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Broadening the Field of Information

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Abstract

Purpose: The paper discusses the notion of information with regard to its carriers, representatives (or structural carriers) and carried-related processes of transmission, accumulation and processing through the developmental periods of the inorganic and organic world. In the first period, information is contained in a representation of the outcome of physical, chemical and other processes in the physical, chemical and other structures of the non-living world and refers to environmental information. In the second period, information begins to be used to create the physical and chemical structures of the living world and is contained in instructions of the genetic code. In the third period, with the evolution of cognitive systems and intelligence of living beings, in addition to those listed, information is finally being used to build its own structures, which in this paper are called knowledge structures.

Design/methodology/approach: In addition to the usual scientific methods in conceptual papers of this type (analysis, synthesis, etc.), the methodology of the paper also relies on the method of analogy, which was used to detect the carriers and representatives of information in the processes of transmission, accumulation and processing of information, and the method of classification in order to propose a new taxonomy related to the concept of information.

Findings: The paper shows that information carriers and information representatives appear in each of the three mentioned processes - transmission, accumulation and processing of information - and that they need to be distinguished from the information itself. This insight opened a new perspective in observing this concept and led to the proposal of a new taxonomy related to the concept of information in a given context, eliminating seemingly incommensurable approaches to its study in different scientific fields.

Originality/value: The conducted synthesis results in information being recognized as a transmittable/transmissible documentation of reality inseparable from its carrier and its representative.

Keywords: information carriers, information representatives, data structures, knowledge structures, environmental information, genetic information.

1. Introduction

In many fields of science, the understanding of the concept of information as the most exposed term today differs considerably. For some, information is just another buzzword in a series that is used for marketing purposes, a "cultural invention" that only came to the fore at a certain historical moment (Peters, 1988, p. 10). For others, it is the basis of a new science - new physics, which will henceforth be based on information, not matter and energy (Wheeler, 1989). It is obvious that this is an extremely polysemic and polysemantic concept that tries to encompass an extremely polymorphic phenomenon (Floridi, 2009, p. 13) that "...every scientific discipline uses... within its own context" (Capurro and Hjørland, 2003, p. 356).

It is enough to pay attention to the concept of information taxonomies to be convinced of the diverse nature of this phenomenon. Thus, L. Floridi differentiates between mathematical, semantic, physical, biological, and economic information, to which he links language and ethical issues (Floridi, 2010). M. Burgin distinguishes information in nature, information in society and technical-technological aspects of information (Burgin, 2010). L. Robinson and D. Bawden distinguish information in relation to the scientific fields in which it is used; there are information in physics, information in psychology, information in biology, etc. (Robinson and Bawden, 2014). The same authors distinguish different concepts of information "...in the physical sciences, in the biological sciences, in computer and communication technology, and in the social sciences" (Bawden and Robinson, 2022, p. 81). It is possible to go on enumerating the types of information that differ in their purpose, function, area, impact, and so on. On the other hand, information is studied from historical (Black, 2006; Weller, 2007), mathematical-statistical (Shannon, 1948; Shannon and Weaver, 1963), semantic (Bar-Hillel and Carnap, 1953), algorithmic (Kolmogorov, 1965; Chaitin, 1977), cognitivist (De May, 1977; Belkin, 1978, 1990), constructivist (Luhmann, 1990; Cornelius, 2002; Foerster, 2003, Bosancic and Matijevic, 2020), anthropological (Capurro, 1996), philosophical (Dretske, 1981; Floridi, 2010; 2011), semiotic (Raber and Budd, 2003; Brier 2008, 2014), pan-informationalist (Dodig-Crnković, 2014), quantum (Wilde, 2017) and other points of view.

Considering its multiplied meaning, the concept of information often includes some other concepts or inevitably overlaps with them, as is the case, for example, with the concepts of data and knowledge. Of course, then, there is neither an unequivocal nor a widely accepted definition of this term that everyone would agree with (Bates, 2009), nor an information theory that could be widely used in all scientific fields (Cornelius, 2002; Capurro and Hjørland, 2003).The consequence of this discrepancy is reflected in the fact that the large number of definitions, taxonomies and theories of information that can be found in the literature today cannot be reduced to a common denominator. The only thing that is possible at this moment is to try to give a comprehensive, if not coherent scientific picture of this term, in other words, to offer a proposal of a new information taxonomy that could be harmonized with other (above mentioned) taxonomies.

In accordance with the stated purpose, in the second section, at the starting point of our research, we will use the information history taxonomy from W. Asprey's paper *The Many Histories of Information* (Asprey, 2015) to preliminary indicate the main processes related to information as well as to consider the insight that every piece of information must have its own carrier. In the third section, three fundamental processes related to the relationship between information and its carrier are presented: the processes of accumulating, transmitting and processing information. In the fourth section, after defining information as a transmittable/transmissible documentation of reality, the role of the general communication model by Shannon and Weaver is highlighted. This model analyzes the creation of key concepts related to the contemporary understanding of this term - data structure and knowledge structure. As a consequence, the discrepancy between the fundamentally different meanings of information (as a, in the first place, transmittable documentation of reality) and in Shannon's theory (as a statistical phenomenon reflected in a choice between two equal possibilities) becomes more understandable. In the same section, knowledge structures are considered as structures composed of interconnected information, distinguishing between non-changeable and changeable knowledge structures. In the fifth and sixth part, in addition to considering information in rudimentary form, two separate and conceptually different types of information will be considered - environmental information and genetic information. In the seventh part, finally, a new taxonomy of information will be presented in relation to its carriers, representatives of processes related to carriers and knowledge structures. Ultimately, the newly proposed information taxonomy in addition to facilitating the understanding of the differences between different types of information in theory, also opens a new perspective in research, removing the differences in incommensurable approaches to the study of this concept in different scientific fields.

2. Many, many histories of information

In the paper *The Many Histories of Information* W. Aspray discusses information history through the six well-defined subdisciplines: archival history, book and publishing history, communication history, computing history, information science history and library history (Aspray, 2015, p. 1).

