THE ESSENCE OF INFORMATION: PARADOXES, CONTRADICTIONS, AND SOLUTIONS

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Abstract.

The information age is upon us and the main paradox is that there is no satisfactory and commonly accepted answer to the crucial question what information is. This results in a quantity of contradictions, misconceptions, and paradoxes related to the world of information. We consider the existing situation in information studies, which is very paradoxical and inconsistent, in the first part of this paper. To remedy the situation, a new approach in information theory, which is called the general theory of information, is developed. The main achievement of the general theory of information is explication of a relevant and adequate definition of information. This theory is built as a system of two classes of principles and their consequences. The first class consists of the ontological principles, which are revealing general properties and regularities of information and its functioning. These principles are explicated in the second part of the paper.

1. Introduction

The information age is upon us and the main paradox is that there is no satisfactory and commonly accepted answer to the crucial question what information is. We are overwhelmed with myriad of information from a wide spectrum of information sources, such as the World Wide Web, emails, images, speeches, documents, etc. At the same time, our experience demonstrates that common sense understanding of the notion of information may be very misleading. Consequently, we have to go to information science and develop theoretical perspective on entertainment. The main problem is to find the right theory.

Looking into information science, we encounter a peculiar situation. On one hand, it has a lot of theories, a diversity of results, and even a proclaimed success. Scientists created a diversity of information theories: statistical or Shannon's, semantic, algorithmic, qualitative, dynamic and so on. On the other hand, as it is written in the introduction of one authoritative book on information policy, "*Our main problem is that we do not really know what information is*."

However, the advancement of science is very fast and a new theory appeared recently. It is called the general theory of information. It comprises all other known theories of information and contains much more.

There have been a lot of discussions and different approaches have been suggested trying to answer the question what information is. According to (Flückiger, 1995), in modern information theory a distinction is made between structural-attributive and functional-cybernetic types of theories. While representatives of the former approach conceive information as structure, like knowledge or data, variety, order, and so on; members of the latter understand information as functionality, functional meaning or as a property of organized systems.

The principal achievement of the general theory of information is that it explains and determines what information is. The new approach changes drastically our understanding of information, this one of the most important phenomena of our world. It displays that what people call information is, as a rule, only a container of information but not information itself. This theory reveals fascinating relations between matter, knowledge, energy, and information.

The general theory of information is built as a system of principles that represent intrinsic properties of information and information processes. The set of the main principles consists of two parts: basic ontological and basic axiological principles. Basic ontological principles are formulated and investigated in the fourth section of the paper. They reflect the most essential properties of information as a natural, social, and technological phenomenon as well as regularities of information functioning. This provides a foundation for the development of the general theory of information.

2. Contemporary Situation in Information Studies and the General Theory of Information

Etymologically the term information is a noun formed from the verb *'to inform*,' which was borrowed in the 15th century from the Latin word '*informare*,' which means 'to give form to,' 'to shape,' or 'to form,' During the Renaissance the word '*to inform*' was synonymous to the word '*to instruct*.' Later its meaning extended essentially and it became one of the most important technical and scientific terms.

The outstanding American mathematician and cybernetician Norbert Wiener was the first who considered information beyond its day-to-day usage. He is one of the founders of cybernetics as a scientific discipline. The aim was to bring together similar research efforts in communication engineering, psychology, sociology, biology and medicine. From the point of view of these disciplines, it is above all the quantity of information which, apart from message, amount of interference (noise) and coding technique, is to be accounted for. According to Wiener the transmission of information is only possible as a transmission of alternatives, for if only one possible state is to be transmitted it is most easily done by not transmitting any message at all. Therefore he calls for the development of a statistical theory of the amount of information, a quantity that has natural affinities to entropy in statistical mechanics. While the amount of information of a system is a measure of the degree of order, the entropy of a system is a measure of the degree of disorder. However, this did not solve the question of a concept of information proper. Throughout his life Wiener attached special importance to finding an answer to this question. To this purpose he made use of the results of a long-term collaboration with medical scientists.

His research led Wiener to make the famous statement (Wiener, 1961):

"*Information is information, not matter or energy*."

