 'outside world' does not prejudge their meaning. It is sufficient that Shannon's theory is widely recognized as a valid information theory, but a theory which represents only a building block for a much broader information theory. A broader theory can no longer be considered separately from the concepts of knowledge and meaning in the context of knowledge acquisition. Therefore, the answer to the question about the 'solidification' of 'information sap' and 'meaning sap' within the 'tree of knowledge' in this paper remain unknown [20].

Perhaps the most impressive contribution of the proposed symbolic representation is the 'visibility' of information itself. Within a process of acquiring knowledge in the real world, the information will always remain hidden, as well as its meaning. In the real world, what is visible always refers to data. At the same time, knowledge is 'felt,' in some way, in the head. Hence, information not only appears as the value of this process, as concluded by Loose (1997), but it can also be taken as one of its parts. The fluidity of 'information sap,' which contains (en)coded 'data ingredients,' represents an important, but beyond the given symbolism, so far an unknown property of information which may refer to its procedural nature. The same conclusion may also refer to the 'meaning sap' composed of conceptual ingredients.' Hence, both processes that take place in reality, informing and attaching/giving a meaning, may actually not be distinguished by their nominal derivatives—information and meaning.

Information by itself has no meaning, but only with meaning can it be perceived and understood. This apparent contradiction seems to disappear once data, information and knowledge are examined through the perspective of one primary, higher-level phenomenon. However, the elaboration of this idea will be left for further reflection. Such reflection must rise above the restrictive, symbolic framework and offer new, entirely scientifically-based views on information.

Notes

[1] Hartley (1928), on the trail of work by Nyquist (1924), calculates a measure for the amount of information as the logarithm of the total number of possibilities of occurrence of an arbitrary string of symbols. This is expressed by the formula: $H = \log s$. Shannon's key generalizations consist of the probabilities in this equation. To be precise, the probability of a specific symbol in an observed sequence is calculated based on the equation for the amount of information. The final, generalized expression is: $H = -K \Sigma p_i \log p_i$.

[2] Although Shannon is not the author of the mentioned neologism, according to Shannon, it was created by J. W. Tukey (Shannon and Weaver, 1963, p. 32).

[3] As J. Gleick stated in his book (Gleick, 2011), it was the meetings sponsored by Frank Fremont-Smith and the Josiah Macy, Jr. Foundation that encouraged debate among experts in different scientific fields. Their conference on cybernetics, moderated by neurophysiologist W. McCulloch, was devoted to consideration of what, at that time, information and communication technology brought, as well as its prominence part—'information theory.' In addition to Claude E. Shannon, Norbert Wiener, John von Neumann, Heinz von Foerster and others who represented researchers from the natural sciences and engineering, the meetings were attended by Donald M. MacKay, Gregory Bateson, Margaret Mead and other researchers from the social sciences and humanities.

[4] A short overview of the work of biologists H. Maturana and F. Varela is given by L. Qvortrup (1993): "...according to Maturana and Varela, information is not a 'thing' or 'substance' in an observed system. First, ...the autopoietic system is a closed system. Second, ... [the autopoietic system] is a self-reference: the components must 'realize' the network that produced them." To explain how one autopoietic system affects others, Qvortrup reaches for a quote from the paper by the biologists: "... the autopoietic conduct of an organism A becomes a source of deformation for an organism B, and the compensatory behaviour of organism B acts, in turn, as a source

of deformation of organism A ...” (Maturana & Varela, 1980, pp. 120) in (Qvortrup, 1993).

[5] Accordingly, a theoretical physicist Craig Hogan at the Fermilab in the United States is building the detector on the principle of the interferometer. It should detect a slight tremor of space on the level of the Planck distance (1.616252×10^{-35} m). If these tremors make a confirmation in practice, Hogan claims it would make sense to talk about space as built by discrete, quantized units—bits of information (Moyer, 2014).