If one tries to find common ground in the approach to the concept of information by the mentioned subdisciplines, it is based on the insight that every portion of information in the historical context must have its carrier/bearer/holder [1]. The idea that information must have a carrier seems to be the closest (to some) common sense understanding of this phenomenon and is implicitly accepted in the papers of most theorists dealing with this concept [2]. Accordingly, archival history, books and publishing history, library history, and partly computing history, are dealing with information that is (in some way) stored or accumulated on its carrier. Whether it is about clay tablets, papyrus, a printed book or a computer hard drive, the information seems inseparable from its carrier on which it has accumulated in unchangeable form. At the same time, such ‘recorded’ or accumulated information can also be considered as a sort of document (Briet and Martinet, 2006; Buckland, 1997).

On the other hand, communication history, among other things, deals with information history of the transmission between the carriers and necessarily precedes document and book history. In addition to the starting point of this history - the age of facial expressions (gestures) and speech, the history of communication includes the age of writing (manuscripts from the 4th century), the age of printing (printed books from the 15th century), and the age of audiovisual media (in the 20th century). Finally, communication history includes the history of the Internet and network communications which have been developing since the second half of the 20th century until today (Poe, 2011).

In the history of computers and computing, furthermore, the history of information can be observed not only through the history of its accumulation and transmission between carriers (in this case, two or more computers), but also through processing within a no longer passive, but active carrier. In addition to being a place for storing information, computers can also process information in their own way. Information that is processed within the carrier (human brain, computer processor) leads to the creation of new information, deletion of old information, but also leads to changing the existing information.

Finally, within the history of information science, information is not so much related to the history of accumulation, transmission and processing of information, but in relation to the acquisition, exchange and processing of knowledge (Capurro, 2009; Lenski, 2010; Bosancic, 2016). If information is considered as “the act of communicating knowledge” (Capurro in Zins, 2007, p. 481), it seems that information science is more concerned with knowledge structures than information itself, even to the extent that it is fully prepared to leave the issue of information transmission to the computer and communication sciences. The information science, therefore, will explore the accumulation, transmission, processing and use of information for the acquisition, exchange and processing of knowledge and further intertwine with all other subdisciplines mentioned in Asprey’s paper.

3. Information carriers and representatives

3.1. Information carriers

What we have learnt from a historical perspective in a previous section boils down to the fact that information in relation to its carriers (bearers/holders) can stand in the following modes: accumulated/stored on the carrier, in transmission between the carriers and processed within the carrier. Information carriers can be passive and active. Passive carriers only ‘carry’ information; papyrus, clay tablets, paper (books), punched tapes, microfilms, hard disks - are examples of passive information carriers. The brains of living beings also represent passive information carriers when information is only 'carried' (e.g. memories). On the other hand, active carriers of information are carriers who, in addition to 'carrying' information, also enable it to be delivered and/or sent to another carrier and in special cases processed within the carrier, which is, in fact, the collective name in which information is linked and used for a specific purpose.

The transmission of information between passive and active carriers needs an intermediary, some sort of medium in which it is possible to send and receive them. The medium in which transmission of information takes place can also be understood as a separate type of carrier - the carrier of information transmission. This type of carrier can be classified as: electromagnetic, sound and other types of waves (X-rays, gamma, microwaves, etc.), electric current, seismic activity, etc., but also anything that in substantive form affects our senses of sight, hearing, touch, smell and taste by which we retrieve the 'external' reality. Even on the basis of this superficial enumeration, it becomes clear that library and information science has hardly dealt with the carriers of information transmission or has, by default, left them to other sciences; this primarily refers to biology, chemistry and physics.

In analogy, in addition to the carriers of accumulated information (e.g. paper) and the carriers of information transmission (e.g. light), it is acceptable to assume that, the carriers of information during their processing may also exist. Although this term is a novelty in a theoretical-conceptual sense, it is easy to present and explain it. All active carriers (computer processor, human mind) are also carriers of information in its processing. In the context of a computer, the hard drive only accumulates information, while the processor does both - carries and processes it. Unlike a computer, a person's brain (or some part of it) accumulates information, while his mind carries it and processes it.

At this point it is important to emphasize that there are two types of information processing. The first refers to goal-oriented activity and includes processing information according to predetermined rules without using the intellect. The closest to this method of processing is computing, i.e. processing information on the carrier according to the mathematical and logical rules for which today's classical computers are capable. On the other hand, there is also reasoning, inference, or derivation of new information and knowledge based on existing information and knowledge using the intellect. It is clear that today's computers are capable of computing all kinds of information, but they are not yet trained for complete and consistent reasoning at the level of which it is carried out by humans.

3.2. Information representatives

The fact that one and the same information, can be accumulated in several different forms on the carrier, or have several representations of its own, following Burgin (2010), leads to the need of introducing the concept of information representatives or structural carriers of information into the discussion [3]. In addition to representing information through a certain form, the representatives of accumulated information also carry it in their own way. Unlike representatives, physical carriers only carry information (e.g. paper). In addition to the text (text record), the representatives of accumulated information can also include images (image record), audio or sound record, video record, etc. The representatives of accumulated information in the human brain can be mental images, thoughts, and perhaps even feelings, while the binary record at the assembler level is an example of the representative of accumulated information on the computer's hard disk.

In analogy with the previous one, this paper also proposes the introduction of the concept of information representative or structural carriers of information in transmission. Namely, in the mathematical theory of communication, which some call the 'theory of information' and which will be discussed more in the next section, C. E. Shannon showed that the information sent through the communication channel must first be coded. This means that, in addition to the media or information carrier in transmission, a code system is also necessary for the transmission of information between carriers in accordance with the nature of the communication channel. In this sense, the representatives of information in transmission refer to the characters of the corresponding code system through which the information is encoded for the purposes of transmission between carriers. Morse code characters (dot, line, space or pause) and binary code (one and zero) are typical examples of information representatives in transmission. It should be noted that the binary record accumulated on the computer's hard disk as a representative of the accumulated information (which is measured in bytes, kilobytes, megabytes, etc.) has nothing in common with the binary sequence by which the same information is sent through the communication channel and which represents the representative of information in transmission (which is measured in bytes per second, kB/s, MB/s, etc.). This means that the binary record on the computer's hard disk and the binary sequence flowing through the communication channel do not necessarily match, even though they represent the same information which are encoded in principle by the same code system. Here it becomes clear that the subject of Shannon's theory never referred to the information itself, or even to the representation of that information on the carrier, but exclusively to its representation in transmission, and that it was precisely for this reason that his theory was more appropriate to be called the 'theory of information representatives in transmission' than the 'theory of information'.