Although it is not a definition of information, this statement contained the message that the actual objects used for communication, i.e., for conveying information, are unimportant.

Gregory Chaitin (1999) has developed this idea. He writes:

"*The conventional view is that matter is primary, and that information, if it exists, emerges from the matter. But what if information is primary and matter is the secondary phenomenon! After all, the same information can have many different material representations in biology, in physics, and in psychology: DNA, RNA; DVD's, videotapes; long-term memory, short-term memory, nerve impulses, hormones. The material representation is irrelevant, what counts is the information itself. The same software can run on many machines.*

INFORMATION is a really revolutionary new kind of concept, and recognition of this fact is one of the milestones of this age".

Since the time of Wiener's pioneering works, information science emerged giving birth to many information theories and producing a quantity of definitions of information. The birth of information theory is placed officially in 1948, when the outstanding American engineer and mathematician Claude Shannon published his first epoch-making paper. In more details his theory and its relation to the general theory of information are considered in the Appendix. Here we discuss only those implications of the Shannon's theory that resulted in a definition of information.

The most popular idea is that information is a message or communication. But a message is not information because the same message can contain a lot of information for one person and no information for another person.

The most utilized scientific definition of information is as follows:

Information is the eliminated uncertainty. (1)

Another version of this definition treats information as a more general essence and has the following form:

Information is the eliminated uncertainty or reflected variety. (2)

But in many cases, people speak about receiving or transmitting information when the variety is undefined and there is no uncertainty. In other cases, there is variety without information.

This is illustrated by the opinions of different authors. For example, an interesting idea is suggested in the book of Knapp (1978): variety is defined in the orthogonal way to information. In non-technical language this means that variety, as a phenomenon, is essentially distinct from information. This approach correlates with what writes Wilson (1993): "*In the real world … we frequently receive communications of facts, data, news, or whatever which leave us more confused than ever. Under the formal definition these communications contain no information…*"

Both definitions (1) and (2) are based on Shannon's information theory (Shannon, 1948). This theory represents statistical approach to information and is the most popular now. However, one of the followers of Shannon, the well-known French scientist Leon Brillouin wrote that in this theory "the human aspect of information" is completely ignored. As a result, statistical approach has been very misleading in social sciences and humanities. So, it was not by chance that Claude Shannon called it a theory of communication but not of information. Besides, Shannon himself never defined information and wrote only about the quantity of information.

A vivid picture of confusion about information is given in the book of Mark Poster (1990). He begins with the statement that information "*has become a privileged term in our culture that evokes a certain feature of the new cultural conjuncture and must be treated with suspicion*." Describing the scientific approach, he writes that some cybernetic theorists define information in a broad sense "*simply as organization of matter and energy*" (Poster, 1990, p.28). In the narrow sense, information is that part of a communication that is not "lost" in its transmission. The part that is "lost" is noise. At the same time, Poster writes about "*many forms of information: words, numbers, music, visual images*" (Poster, 1990, p.27).

If we take such an authoritative source of definitions as The American Heritage Dictionary (1996), we see the following definitions.

Information is*:* **1.** *Knowledge derived from study, experience, or instruction.* **2.** *Knowledge of a specific event or situation; intelligence.* **3.** *A collection of facts or data: "statistical information."* **4.** *The act of informing or the condition of being informed; communication of knowledge: "Safety instructions are provided for the information of our passengers."* **5.** (*in* Computer Science) *A nonaccidental signal or* *character used as an input to a computer or communications system.* **6.** *A numerical measure of the uncertainty of an experimental outcome.* **7.** (*in* Law) *A formal accusation of a crime made by a public officer rather than by grand jury indictment.*

Similar definitions of information are in the Roget's New Thesaurus: **1**. *That which is known about a specific subject or situation: data, fact (used in plural) , intelligence, knowledge, lore.* **2**. *That which is known; the sum of what has been perceived, discovered, or inferred: knowledge, lore, wisdom. And in both cases, there is a reference to the concept knowledge.*

In (O'Brien, 1995), which is used as a textbook at universities and colleges, it is written that terms *data* and *information* are used interchangeably, but while *data are raw material resources, information are data that has been transformed into a meaningful and useful context*. In (Laudon, 1996), we find a similar notion of information, which is defined as *an organized collection of data that can be understood*.