[6] These are the following books: “Theory of Information—Fundamentality, Diversity and Unification” by the mathematician M. Burgin, published in 2010, in which author proposes his own General Theory of Information (GDI); “Information and Computation—Essays on Scientific and Philosophical, Understanding of Foundations of Information and Computation”, a collection of papers that have been edited by Gordana Dodig-Crnkovic and Mark Burgin; and “Emergent Information—A Unified Theory of Information Framework” by Wolfgang Hofkirchner, published in 2013, in which the author considered a Unified Theory of information (UTI).

[7] According to Capurro’s trilemma (Fleissner & Hofkirchner, 1995), information can mean: anything equally at all levels (univocity); something similar at all levels (analogy); and something different at different levels (equivocity). Therefore, Capurro concluded that this is a concept with incredibly wide meaning, elusive for any theory.

[8] For example, realizing knowledge as an objective phenomenon is attributed to the Austrian philosopher Karl Popper and his concept of ‘three worlds.’ Often cited in the literature, Popper's idea of simultaneous existence of three worlds is related to: the physical world (World 1), the world of mental states (World 2) and the so-called Popper's third world—the world of objective knowledge or intellectual content of human thought (World 3). All that mankind ever spiritually created falls into Popper's third world, that is, scientific, artistic and literary works, as well as texts of religious traditions. According to Popper, there is no difference between information and knowledge—that is all ‘logical content’ that belongs to World 3.

[9] In his paper, Søren Brier (2014) aims to produce a transdisciplinary framework that allows interdisciplinary connections between information and related terms under the patronage of a relatively new discipline—cybersemiotics. The result is represented by the Cybersemiotic Star, which includes a fourth world and four different types of research topics: the three top stars, more or less, coincide with Popper's idea of three worlds, while the fourth star relates to the world of living organisms, which Popper might easily rank in the world of physical things. Brier says: “As a consequence of the widely shared perspective that human beings are embodied, feeling, knowing, and enculturated beings participating in semiosis and language processes, our analysis so far points to the fact that they can be seen as living simultaneously in four different worlds” (Brier, 2014, p. 37).

[10] The concept of information being developed as a part of the Unified Theory of Information also has the ambition to bridge the definitional dichotomy, but by completely different theoretical assumptions (Hofkirchner, 2009).

[11] Brooks' 'fundamental equation of information science' has the form: K [S] + ΔI = K [S + ΔS]. It can be interpreted as follows: knowledge structure K [S] changes with each new information inflow ΔI (Brookes, 1980).
[12] Among publications that have the 'tree of knowledge' phrase in their titles are the novel by Pio Baroja, the book by Marshall Cavendish and the book 'The Tree of Knowledge: The Biological Roots of Human Understanding' by Chilean biologists Humberto Maturana and Francisco Varela, previously mentioned in this paper. There are also the silent film by William Cecile de Mill and drama by Danish director Nils Malmros.
[13] It is interesting that the flow of information can also be understood as an electromagnetic phenomenon. On that way, it may be speculated the possible ways of leaving this symbolic perspective, but that possibility will not be considered further in this paper.
[14] There is a possibility that the 'tree of knowledge' is entirely realized as Popper's World 3. This would also mean giving up the clear distinction between data as 'recorded knowledge' and as a pure knowledge in the researcher's head, which was preferred by Popper. In this case, 'data ground/soil' can be considered as Popper's World 1 (the world of physical things) and the atmosphere, in which the 'tree of knowledge' is growing, as his World 2 (the world of mental states).
[15] Of course, in this way the concept of data is relativized, making it much more like the concept of information.
[16] In the same way, one can view 'genetic information' as representing data coded by the connections among amino acids in DNA. When RNA was 'informed' about these connections it acquires a knowledge, how to managing the construction of living cells.
[17] This symbolic image and its interpretation offer a symbolic explanation, even in those cases where certain information is considered to be true for some time. Based on certain knowledge, it is uncovered as false at some point. A good example of this is the information which supported the certainty of the Ptolemaic geocentric system, long believed to be based on actual data. It was useful at the time, when new observations (data) had not refuted the Ptolemaic geocentric system by a precise description of nature based on the possibility of a heliocentric system.
[18] For example, one can imagine a situation in which one particular 'rain cloud,' just above 'tree of knowledge,' is in a position to block the 'mind sun rays' or only partially let them through. This situation may provide some new ingredients to the 'tree of knowledge' in the form of 'raindrops.' The 'cloud' and its 'raindrops' may represent a metaphor for some sort of ideology or prejudice imposed by the Another or the Second (the Another, here, means something different from the rational nature of our mind; perhaps it is some sort of political influence or pressure). In addition, the 'raindrops' of the imposed ideology can be combined with 'information' and 'meaning sap' in the leaves of the tree. This image may symbolize a case in which a man may think he is solely responsible for his opinion and knowledge, as well as the process of attaching meaning to the things in the world, but a significant amount of ideology and prejudice are involved. Of course, this atmospheric effect on the growth of 'tree of knowledge'