Finally, if information representatives in processing were also introduced into the discussion, by analogy, it would contribute to the realization that these once again refer to the representatives of accumulated information. However, they are now exposed to typical operations that are performed on them, which result in linking and unlinking with other information, sharing, duplicating, versioning and generally modifying, as well as creating new and deleting old information. Behind all these changes, of course, is the process of information processing; in the case of a human, the thinking process, and in the case of a computer, the execution of an algorithm.

4. Information and knowledge structures

4.1. Information as documentation of reality, not reality itself

In the discussion undertaken so far, the carriers and representatives of information were discussed, but not the concept of information itself. In this section, attention will be directed to the question: what is considered as information regarding the established distinctions between information itself on one side and information carriers and representatives on the other side?

If information is first of all understood as something represented by the information representatives that can be accumulated, transmitted or processed on/between/in information carriers, what is then information itself? In a general sense, information is (always) about something, but something what? The answer is necessarily general and reads: about some aspect of reality [4]. In the broadest possible sense of the word, aspect of reality refers to some previously identified part of reality - regardless of the way it is perceived. Thus, information is first discerned as documentation of various aspects of reality and not that reality itself. That is why it never refers to itself, but always to something else.

In the broadest sense, information is a documented statement/assertion about any entity – thing, property, process, system, modes, etc. For example, the assertion that a passenger (property) train (thing), which according to the timetable (system) was supposed to arrive (process) in London at 9 AM is late (modes), is a typical, even complex, piece of information. There are many representation forms of this information, we can write it, speak it, draw it, in each of these cases we can break down this information into bits to measure it and by representations of bits – 1 (one) and 0 (zero) - transmit it somewhere else in different ways. However, information that the passenger train arrives in London at 9 AM (and delayed) is one and unique, and it is not physical. Already at this point it can be seen that information is inseparable from its representation through its representatives (structural carriers) and its carrier. Information cannot be communicated without representation on an appropriate carrier. In this case, the information is represented through the letters of the English language, but it is very easy to imagine that it is communicated in another language, with the same or similar meaning. What makes information unique, and information in general, is its meaning, not its representation.

Now we can mention its second main functional characteristic, which M. Buckland points out in his paper 'Information as a thing': "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). This also means that information informs one aspect of reality about another aspect of reality in such a way that the latter documents within itself. Therefore, information is discerned in the process of informing on the route 'some aspect of reality that can send information' - 'some other aspect of reality that can receive information' and that is all. It is not a mistake to assert that information is, in principle, documentation of reality that is transmitted between different aspects of reality that can accumulate it. If we bring carriers back to the discussion it can be concluded that, information is discernible in the form of documentation of reality in the transmission between the information carriers, in order to accumulate and/or process it on them [5].

The next section will describe how this view of information fits into Claude E. Shannon's theory presented in his, in many respects, revolutionary paper The Mathematical Theory of Communication, published in 1948.

4.2. Information as a message from a predefined set of messages

C. E. Shannon was the first scientist who managed to introduce the concept of information into the wider scientific discourse. It is interesting that Shannon does not talk about information, but about the "amount of information" that is transmitted through a communication channel. The real surprise was the fact that the effectiveness of the mentioned transmission depended on the "amount of information", and not on some physical property of the channel itself or the meaning of the message that was sent. In other words, for the purpose of transmitting information, in a strictly technical sense, Shannon did not need to know what the information meant, but only how much of it there was.

Shannon consolidated his ideas in the image of a well-known communication model, in which it is possible to distinguish aspects of reality that transmit information from those that receive it. Thus, it is possible to distinguish information carriers as senders and information carriers as receivers. Certain ‘information content’ or message is transmitted through a communication channel from the sender to the recipient (or from point A to point B), while the 'amount of information' as a new quantity in the calculations was calculated, not in relation to the possibility of informing the recipient, but in relation to the "predefined" total number of all ‘information content’ or messages transmitted through the channel as well as their probability during generation, selection and sending.

The communication theory author suggested the necessity for the existence of a certain structure on the sender's side in which all 'information content', which is planned to be transmitted through the channel, would be pre-installed and divided into its component parts (messages, events, possibilities, choices etc.). In this sense, two criteria can be distinguished for the structural division of the 'information content' transmitted through the communication channel in the general communication model: probabilistic - according to which messages differ from each other in terms of the probability of selection or appearance in relation to other messages, and the uniqueness that dictates their coding so that each message in a set or structure is irreplaceable with other messages. This structure, which is the source and trigger of all messages that can be transmitted through the communication channel, Shannon called a predefined set of messages or choices. However, in this paper, the name predefined data structure is proposed. The totality of data that can be extracted in the observed domain of one aspect of reality forms its own structure, which can be called a data structure.

Therefore, it can be said that Shannon was concerned with calculating the amount of information that each piece of data as a message from a "predefined set of messages" carried on its way to the recipient. This distinction may not be important in a practical sense, but it is of exceptional importance in a theoretical sense. On its basis, for example, one may conclude that information consists of data (Floridi 2011, p. 84). But, on the other hand, other interpretations can also come into play. It can also be said that information is a property of data, that is, its informativeness, as is done in some other theoretical approaches (Bosancic 2020, p. 900). It does not matter which theoretical approach is chosen if both work in a practical sense within the framework of Shannon's theory.

Now the following question can be asked: can the 'written', accumulated information on clay tablets, printed books, etc. be considered as data structures? On the basis of the introduced distinction between the representatives of information on the carrier and in transmission, the two types of data should be distinguished as the basic form of information representatives. One type of data occurs in data structures that represent information in transmission, and the other, so far not considered, should refer to data structures that represent information on the carrier.

However, in addition to the above, it seems that the 'written' information on clay tablets and in books has another characteristic that data as information representatives on the carrier do not have. In addition to uniqueness, the represented information on the carrier is connected to other represented information through certain relations that provide them with context and meaning. What is written on a clay tablet is not informative regarding the amount of information that is calculated in relation to the frequency of individual signs, words, numbers or symbols on the sender carrier, but in relation to the number of established relations with other 'written information' on the carrier recipients (Bosancic 2020, p. 900). We recognize such structures in which information is interconnected by relations, no longer as data structures, but as knowledge structures.