One more definition of information is presented in (Rochester, 1996). According to him, *information is an organized collection of facts and data.* Rochester develops this definition through building a hierarchy in which data are transformed into information into knowledge into wisdom. Thus, information appears as an intermediate level leading from data to knowledge.

Ignoring that an "*organized collection*" is not a sufficiently exact concept, it is possible to come to a conclusion that we have an appropriate definition of information. This definition and similar ones are used in a lot of monographs and textbooks on computer science. Ignoring slight differences, we may assume that this is the most popular definition of information. This gives an impression that we actually have a working concept.

Many will say, "*If such definition exists and people who are experts in computer science use it, then what's wrong with it? Why we need something else?*"

To explain why this definition is actually incoherent, let us consider some examples where information is involved.

The first example is dealing with a text that contains a lot of highly organized data. However, this text is written in Chinese. An individual, who does not know Chinese, cannot understand this text. Consequently, it contains no information for this person because such a person cannot distinct this text from a senseless collection of hieroglyphs. However, we have one and the same collection of organized data, while it contains information only for those who know Chinese. Thus, we come to a conclusion that information is something different from this collection of organized data.

It is possible to speculate that this collection of data is really information but it is accessible only by those who can understand the text. In our case, they are those who know Chinese.

Nevertheless, this is not the case. To explain this, we consider the second example. We have another text, which is a review paper in mathematics. Three people, a high level mathematician **A**, a mathematics major **B**, and a layman **C**, encounter this paper, which is in the field of expertise of **A**. After all three of them read or tried to read the paper, they come to the following conclusion. The paper contains very little information for **A** because he already knows what is written in it. The paper contains no information for **C** because he does not understand it. The paper contains a lot of information for **B** because he can understand it and knows very little about the material that is presented in it.

So, the paper contains different information for each of them. At the same time, data in the paper are not changing as well as their organization.

This vividly shows that data, even with a high organization, and information have an extremely distinct nature. Structuring and restructuring cannot eliminate these distinctions.

These inconsistencies that appear when we try to apply the given definition explicitly demonstrate that this definition is not adequate. It does not reflect real situations, and we need an essentially dissimilar definition.

In general, information has been considered as the following essences: as structures; processes (like becoming informed); changes in a knowledge system; some type of knowledge (for example, as personal beliefs or recorded knowledge); some type of data; an indication; intelligence; lore; wisdom; an advice; an accusation; signals; facts; acts; messages; as different things; as meaning; and as an effect like elimination of uncertainty (Buckland, 1991; Wersig&Neveling, 1976; Ursul, 1971; Brillouin, 1957; Wilson, 1993; etc.).

Consequently, it is not surprising that, as it is stated in the introduction, intelligent people come to a conclusion that the main problem is that people and even experts in the field do not really know what information is (Bosma, 1985).

Moreover, in one of his lectures the well-known American philosopher John Searle stressed that "*the notion of information is extremely misleading*." At the same time, the famous French mathematician Rene Thom (1975) calls the word '*information*' a "*semantic hameleon*," that is something that changes itself easily to correspond to the environment. Various scientific and laymen imaginations about information stand often without the least explicit relationship to each other. We see that "too many" definitions may be as bad as "too little."

All this demonstrates that the existing variety of definitions lacks a system approach to the phenomenon and for a long time there has been a need to elaborate a concept that reflects the main properties of information. This concept has to be the base for a new theory of information, giving an efficient tool for information processing and management.

However, knowing about information is not only a theoretical necessity but is a practical demand. Considering the United States of America in the information age, Giuliano V.E. (1983) states that the "*informatization process is very poorly understood. One of the reasons for this is that information work is very often seen as overhead; as something that is necessary but not contributory*."

In addition to this, there were other problems with theoretical studies of information. For example, Shannon's information theory applies only in those contexts where its precise assumptions hold, i.e., never in reality. However, experts in information studies understood that this does not imply that an attempt to create a more general theory of information should not be pursued. On the contrary it should. The existing theories are actually too restrictive.