has crucial importance to some researchers from the social sciences. At times, one must sadly conclude that, yes, it has.
[19] According to Weaver's interpretation of 'information theory,' more associated with 'what could you say' than with 'what you said,' the 'data ground/soil' might be seen as the total number of possibilities of 'external reality' in the form of 'data ingredients' that can be excreted on the tips of the 'tree of knowledge' roots. This includes 'information sap.' In this manner, truly provocative questions can be asked: Does the overall set of 'outside world' possibilities really fit the space-time reality? Does its coding really suit our mathematical methods (geometry, algebra, etc.), which are used to retrieve it? Of course, the answers to these questions are left for further discussion.
[20] We may think that the solid parts of the 'tree of knowledge' must be created at the very roots, and even at the very tips of the roots. This means, in a metaphorical sense, that they are very 'close' to 'information theory.' However, as has been shown by appropriate metaphorical interpretation, 'meaning sap' is also necessary. However, the 'meaning sap' was never been considered by Shannon's theory. It is a mystery, at the moment, even for proposed symbolic image.

References

Ackoff, R. (1989), "From Data to Wisdom", Journal of Applied Systems Analysis, Vol. 16, pp. 3-9.

Alavi, M. and Leidner, D. (2001), "Review: knowledge management and knowledge management systems: conceptual foundations and research issues", MIS Quarterly, Vol. 25 No.1, pp. 107-136.

Bar-Hillel, Y. and Carnap, R. (1953). Semantic information, British Journal of Science, Vol. 4, pp. 147-157.

Barwise, J., & Perry, J. (1983). Situations and attitudes, MIT Press, Cambridge, Massachusetts.

Barwise, J., and Seligman, J. (1997). Information flows: The logic of distributed systems, Cambridge University Press, Cambridge, UK.

Bates, M.J. (2006). "Fundamental Forms of Information", Journal of the American Society for Information Science and Technology, Vol. 57 No. 8, pp. 1033–1045.

Bates, M.J. (2009), "Information", in Bates, M.J. and Maack, M.N. (Eds.), 3rd ed., Encyclopedia of Librarian and Information Sciences, CRC Press, pp. 2347-2360.

Bateson, G. (1972), Steps to an Ecology of Mind, Ballantine Books, New York, NY.

Belkin, N.J. (1980), "Anomalous states of knowledge as a basis for information retrieval", The Canadian Journal of Information Science, Vol. 5, pp. 133-143.

Belkin, N.J. (1975), "Some soviet concepts of information for information science", Journal of the American Society for Information Science, Vol. 26 No. 1, pp. 56–64.
DOI: http://doi.org/10.1002/asi.4630260109

Belkin, N.J. and Robertson, S. E. (1976), „Information Science and the Phenomenon of Information", Journal of the American Society for Information Science, Vol. 27 No. 4, pp. h

Borgman, C. (2015), Big Data, Little Data, No Data: Scholarship in the Networked World, The MIT Press, Cambridge, MA.