4.3. Knowledge structures as an information-documentation reflection of the world

In principle, ‘information content’ informs about something. However, for the ‘information content’ to be informative in the true sense of that word, from the perspective of the recipient, it must be new to the recipient. Therefore, information is not only a measure of system order (Wiener, 1961) or disorder (Shannon, 1948), it is also a measure of novelty within the system. This measure of novelty within the system can be measured through the corresponding effect of the information on the recipient (Shannon and Weaver, 1963, p. 4) and indirectly through the modification of his knowledge structure (Brookes, 1980, p. 131).

Therefore, knowledge structures, in general, refer to a changeable set of structurally interconnected information on a recipient carrier. The structural association of two or more pieces of information - or data carrying a certain 'amount of information' - is sufficient to establish a knowledge structure, and the property of changeability to maintain it. In the case of active, organic carriers of information, the structural interconnection is realized through predefined relations which, according to the German philosopher Immanuel Kant, arise from the cognitive power of living beings to perceive all phenomena in an a priori given space and time (Kant, 1998) [6].

The relations ‘follows’ and ‘precedes’ can be taken as examples of temporal relations, while the relations ‘above’ and ‘below’ represent examples of spatial relations which result from *a priori* perception of the space and time. Thus, one piece of data (e.g. binary digit 1) can follow or precede another piece of data (e.g. binary digit 0) in time, or be above or below another piece of data in space, etc.

After Shannon showed how to calculate the amount of information that each piece of data receives in relation to the data structure on the sender's carrier, now it is necessary to determine the informative value of each incoming piece of data in relation to the receiver’s knowledge structure. If such piece of data is not able to realize (achieve) any relation with the existing content within the structure of the recipient's knowledge, then it cannot be considered as information from the recipient's perspective and vice versa (Bosancic 2020, p. 901).

In general, the structural interconnection of information through a predefined set of relations in the recipient's knowledge structure results in the production of meaning as we have seen in an example about the passenger train. The concrete meaning of one piece of information is largely determined by its relationship with other pieces of information. Even an insignificant number of established relations between incoming information can cause a huge number of meanings that can be attributed to that information. Without going into discussion whether information in itself has meaning or not and what, in fact, is meaning, which is widely discussed in the literature, here we just want to point out that the greater interconnection of information in the knowledge structure implies the number of meanings that will to be added to them. In its purely representative form, the knowledge structure is nothing more than an information-documentation reflection of the reality that surrounds its carrier that is, in principle, a subjective specification of the documentation of reality of a cognitive agent, which is subject to change.

4.4. Types of knowledge structures

So far, we have talked about knowledge structures in active, organic carriers of information. But, in accordance with the announcement from the previous section, can we also talk about knowledge structures in passive, inorganic carriers? Let's recall that in active, organic carriers of information, information with informative value led to a change in the knowledge structure - a new relationship was established or an old one was changed/deleted. The aforementioned exchangeability property of the knowledge structure was observed and formulated by the British scientist B.C. Brookes through his "fundamental equation of information science": the knowledge structure K [S] changes with the flow of information ΔI (Brookes 1980, p. 131). However, in a broader historical context, it cannot be said that all knowledge structures possess this property. If one examines the content engraved on a clay tablet or printed in a book, regardless of the accumulation of information and their interconnections, the question arises whether such content can be considered as a knowledge structure, although it is not possible to change it once it is "engraved" or printed? This can only be done if a new taxonomy is introduced into consideration that will take this difference into account. In other words, with regard to the aforementioned properties of information carriers, this paper proposes a division into two basic types of knowledge structures:

- changeable knowledge structures in active, living carriers of information (carriers of knowledge structures are living beings)
- non-changeable, surrogate knowledge structures in passive, inanimate carriers of information (carriers of knowledge structures are clay tablets, books, etc.)

There is no doubt that the first knowledge structures, in general, were changeable and that they had to arise in the cognitive systems of the first living beings on our planet. However, when exactly this happened cannot be confirmed with certainty. Likewise, it is undoubted that these knowledge structures led to the creation of immutable surrogate knowledge structures on passive carriers many years later: information from changeable knowledge structures begins to be written on passive carriers in an unchangeable form (at first, on clay tablets, then papyrus, books, punched tapes, etc.). The surrogate knowledge structures, unlike knowledge structures on active carriers, do not change over time, which has become the basic criterion for distinguishing between active and passive information carriers.

Furthermore, the development of information and communication technology led to the emergence of changeable knowledge structures in inanimate, passive carriers of information. This primarily refers to the appearance of changing knowledge structures in classic computers. Although a passive carrier of information – the classic computer, is trained to change and upgrade knowledge structures. A new term enters the terminology - knowledge base. Knowledge bases represent changeable knowledge structures in a classical computer. The carrier of information processing is the computer processor, and the representative is the code written in the appropriate programming language that represents the algorithm.

Finally, with the advent of the artificially intelligent computer, the passive carrier of information begins not only to encode, but also to process information in its own way. In other words - to act as an active information carrier. If the classic computer made changes in the knowledge bases using the computing process, the artificially intelligent computer makes changes using the reasoning process. What will happen in the future, whether an inanimate, passive carrier of information will truly transform into an active one, is the subject of discussion by many theoreticians and programmers and the final answer is difficult to predict at this time. However, most researchers leave this possibility open.

5. What is considered to be information?

Considering everything that has been said so far in the paper, every piece of information in its most rudimentary form is characterized by:

1. having its own carrier - the carrier of accumulated information (e.g. paper), the carrier of information transmission (e.g. electricity) and the carrier of information processing (e.g. the human mind).

2. having its own representatives (or structural carriers) on each of the listed carriers of information - text (e.g. letters, numbers, symbols), images, etc. on the carrier of the accumulated information; characters of the corresponding code system (e.g. binary code, Morse code, etc.) on the carrier of information in transmission, and the thinking process (in the case of a human), or execution of an algorithm (in the case of a computer) on the carrier of information in processing.

3. being transmittable/transmissible between and through its carriers in order to be accumulated and/or processed on/in them.