At the same time, in spite of a multitude of papers and books concerning information and a lot of studies in this area, many important properties of information are unknown. As writes Tom Wilson (1993), " '*Information' is such a widely used word such a commonsensical word, that it may seem surprising that it has given 'information scientists' so much trouble over the years*." That is one of the reasons why no adequate concept (as well as understanding) of information phenomenon has been produced by information theory till the last decade of the 20th century.

It is possible to compare the development of information sciences with the history of geometry. At first, different geometrical objects (lines, angles, circles, triangles etc.) were investigated. When an adequate knowledge base of properties of geometrical objects was created, a new step was taken by introduction of the axiomatic theory that is now called the Euclidean geometry. In a similar way, knowledge obtained in various directions (*statistical* (Shannon, 1948), *semantic* (Bar-Hillel and Carnap, 1958), *algorithmic* (Solomonoff, 1964; Kolmogorov, 1965; Chaitin, 1966), *qualitative* (Mazur, 1984), *Fisher information* (Frieden, 1998), *economical* (Marschak, 1971), *social* (Goguen (1997), etc.) of information theory, as well as practical experience of information technology, made it possible to take a new step - to elaborate a unifying theory. It is called the *general theory of information*.

The general theory of information is developed on the base of axiomatic methodology (Burgin, 1991; 1994; 1995). However, a great complexity of the phenomenon of information implies a necessity to utilize not the standard axiomatic architecture but its more developed form. At first, the main principles are formulated. Then (on the second stage of the development of the general theory of information) a mathematical model and corresponding axiomatic theory are created. This mathematical theory is based on the main principles as well as on the apparatus of the theory of named sets or fundamental triads (Burgin, 1990). In this mathematical context, axioms of the general information theory are introduced. These axioms are mathematical images of the main principles. They provide a possibility to construct a formal theory of information, which is exposed elsewhere.

Information studies have a two-fold aim. On the one hand, we want to understand what is information, how it exists and functions. On the other hand, to achieve this goal, it is necessary to know how to get this knowledge. In other words, we need to find how to acquire information about information properties and to derive regularities of information functioning. In accordance with this two-fold aim, the set of the main principles of the general theory of information consists of two groups: the basic ontological and basic axiological principles. Basic ontological principles reflect the most essential properties of information as a natural, social, and technological phenomenon as well as regularities of information functioning. Basic axiological principles explain how to measure and evaluate information. They systematize and unify different approaches, existing as well as possible, to construction and utilization of information measures. This, axiological aspect of the theory is not less important than the ontological one because methods of modern science emphasize importance of measurement and evaluation that are technical means of observation and experiment.

Basic ontological and basic axiological principles are considered in the next two sections.

3. Basic Ontological Principles of the General Theory of Information

Ontological Principle O1. *It is necessary to separate information in general from information (or a portion of information) for a system* $\boldsymbol{R}$. In other words, *empirically, it is possible to speak only about information (or a portion of information) for a system.*

Definition 3.1. The system $\boldsymbol{R}$ is called the *receiver* of the information $\boldsymbol{I}$.

Why is this principle so important? The reason is that all conventional theories of information assume that information exists as something absolute, like time in the Newtonian dynamics.

Consequently, this absolute information may be measured, used, and transmitted. In some abstract sense it is true, but on practice, or as scientists say, empirically, this is not so.

To demonstrate this, let us consider the following situation. We have a book in Japanese and want to ask what information it contains. For a person who does not know Japanese, it contains no information. At the same time, its information for those who know Japanese may be immense.

Another situation: let us consider a textbook, for example, in mathematics. If it is a good textbook, then it contains a lot of information for a mathematics student. However, if we show this book to a professional mathematician, she or he might say, "Oh, I know everything in this book, so it contains no information for me."

We will have the same result but for a different reason if we give this book to an art student who is bored with mathematics.

To make situation more evident, imagine a completely deaf and blind person who comes to a movie theater without any devices to compensate his deficiencies. How much information this person will get there?