Bousso, R. (2002), "The holographic principle", Review of Modern Physics, Vol. 74 No. 3, pp. 825–874.

Brier, S. (2014). "The transdisciplinary view of information theory from a cybersemiotic perspective", in Ibekwe-SanJuan, F. and Dousa, T. M. (Ed.), *Theories of Information, Communication and Knowledge: a Multidisciplinary Approach*, Studies in History and Philosophy of Science, Vol. 34, Springer, Dordrecht, New York, pp. 23-49.

Brillouin, L. (1956), Science and Information Theory, Academic Press, New York, NY.

Brookes, B. C. (1980), "The foundations of information science: Part I: Philosophical aspects", Journal of Information Science, Vol. 2, pp. 125-133.

Buckland, M. K. (1991), "Information as Thing", Journal of the American Society for Information Science, Vol. 42 No. 5, pp. 351–360.

Burgin, M. (2010), Theory of Information: Fundamentality, Diversity and Unification, World Scientific Series in Information Studies, Vol. 1, World Scientific, New Jersey, London etc.

Bush, V. (1945), "As We May Think", Atlantic Monthly, Vol. 176 No. 7, pp. 101-108.

Capurro, R. (1991), "*What is information science for? A philosophical reflection*", in Vakkari, P. and Blaise Cronin, B. (Eds.), *Conceptions of Library and Information Science: Historical, empirical and theoretical perspectives*, Taylor Graham, London, UK, pp. 82-98.

Capurro, R., Fleissner, P. and Hofkirchner, W. (1999), "Is a Unified Theory of Information Feasible?", in *The Quest for a unified theory of information*, Proceedings of the 2nd International Conference on the Foundations of Information Science, pp. 9–30.

Capurro, R. and Hjørland, B. (2003), "The concept of information", *Annual Review of Information Science and Technology*, Vol. 37 No. 1, pp. 343–411. http://doi.org/10.1002/aris.1440370109

Chaitin, G.J. (1966), "On the Length of Programs for Computing Finite Binary Sequences", J. Association for Computing Machinery, Vol. 13, No. 4, pp. 547–569.

Chaitin, G. (2010). "Mathematics as a biological process", in Dodig-Crnkovic, G. and Burgin, M. (Eds.), Informatio, and computation, World Scientific Publishing Co., Singapore, pp. 79–88.

Chalmers, A. F. (1999), What is this thing called science?, Open University Press, Buckinghamm, UK.

Cornelius, I. (1996), "Information and interpretation", in Ingwersen, P. and Pors, N. 0. (Eds.), CoLIS 2: Second International Conference on Conceptions of Library and Information Science: Integration in perspective, Royal School of Librarianship, Copenhagen, pp. 11-21.

Cornelius, I. (2002), "Theorizing information for information science", *Annual Review of Information Science and Technology*, Vol. 36 No. 1, pp. 392–425. doi:10.1002/aris.1440360110

De Mey, M. (1977), The cognitive viewpoint: its development and scope, in CC 77: International Workshop on the Cognitive Viewpoint, Ghent, Belgium, pp. 16-32.

Dodig-Crnkovic, G. (2010), "The cybersemiotics and info-computationalist research programmes as platforms for knowledge production in organisms and machines", *Entropy*, Vol. 12 No. 4, pp. 878–901.

Dretske, F. (1981), *Knowledge and Information flow,* The MIT Press Cambridge, MA.

Fleissner, P. and Hofkirchner, W. (1995), "Informatio revisited", Wider den dinglichen Informationsbegriff, Informatik Forum, Vol. 3, pp. 126–131.

Floridi, L. (2004), "Outline of a theory of strongly semantic information", *Minds and Machines*, Vol. 14 No. 2, pp. 197-221.

Floridi, L. (2010). *Information: a very short introduction*, Oxford University Press, Oxford, UK.

Floridi, L. (2011), *The Philosophy of Information*, Oxford University Press, Oxford, UK.