4. referring to the documentation of (some aspect of) reality, not reality itself.

It follows that information in its most rudimentary form is, in the first place, a transmittable, and then a storable and processable documentation of reality, inseparable from its carrier and its representatives. The listed four statements about information could also be understood as criterions/conditions which, in our opinion, conditions must be satisfied to determine the existence of information in general - in nature, on a computer, in the human brain etc. In short, information is not information if it is not transmissible (in addition to being storable and processable), if it has not its representation and if it is consider as reality and not its documentation [7].

And after introducing into the discussion relatively new, information-related structures - data structures and knowledge structures, at a higher level of abstraction, what can be considered to be information should meet the additional criterion/condition:

5. every piece of information is transmitted from the data structure of the information carrier-sender and received into the knowledge structure of the information carrier-receiver. At the same time, the information carrier-sender data structure does not change by sending information (Shannon, 1948), also the information carrier-receiver knowledge structure is changed by the receipt of information (Brookes, 1980).

It follows that information is not information if it is not sent from the data structure of one carrier and received into the knowledge structure of another carrier. However, as we can see in the next section, not all kinds of information which are mentioned in the literature could fulfill the listed criterions/conditions for information.

Likewise, the listed conditions/criterions do not offer an answer to the question how information that reaches the recipient for the first time is created. Shannon's theory also does not explain this. It is tacitly assumed that the determination or generation of data is done in relation to a predetermined background theory in accordance with ‘the principle of theory-ladenness’ (Brewer and Lambert, 2001). In Shannon's case, 'binary theory' is a predetermined background theory. Shannon's theory, like many other theories, starts from the middle (as the poststructuralists would argue) and says nothing about the ends, at least not in the form of the special cases that we want to consider here. One of them is the answer to the question - how was the first information created? In what way are they 'pre-coded', if there is no longer any predetermined background theory of the recipient at play? Because it is not possible to imagine that the recipient knowledge structure precedes something from which it itself arose, the answers to these questions must be sought outside of Shannon's theory.

The answer to this question will also be considered in the next section, in which two new types of information will be introduced into the discussion - environmental information and genetic or biological information. These types of information will also be tested to see if they meet the established criteria according to which they could be considered as information.

6. Are "environmental information" and "genetic information" types of information?

6.1. "Environmental information" as a type of information

At what moment (of the communication process) and under what circumstances does information arise from transmittable 'information content' in the form of documentation of reality? If it is about the documentation of reality, and not reality itself, then the initial form of this type of content can only refer to the representation of the outcome of physical and chemical reactions in nature, and not the physical and chemical reactions themselves. Therefore, the main characteristic of these 'pre-information' is that they represent a kind of reflection of reality, and not reality itself. It is also interesting that for a large number of Soviet authors who wrote about information theory in the 1960s and 1970s - information is precisely a reflection of reality. As eliminated uncertainty or reflected diversity, information is a property of both matter and our consciousness (Belkin, 1975; Ursul 1966).

Is it possible to map this type of 'pre-information' with B. Hjørland's definition of information: "Information is, in fact, the causal result of existing physical components and processes" (Hjørland in Zins, 2007, p. 484)? Although Hjørland believes that the first information appears only in the biological world, his definition can be used to arrive at the first acceptable definition of environmental information. Environmental information is information resulting from the causal results of physical, chemical and other processes in the physical, chemical and other structures of the inanimate world through which the environment, in its own way, talks about "itself".

At the beginning of his reflection on the concept of information, the theorist and philosopher Luciano Floridi observed it in a much broader way. In addition to information as documentation of reality or, as he calls it, information about reality (or semantic information), Floridi also points out the two more rudimentarily different types of information: environmental information from which reality itself is made of or, as he calls it, information as reality; and information as instructions, or as he calls it, information for reality. The latter, of course, includes genetic or biological information that is used to build living structures of the organic world (Floridi, 2004, p. 560) [8].

However, it should be noted that Floridi's understanding of environmental information differs from the concept of 'pre-information' as a reflection of reality, but also from Hjørland's understanding of information as the outcome of chemical and physical reactions in reality. Environmental information, according to Floridi, is primarily a sign that data has its own meaning, independent of the meaning given to it by the sender and receiver of the message in the communication process. Floridi, for example, recognizes environmental information in tree rings, fingerprints, but also as a signal light in a car (which inform, for example, that the battery is discharged). Their origin can be natural or artificial. Floridi points out that environmental information generally involves a link between at least two systems according to the following pattern: an occurrence (F) in one system (a) informs another occurrence (G) in another system (b). For example, "...the low-battery indicator (a) flashing (F) is triggered by, and hence is informative about, the battery (b) being flat (G)." (Floridi, 2010, p. 33).

However, all these examples cited by Floridi initially assume the existence of the recipient's predetermined background knowledge on the nature of the relationship that interconnects the phenomena between the two systems on which the understanding of environmental information is based, which also means the implementation of the usual communication process. The only difference is the fact that the sender is not some other knowledge structure, but a certain pattern of a natural or technical character. But are not patterns or regularities of a natural and artificial (technical) nature 'something' that this world immersed in the remaining chaos mainly consists of? Is this not proof that nature is flooded with environmental information that manifests everywhere as its representations? Therefore, it does not seem to make sense to talk only about the environmental information contained in tree rings or the signal lights of a car, when through them it can also become known that something is above or below, larger or smaller than something else. In other words, it would be more precise to say that one thing, thanks to the property of representation, can carry information about another thing.

Physicist Carlo Rovelli also stands on this line of understanding, believing that the information of one physical system in nature is maintained on another, that one system carries information about another. "...[T]he light which arrives at our eyes carries information about the objects which it has played across; the color of the sea has information on the color of the sky..." (Rovelli, 2017, p. 242).

Following what has been said, environmental information can be asserted to represent a reflection of ever-changing relationships in reality. Therefore, chemical or physical constituents of reality (molecules, atoms, quarks, quantum fields, etc.) and chemical or physical substances derived from them can appear as the smallest sources or carriers of information and not information itself.