Being more adequate to reality than those assumptions that are made in other directions of information theory, the first ontological principle makes possible to resolve a controversy that exists in the research community of information scientists. Some of them suggest that information exists only in society, while others ascribe information to any phenomenon. Basing on the principle O1, the general theory of information states that if we speak about information for people, then it exists only in society because now people exist only in society. In other words, information for people does not exist without people. However, when we consider a more general situation, then we see that information exists in everything and it is only a problem how to extract it. For example, for a biologist any living creature contains information. Stars contain information for astronomers, while stones contain information for geologists.

Thus, the first principle explicates an important property if information, but says nothing what information is. This is done by the second principle that exists in two forms.

Ontological Principle O2. *In a broad sense, information* $\boldsymbol{I}$ *for a system* $\boldsymbol{R}$ *is any essence causing changes in the system* $\boldsymbol{R}$.

This principle has several consequences. First, it demonstrates that information is closely connected with transformation. Namely, it means that information and transformation are functionally similar because they both cause changes in a system. At the same time, they are different because information is a cause of change while transformation is a change itself.

Second, it explains why information influences society and individuals. Namely, reception of information implies transformation. In this sense, information is similar to energy. Moreover, according to Principle O2, energy is a kind of information in a broad sense. This exactly corresponds to the Carl Friedrich von Weizsäcker's idea (cf., for example, Flükiger, 1995) that *energy might in the end turn out to be information*. In its turn, the von Weizsäcker's conjecture explains the exact correspondence between such characteristic of energy as the thermodynamic entropy, which is given by the Boltzmann-Planck formula $S = k \cdot \ln P$, and such characteristic of information as the quantity of information, which is given by a similar Hartley-Shannon formula $I = K \cdot \ln N$.

Third, Principle O2 makes it possible to separate different kinds of information. For example, any person as well as any computer has many kinds of memory. It is even supposed that each part of the brain has several types of memory agencies that work in somewhat different ways, to suit particular purposes (Minsky, 1986). It is possible to consider each of these memory agencies as a separate system and to study differences between information that changes each type of memory. This would help to understand the interplay between stability and flexibility of mind, in general, and memory, in particular.

It is true, to be sure, that an adequate theory, whether of the information or anything else, must be in significant accord with our common ways of thinking and talking about what the theory is about. Else there is the danger that theory is not about what it purports to be about. But, on the other hand, it is wrong to expect that any adequate and reasonably comprehensive theory will be congruent in every respect with common ways of thinking and speaking about its subject, just because those ways are not themselves usually consistent or even entirely clear. To achieve this goal, we introduce information in the strict sense, which is based on the concept of an infological subsystem of a system.

Definition 3.2. A subsystem IF(***R***) of the system ***R*** is called an infological system of ***R*** if IF(***R***) contains infological elements.

Infological elements are different kinds of structures (Burgin, 1991; 1997). Let us take as a standard example of infological elements knowledge, data, images, ideas, fancies, abstractions, beliefs, etc. If we consider only knowledge and data, then the infological system is the system of knowledge. This system is very important, especially, for intelligent systems. The majority of researchers believe that information is intrinsically connected to knowledge (cf. Flückiger, 1995).

Consequently, we take the system of knowledge of ***R*** as a model example of an infological system IF(***R***) of an intelligent system ***R***. It is called in cybernetics the thesaurus Th(***R***) of the system ***R*** .

When ***R*** is a material system, its infological subsystem IF(***R***) consists of three components: a material component, which is a system of physical objects; a functional structure realized by the material component; and the system of infological elements. For example, the material component of the infological subsystem of a human being is her/his brains. The corresponding functional structure is her/his mind. Infological elements in this case will be the knowledge of the individual.

Another example of an infological system is the memory of a computer. Such a memory is a place in which data and programs are stored.

Remark 3.1. An arbitrary complex system ***R*** has, as a rule, different infological subsystems. Fixing one of these subsystems, we determine what is information for ***R*** and changing our choice of IF(***R***) we change the scope of information entities.

For example, computers have different kinds of memory: processor registers, addressed memory, main storage, buffer storage, external storage, working storage etc. Each of them or any combination of them may be considered as an infological subsystem of a computer ***R*** . If the processor registers are treated as an infological subsystem, then no program (even such that is kept in the main storage of this computer) does not have information for ***R*** until execution of instructions of this program begins.