Foerster, H. von (1980), "Epistemology of Communication", in Woodward, K. (Ed.), *The Myths of Information: Technology and Postindustrial Culture*. Coda Press, Madison, pp. 18–27.

Foerster, H. von (1984), *Observing systems*, CA Intersystems Publications, Seaside.

Fricke, M. (2008), "The knowledge pyramid: a critique of the DIKW hierarchy", *Journal of Information Science*, Vol. 35 No. 2, pp. 131–142. doi:10.1177/0165551508094050

Furner, J. (2014). "Information without Information Studies", in Ibekwe-SanJuan, F. and Dousa, T. M. (Ed.), *Theories of Information, Communication and Knowledge: a Multidisciplinary Approach*, Studies in History and Philosophy of Science, Vol. 34, Springer, Dordrecht, New York, pp. 143-179.

Gleick, J. (2011), *The information: a history, a theory, a flood*, Fourth Estate, London, UK.

Greene, B. (2011), *The hidden reality: Parallel universes and the deep laws of the cosmos*, Knopf, New Yorke, NY.

Benthem, J. V. and Adriaans, P. (Eds.) (2007), Handbook of the Philosophy of Science: Philosophy of Information.

Hartley, R.V.L. (1928), "Transmission of information", *Bell System Technical Journal*, Vol. 7, pp. 335-363.

Hjørland, B. (1998), "Theory and metatheory of information science: a new interpretation", *Journal of Documentation*, Vol. 54 No. 5, pp. 606–621. doi:10.1108/EUM0000000007183

Hofkirchner, W. (2013), *Emergent information: a unified theory of information framework*, World Scientific series in information studies, Vol. 3, World Scientific, Singapore, Hackensack.

Hofkirchner, W. (Ed.) (1999), *The Quest for a Unified Theory of Information*, in Proceedings of the Second International Conference on the Foundations of Information Science, Gordon and Breach Publ.

Ibekwe-Sanjuan, F. and Dousa, T. M. (Eds.) (2014), Theories of information, communication and knowledge: a multidisciplinary approach

IEEE Information Theory Society (2015), „About", available at: http://www.itsoc.org/about/ (accessed 10 September, 2015)

Kolmogorov, A.N. (1965), "Three approaches to the quantitative definition of information", *Problems of Information and Transmission*, Vol. 1, No. 1, pp.1-7.

Kuhn, T.S. (2012). *The structure of scientific revolutions*, 4th ed., The University of Chicago Press., Chicago , IL, London, UK.

Liew, A. (2007), "Understanding data, information, knowledge and their inter-relationships", *Journal of Knowledge Management Practice*, Vol. 8 No. 2, pp. 1-16.

Losee, R.M. (1997), "A discipline independent definition of information", *Journal of the American Society for Information Science*, Vol. 48 No. 3, pp. 254–269.

Luhmann, N. (1990), *Essays on self-reference*, Colombia University Press, New York, NY.

Luhmann, N. (1995), *Social systems*, Stanford University Press, Stanford.

Machlup, F. and Mansfield, U. (Ed.) (1983), *The Study of information: interdisciplinary messages*, John Wiley & Sons, New York, NY.

MacKay, D. M. (1969), *Information, mechanism and meaning*, The M.I.T. Press, Cambridge, MA, London, UK.

Marschak, J. (1954), "Towards an economic theory of organization and information", in Thrall, R. M., Coombs, C. H., and Davis, L. (Ed.), *Decision Processes*, John Wiley & Sons, New York, pp. 187–220.

Maturana, H. R. and Varela, F. J. (1980). *Autopoiesis and cognition*: *the realization of the living*, Reidel, Dordrecht, The Netherlands.

Maturana, H. and Varela, F. (1986), *The Tree of Knowledge: Biological Roots of Human Understanding*, Shambhala Publishers, London, UK.

Moyer, M. (2014), "Is space digital?", *Scientific American: Special Collector's Edition*, Vol. 23 No. 3, pp. 104-112.

Nyquist, H. (1924), "Certain factors affecting telegraph speed", *Bell System Technical Journal*, Vol. 3, pp. 324-346.