From the point of view of the Shannon-Weaver communication model and the conditions for information to be transmitted from the data structure, one can speak of a kind of potential data, 'pre-data', in the context of environmental information. This 'pre-data' is of course a kind of environmental data, in other words, some sort of representatives of information in emerging, until they have yet differentiated into representatives on carriers and representatives in information transmission. In accordance with this, some sort of rough definition of the initial 'pre-data', environmental data, could be: environmental data as data with a potential informative value (for a recipient) manifest as representation outcomes of physical and chemical processes in a space and time which are, so to speak, 'pre-coded' by them. In this sense, the a priori spatio-temporal framework as a condition for observing all phenomena in the world is recognized as an initial code system that precedes every other such system.

It is interesting that a link in this place can be established between environmental information and Kant's teaching about appearances and the 'thing in itself'. According to Kant, we perceive only the appearance of things in space and time, not the 'thing in itself'. If 'pre-data' and hence environmental information are 'pre-coded' by space and time, then they can be considered phenomena in space and time in Kant's sense. This also means that appearances (phenomena) in space and time can be considered as informational representatives of environmental information.

However, the main problem with environmental information is that it requires a recipient to be considered information in the full sense of the word (according to the conditions given in the previous section). If it is absent and if they are only maintained by the things of this world, the knowledge structure is not in play, and then the corresponding effect is not in play either. This is why environmental information as representations of reality can only be spoken of as potential information, as Gordana Dodig-Crnkovic calls it. "Information that is the fabric of the universe is potential information before any interaction with an (observing) agent." (Dodig-Crnković, 2014, p. 225). In fact, for Dodig-Crnkovic, the world can be described for the observer as a structure of either potential information or data. "Patterns of potential information (potential data) are both in the world and in the structures of the agent..." (Dodig-Crnkovic, 2014, p. 227). The author also calls potential information proto-information.

And if the knowledge structure in the world of environmental information is missing, then any information processing is not possible, information could only be transmitted and stored in the sense explained above. Therefore, environmental information or (environmental) data is only potential information, a certain type of proto-information, which "came to life", became information in the true sense of the word only with the appearance of life and the first knowledge structures in living beings.

6.2. Genetic information as a type of information

After the role of DNA and RNA molecules in the storage and transmission of genetic (or biological) information was revealed, it became clear that every living organism, regardless of the ability to memorize and process information, has at least one active carrier of information in each of its cells. However, it also became clear that genetic information does not contribute (at all) to the creation and development of knowledge structures, and that even in their case it is not clear whether they can be considered information in the true sense of the word, considering the criteria defined in the previous section. Can genetic or biological information be considered a transmittable documentation of reality? Although they are based on code and transmission, it has been shown that they do not express their resulting "knowledge" through their own structures, but genetic information is used exclusively as instant instructions for building the physical and chemical structures of a living organism. In a very abbreviated form, the next paragraph will try to represent the 'communication process' in the genetic model of information transmission [9].

In the context of the Shannon-Weaver communication model, the process of replication of the genetic code represented by a chain of nucleotides twisted into a double helix of the DNA molecule is complementary to the process of encoding genetic information in the information source. The genetic code itself consists of 'code words' or codons. Each codon consists of a unique combination of three nitrogenous bases (nucleotides) and represents a message about which amino acid will be synthesized in the protein chain. As there are 4 'letters' or 4 nitrogenous bases in the genetic alphabet - adenine (A), guanine (G), cytosine

(C) and thymine (T) - there are also 64 possible combinations or codons. The transcription process of genetic code from DNA to RNA molecule, on the other hand, corresponds to the process of "selecting one or more messages from a predefined set of messages". Furthermore, the messenger RNA (mRNA) molecule represents the means of communication or the 'vehicle' of genetic information, while the cytoplasm represents the communication channel. Finally, the process of translating the genetic code is complementary to the process of decoding the genetic message. What in the Shannon-Weaver model is the destination of the message in the genetic model of information transmission refers to the ribosome, a special cellular structure composed of proteins, which through another separate RNA molecule - the transfer RNA (tRNA) molecule interacts with parts of the genetic code and performs the process of protein synthesis. In biologist literature it is usually stated that the ribosome is first attached to the messenger RNA and then, with the help of the transfer RNA, it finds the start codon, i.e. the beginning of the genetic message. In order to do this, the transfer RNA must have a special structure: at one end there is an anticodon, the same genetic structure as the codon (in the case of the start codon, it is a mixture of methionine), and at the other end the corresponding amino acid. It should be emphasized that anticodon and codon are related as a key to a lock. After a specific tRNA finds a start codon thanks to the complementarity of the anticodon and codon genetic codes, the next tRNA steps in and finds the next codon in the same way. However, at that moment, what is crucial to the whole process, due to the proximity of the amino acids of the two transfer RNA molecules in the chain, they are synthesized, after which the first tRNA is released from the messenger RNA. Then the procedure is repeated with the second and third tRNA, etc. At the very end, after the ribosome encounters the codon that announces the end of the genetic message, the so-called stop codon is released from the mRNA and the protein synthesizing process is completed.

This description emphasizes that it never happens that the ribosome, thanks to some kind of background knowledge, "knows in advance" which amino acid should be incorporated into the resulting protein chain, but it does so thanks to a specific physico-chemical mechanism of the translation process, which was previously described [10]. The very intention of attaching precisely defined amino acids to the protein chain was achieved by 'reading' the genetic code of the RNA helix. The transmission of the genetic message, as well as the genetic message itself and its decoding, are of a chemical and physical nature. The genes themselves therefore cannot be said to represent carriers of genetic information; the genetic code or, better, the genes, are the information representatives or structural carriers of its own - a kind of dynamic procedural information structure like algorithms and program commands that serves as instructions to do something on a physical-chemical level of reality. As Floridi pointed out: they are information 'for something', not 'about something' (Floridi 2010, p. 70). But in our opinion, genes are not exactly information, rather they are a special form of information representatives which carried a special form of potential information that has not yet manifested in the world, for example, the color of eyes or the gender of a human being.

7. Types of information in relation to its carriers, representatives and *carrier-related processes*

Table 1 shows a proposed taxonomy of the term information with regard to its carriers, representatives and processes of accumulating, transmitting and processing information on its carriers. And although it has the effect of broadening the field of information, time will tell whether the proposed taxonomy of information can result in a more comprehensive and coherent scientific picture of this concept in theory.