Ontological Principle O2a. *Information in the strict sense or, simply, information for a system* ***R****, is everything that changes the infological system* IF(***R***) *of the system* ***R***.

This principle and Remark 1 imply that for a complex system there are different kinds of information. Each infological system determines a specific kind of information. For example, information that causes changes in the system of knowledge is called cognitive information. This kind of information is crucial for pedagogy.

Remark 3.2. In what follows, we use the terminus "information" instead of "a portion of information" when it does not cause misunderstanding.

Ontological Principle O2a implies that information is not of the same kind as knowledge and data, which are structures (Burgin, 1997). Actually, if we take that *matter* is the name for all substances as opposed to *energy* and the *vacuum*, we have the relation that is represented by the following diagram.

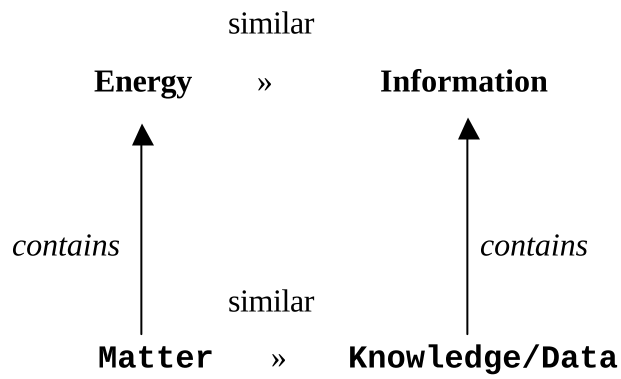

Fig. 3.1. Information/Energy Diagram

In other words, ***information is related to knowledge and data as energy is related to matter.***

Distinction between knowledge and cognitive information implies that transaction of information (for example, in a teaching process) does not give knowledge itself. It only causes such changes that may result in the growth of knowledge.

This correlates with the approaches of Dretske (1981) and MacKay (1969), who declare that information increases knowledge and knowledge is considered as a completed act of information.

However, the general theory of information differs from this conception of information because it demonstrates that information transaction may result also in the decrease of knowledge (Burgin, 1994).

According to (Flückiger, 1995), in modern information theory a distinction is made between structural-attributive and functional-cybernetic types of theories. Representatives of the former approach conceive information as structure, like knowledge or data. Adherents of the latter understand information as functionality, functional meaning or as a property of organized systems.

Our conception of information belongs to the functional approach because it is possible to consider many kinds of conventional information as a property of knowledge. At the same time, functional conception looks incoherent with respect to the structural approach, and we have the question whether it is worth to have two notions of information as they have historically emerged or it is necessary to preserve only one of them to achieve higher integrity of sciences.

To find a grounded answer, we have both historical and methodological arguments. From history, we know that when physics was only emerging as a science, there was a lot of controversy on the problem what was energy. However, necessity to build exact mathematical models of physical phenomena resulted in making the term 'energy' sufficiently precise and giving other names to similar phenomena. Consequently, the term '*information*' also has to be sufficiently precise. It might be possible only if we choose either functional or structural approach to definition of information.

In addition to this, we have the following methodological arguments explaining why it is not reasonable, logical, and even consistent to consider information as a kind of knowledge or knowledge as a kind of information.

1. Only some kinds of information are related to knowledge. There are other kinds, which, for example, are connected to emotions, which are often contrasted to knowledge (Burgin, 2001).
2. According to the methodological principle that is called *Occam razor*, it is not necessary to call one and the same thing by two names *knowledge* and *information*. One name is sufficient, and *knowledge* is better in this case. Besides, as it is demonstrated in the previous section, properties of information are essentially different from properties of knowledge.
3. In addition to this, it is not logical to consider information as some structure because structural aspects of the world are covered by other scientific concepts. Consequently, like matter is only a vessel for energy, but not energy itself, static structures (knowledge, data, signs, texts, etc.) are only carriers for information, while information reflects dynamic aspects of reality.

So paraphrasing Wiener, we may say that *information is not knowledge and knowledge is not information*.