Oeser, E. (1976), *Wissenschaft und Information [Science and information]*, Oldenbourg, Vienna.

Parker, E.B. (1974). "Information and society", in C.A. Cuadra and M.J. Bates (Eds.), *Library and information service needs of the nation*, Proceedings of a Conference on the Needs of Occupational, Ethnic, and other Groups in the United States, U.S. Government Printing Office, Washington, DC, pp. 9–50.

Peirce, C.S. and Buchler, J. (1955), Philosophical Writings of Peirce, Dover Publications, Mineola, NY.

Popper, K.R. (1978), "Three Worlds", *The Tanner Lecture on Human Values*, The University of Michigan, MI.

Pratt, A.D. (1977), The information of the image: a model of the communications process, *Libri*, Vol. 27 No. 3, pp. 204–220.

Qvortrup, L. (1993) “The controversy over the concept of information”, *Cybernetics & Human Knowing*, Vol. 1 No. 4, pp. 3-24.

Rapoport, A. (1956). "The promise and pitfalls of information theory", *Behavioral Science*, Vol. 1, pp. 13-17.

Robinson, L. and Bawden, D. (2012), *Introduction to Information science*, Facet Publishing, London, UK.

Robinson, L. and Bawden, D. (2014), "Mind the Gap: Transitions Between Concepts of Information in Varied Domains", in Ibekwe-SanJuan, F. and Dousa, T. M. (Ed.), *Theories of Information, Communication and Knowledge: a Multidisciplinary Approach*, Studies in History and Philosophy of Science, Vol. 34, pp. 121-141.

Rowley, J. (2007), “The wisdom hierarchy: representations of the DIKW hierarchy”, *Journal of Information Science, Vol. 33 No. 2*, pp. 163-180.

Saracevic, T. (1999), Information science. *Journal of the American Society for Information Science*, Vol. 50 No. 12, pp. 1051–1063. doi:10.1002/(SICI)1097-4571(1999)50:12<1051::AID-ASI2>3.0.CO;2-Z

Shannon, C. E., and Weaver, W. (1963), *The mathematical theory of communication*, University of Illinois Press, Urbana.

Solomonoff, R.J. (1960), A Preliminary Report on a General Theory of Inductive Inference, Technical Report ZTB-138, Zator Company, Cambridge, Mass.

Stonier, T. (1990), Information and the Internal Structure of the Universe: An Exploration into Information Physics, Springer, New York, London.

Susskind, L. (1995), “The world as a hologram”, Journal of Mathematical Physics, Vol. 36 No. 11, pp. 6377–6371.

Thompson, F.B. (1968), “The organization is the information”, *American Documentation*, Vol. 19 No. 3, pp. 305–308.

't Hooft, Gerard (1993), “Dimensional Reduction in Quantum Gravity”, *ArXiv*, available at: http://arxiv.org/abs/gr-qc/9310026v1 (accessed 10 August, 2015)

Ursul, A.D. (1971), *Information*, Nauka, Moscow.

Wersig, G. (1997), "Information theory", in J. Feather and P. Sturges (Eds.), *Encyclopaedic Dictionary of Library and Information Science*, Routledge, London, UK, pp. 220-227.

Workshop on Complexity, Entropy, and the Physics of Information, & Zurek, W. H. (1990), *Complexity, entropy, and the physics of information: Proceedings of the 1988 [i.e. 1989] Workshop on Complexity, Entropy, and the Physics of Information, held May 29 to June 10, 1989 in Santa Fe, New Mexico*. Redwood City, Calif: Addison-Wesley, The Advanced Book Program.

Zeleny, M. (1987), "Management Support Systems: Towards Integrated Knowledge Management", *Human Systems Management*, Vol. 7 No. 1, pp. 59-70.

Zins, C. (2007), “Conceptual approaches for defining data, information, and knowledge”, *Journal of the American society for information science and technology*, Vol. 58 No. 4, pp. 479-493.