As one can notice from Table 1, information source of environmental information is outcomes of physical and chemical processes (according to the realistic point of view) or the 'thing in itself' (according to Kantian, transcendental, constructivist point of view). An information carrier of those outcomes in the transmission process is mostly light, although we can imagine other carriers, for example, gas, taste and so on. But what is crucial, information representatives of each environmental information are always 'pre-coded' by the spatio-temporal framework, so, they always appear in the form of phenomena (appearance) in space and time (e.g. the appearance of the sky). On the other side, in the accumulation process, an information carrier can only be some other appearance in space and time (e.g. the sea surface). It follows that in the case of environmental information, the information source cannot be the information carrier at the same time. Finally, in the same process, reflected space-time appearance (e.g. the space-time reflection of the appearance of the sky on the sea surface) could play the role of information representative in the accumulation process. Information itself transmitted and accumulated in all of these processes in this example could be interpreted as: the sky is blue, which means it is not red or black in the sense of Shannon's predefined set of previously known values (sky colors).

Regarding genetic information, an information source is a specific characteristic of living beings in a general sense coded in DNA, information carrier in transmission is RNA, information carrier in accumulation (replication) is DNA, and information representative in both cases are genetic code or codons. The information which the genetic code carries is, for example, eye color, gender of human beings and so on.

It is interesting that information sources for the first primitive knowledge structures in living beings could only be environmental information itself. Other statements from the table have already been mentioned in the previous sections, therefore we will not repeat them. However, it is important to note that the content of Table 1 is only indicative, and that it requires more detailed research and refinement in the future.

Table 1

Types of information in relation to its carriers, representatives and carrier-related processes.

No.	TYPE OF INFORMATION	INFORMATION SOURCE	INFORMATION PROCESSES	INFORMATION CARRIER	INFORMATION REPRESENTATIVE(S)	INFORMATION EXAMPLES (represented by the human language)
1	*ENVIRONMENTAL INFORMATION*	outcomes of physical-chemical processes or the "thing in itself"*	TRANSMISSION	light (electromagnetic waves), gas, taste, etc.	appearance in space and time (e.g. the appearance of the sky)	The fact/claim "The sky is blue" (and not red or black).
		appearance in space and time	ACCUMULATION	some other appearance in space and time (sea surface, retina of the eye, etc.)	reflected space-time appearance (e.g. the space-time reflection of the appearance of the sky on the sea surface)	
		n/a	PROCESSING	n/a	n/a	
2	*GENETIC INFORMATION*	the properties of living beings coded in DNA	TRANSMISSION (transcription and translation)	RNA	genetic code / codons	The property "The eyes will be blue" (and not brown or green)
		RNA	ACCUMULATION (replication)	DNA	genetic code / codons	
		n/a	PROCESSING	n/a	n/a	
3	*INFORMATION IN CHANGEABLE, ORGANIC KNOWLEDGE STRUCTURES*	environmental information	ACCUMULATION	organic carriers / brains/neurons of living beings	cognitive systems / cognitive representations (words, mental images)	A remembered fact "The sky is blue" in the human brain
		knowledge structure in living beings	TRANSMISSION	soundwaves, light	voices, gestures	Spoken text "The sky is blue"
			PROCESSING: computing / reasoning	human mind	thoughts, thinking process	A derived claim "The sky is blue" in the reasoning process
4	*INFORMATION IN NON-CHANGEABLE, INORGANIC, NON-COMPUTER KNOWLEDGE STRUCTURES*	knowledge structure in living beings	ACCUMULATION (writing)	inorganic, artificial carriers (ancient clay tablets, books)	text (letters of alphabets, numbers, symbols, etc.), images	Written and read text "The sky is blue" in the book.
		text, images in books	TRANSMISSION (reading)	light	appearance in space and time (e.g. appearance of the letters in text)	
		n/a	PROCESSING	n/a	n/a	
5	*INFORMATION IN CHANGEABLE, INORGANIC COMPUTER DATA STRUCTURES AND KNOWLEDGE STRUCTURES*	knowledge structure of living beings computer knowledge base	ACCUMULATION	artificial carriers (hard disc)	code systems (e.g. binary) (Kb, Mb) code representations (text, image, audio and video files)	Stored text "The sky is blue" in a text file on the computer
		data structure in digital devices and computers	TRANSMISSION	electricity	code systems (binary, Morse) (Kb/s, Mb/s)	Binary coded message "The sky is blue" sent through the channel
		computer knowledge base	PROCESSING: computing	computer processor of a classic computer	algorithms	A derived claim "The sky is blue" in the computer knowledge base
			PROCESSING: reasoning	computer processor of an AI computer	AI algorithms	A derived claim "The sky is blue" in the reasoning process of an AI computer

* The source of information at the 'zero level of reality' can be either the outcomes of physical-chemical processes according to the point of view of (naïve) realism or a 'thing in itself' according to the transcendental, Kantian, constructivist view of reality.

8. Conclusion

The paper showed that in its rudimentary form, before the appearance of knowledge structures, information appears as a transmittable (and storable) documentation of reality, inseparable from its carrier and its representatives (structural carriers) [11]. This definition can be applied to the first types of information in general - environmental and genetic information. However, at a higher level of abstraction, when information begins to build its own structures, which in this paper are called knowledge structures, new possibilities appear on the scene, mainly related to information processing. Information is now transmitted from the data structure and received and processed in the knowledge structure.

Knowledge structures are such structures that are literally composed of information about other types of structures (physical, chemical, etc.) which, because they are not physical and chemical structures but only their representations, are necessarily coded. Based on this, knowledge structures must initially rest on an additional, structural carrier of information. It would not be wrong to say that knowledge structures are essentially semiotic, in other words, structures that are always mediated by signs. What can be physical in any sense of that word are information carriers (atoms, molecules, genes, matter, energy) and information representatives (signals, genes, signs in non-changeable knowledge structures, etc.), not the information itself.

Accordingly, we have shown that it is possible to distinguish three main types of knowledge structures (in addition to two subtypes), and to distinguish the ways of transmission, accumulation and processing of information on them:

- changeable knowledge structures in active, living carriers of information placed in the cognitive systems of living beings,
- non-changeable, surrogate knowledge structures in passive, inanimate carriers of information in which information is interconnected in an unchangeable way by writing, drawing, etc. (clay tablets, books) and
- changeable knowledge structures in computers, which can be divide to:
    - changeable knowledge structures in passive, inanimate (inorganic) information carriers (the carriers of the knowledge structure are classic computers)
    - changeable knowledge structures in active, non-living (inorganic) carriers of information (carriers of the knowledge structure are artificially intelligent computers).

However, it seems that the proposed precise definition of information, according to which information is a transmissible, storable and processible documentation of reality inseparable from its carrier and from its representative could be implemented only on information which is able to reach the knowledge structures. In terms of environmental and genetic information, due to the lack of knowledge structures, there is no information processing. Therefore, before the emergence of knowledge structures in living beings, environmental information and genetic information were only 'proto-information'. However, after the appearance of the first knowledge structures in living beings, environmental information can be treated as a common type of information, but genetic information, even in this case, remains only ‘proto-information’.

Notes

[1] In this paper, the terms carrier, bearer and holder are treated as synonyms.

[2] However, this does not mean that it is an unquestionable scientific fact according to L. Floridi: "The view that there is no information without physical implementation is an inevitable assumption when working on the physics of computation, since computer science must necessarily take into account the physical properties and limits of the carriers of information..." (Floridi, 2008: 128). However, from a historical, and not a philosophical point of view, it is acceptable to state that every piece of information is embodied in its carrier. Taylor (1986), R. Landauer (1991), M. Burgin (2010) and G. Dodig-Crnkovic (2014) also write about physical carriers of information.

[3] However, the same term (information representatives) appears in the literature most often in an entirely different meaning, referring to Public Information Representatives. In order to clarify the term 'representatives of information’, we will use M. Burgin's explanation: „For instance, a text written on a piece of paper is a representation of information and a carrier of this information as well. At the same time, the piece of paper with this text is only a carrier of the corresponding information [...] The text is the structural carrier of information in the book [...] The observer [...] who considers [something] in his own subjective framework corresponds to the mental carrier of information.” (Burgin, 2010, p. 121-122). One may notice that Burgin uses the term 'representation of information' instead of ‘information representative(s)’ or 'representative(s) of information' that we suggest in this paper.

[4] Without going into a deeper philosophical discussion on this issue, reality is the term we use to encompass our entire experience, whether we experience it objectively or perform it subjectively.

[5] However, this 'information transmittability’ should not be confused with the material transferability of physical or material particles from one place to another, which takes place during physical and chemical processes (such as copying).

[6] Very generally, the German philosopher Immanuel Kant detected four fundamental categories through which the human mind judges the world around it: quantity, quality, relation and modality. All other categories can be derived from the mentioned categories. And then wrote: „...among all representations combination [ger. *die Verbindung*] is the only one that is not given through objects but can be executed only by the subject itself...“ (Kant, 1998, p. 245). „But for the peculiarity of our understanding, that it is able to bring about the unity of apperception a priori only by means of the categories and only through precisely this kind and number of them, a further ground may be offered just as little as one can be offered for why we have precisely these and no other functions for judgment or for why space and time are the sole forms of our possible intuition“ (Kant, 1998, p. 254).

[7] In our opinion, even Wheeler's famous dictum 'It from bit' can be understood in support of the definition of information as a documentation of reality, not against it. Wheeler's statements: "...every item of the physical world has at bottom — at a very deep bottom, in most instances — an immaterial source and explanation" and "...all physical things are of information-theoretic origin" (Wheeler, 1989, p. 311) can also be understood that all physical things we perceive are first documented in information. That is, if we get anything from reality, it is information.

[8] According to Floridi: "Information can be viewed from three perspectives: information as reality (for example, as patterns of physical signals, which are neither true nor false), also known as ecological information; information about reality (semantic information, alethically qualifiable); and information for reality (instruction, like genetic information)" (Floridi, 2004, p. 560). Later, Floridi started to use the term environmental information instead of ecological information (Floridi, 2011: 30).

[9] Crick and Watson (1953), Gamow (1961), Yockey (2005), Cobb (2013) and other authors wrote about genetic (or biological) information in general, as well as the procedures of replication, transcription and translation of the genetic code from a biological point of view. On the basis of these papers, a description of the transmission of genetic information is written in this section.

[10] In the context of genetic information, one might think that the human body is built according to genetic information which can be considered its knowledge structure. Although attractive, this idea, in our opinion, seems problematic/far-fetched. Perhaps it could be said, in the footsteps of early European documentarians such as Suzanne Briet, that information about the gender of a human being has its record or evidence in the human body, and that the human body should be taken as a document in this sense. However, from the point of view of this paper, the human body is recognized only as a source of environmental information, because it is the outcome of physical and chemical reactions within it. Human body is the source or cause, not the carrier and/or representative of information. Just as the sky is the source/cause and the sea is the carrier of the information that the sky is blue.

[11] Since the term documentation has a special meaning for this journal, we point out that the proposed broadening of the field of information also implies the broadening of the field of documentation. Namely, in the context of this paper, a document as a result of human activity is interpreted as a knowledge structure, because it contains interconnected information. A document is, therefore, only a special form of knowledge structure about some aspect of reality. As a knowledge structure, a document can become a source of information for another knowledge structure, etc. However, some aspects of reality can be documented in their own way by non-human activities, and we have shown this on the examples of environmental information and genetic information (the color of the sky is documented on the surface of the sea, the gender of a living being is documented in genes). These examples, in addition to broadening of the field of documentation, also imply a difference between the source of information and the carriers of information. Because of that, the 'Suzanne Briet antelope', to use a well-known example from the theory of

documentation, in our opinion can only be a source of information and not a document, regardless of the fact that it is in a zoo. In addition, the proposed definition of information as documentation of reality reminds us that information science emerged from the field of documentation. For example, "The American Documentation Institute, founded in 1937, became the American Society for Information Science in 1968." (Bawden and Robinson, 2022, p. 10). It is interesting that the Journal of Documentation, founded in 1945, did not make this terminological intervention and changed its name to the Journal of Information Science before the Information Scientist did in 1967. One may think that it could have changed the name to Journal of Information, but in our opinion, it is no longer necessary, after observing that information itself is a transmittable documentation of reality.

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