Remark 3.3. The symbol IF may be considered as an operator that is defined on a space of systems of some chosen kind (may be on the space of all systems). Being applied to a system ***R***, the operator IF defines in ***R*** its infological subsystem IF(***R***). However, as a rule, this is a multivalued or variable operator because it is possible that ***R*** has several infological subsystems.

Remark 3.4. It is possible to argue that the concept of an infological system is too ambiguous and fuzzy. However, ambiguity may be a positive property if you can use it. For example, if you can control and change ambiguity, it becomes not an ambiguity but a parameter that is utilized to tune and control the system under consideration.

This is just the case with the infological system in the general theory of information. Thus, it is natural that a human being has not the same infological system as a biological cell or a computer.

Remark 3.5. As it is mentioned above, in modern information theory there is the structural-attributive direction, representatives of which conceive information as structure, like knowledge or data, variety, order, and so on (cf., for example, MacKay, 1969; Nauta, 1970; Seifert, 1968; Dretske, 1981; Flückiger, 1995). According to the general theory of information such structures are not information *per se*. They are infological elements, which are structural carriers of information. Consequently, all theories that belong to the structural-attributive direction are included in the scope of the general theory of information through the subtheory of infological systems and elements.

The fact that information influences human behavior to such a great extent is a consequence of the fact that human infological systems (or subsystems) control human actions. The latter is a necessary trait for adaptation of an individual both in nature and society.

A possibility to choose an infological system in a different way is very beneficial. It helps to discover existence of different types and kinds of information. Each type of information corresponds to some type of infological system. Examples of such types are considered in the sixth section of the paper.

In what follows, we consider only information in the strict sense.

Definition 3.3. If information, or more strictly, a portion of information ***I*** changes only IF(***R***) (and nothing more), then I is called (a portion of) *pure information*.

Definition 3.4. If information ***I*** changes IF(***R***) and some other parts of ***R*** then ***I*** is called extended information or more strictly, (a portion of) *extended information*.

For example, when a boxer receives a knock, it is extended information because it adds to the boxer's knowledge that he has received a knock and at the same time it changes his physical state.

Sometimes it is difficult to make an exact distinction between pure and extended information. For example, some individual watched TV and what she saw impressed her so much she changed her life. In particular, being fat she stopped eating too much and became slender and active. Thus, information that this person had gotten watching TV had changed her even physically. Consequently, on one hand this information is pure because it had changed only knowledge of this person. On the other hand, it looks, according to Definition 4.4, like an extended information.

Even a text may contain extended information. Let us consider a letter L that contains information about death of some person **A**. Imagine such a situation. A close relative **R** of **A** receives this letter, reads it and then has a stroke because the news from the letter was so horrible for him. Thus, we can state that the letter L contained for **R** some portion of extended information.

Definition 3.5. If information ***I*** (in the general sense) does not change IF(***R***), then ***I*** is called *quasiinformation* for ***R***.

In what follows, we do not consider quasiinformation, i.e., such generalized information, which does not include pure information. However, this concept is very important for the entertainment industry, which suffers from a lot of reproaches for disseminating quasiinformation.

Let ***I*** be some portion of information for a system ***R*** .

Ontological Principle O3. *There is always some carrier* ***C*** *of the information* ***I****.*

Really, people get information from books, magazines, TV and radio sets, computers, and from other people. To store information people use their brains, paper, tapes, and computer disks.

Carriers of information belong to three classes: material, mental, and structural. For example, let us consider a book. It is a physical carrier of information. However, it contains information only because some meaningful text is printed in it. Without this text it would not be a book. The text is the structural carrier of information in the book. Besides, the text is understood if it represents some knowledge. This knowledge is the mental carrier of information in the book.

These distinctions in carriers are of a great importance when something (such as film) is produced for entertainment. To achieve better information transmission, it is necessary to pay attention how all three types of carriers are organized and produced.

For adherents of the materialistic approach Principle O3 must be changed to a stronger version:

Ontological Principle OM3. *There is some substance* ***C*** *that contains information* ***I.***

Definition 3.6. This substance ***C*** is called the physical carrier of ***I***.

The first three ontological principles ((O1)-(O3) or (O1)-(OM3)) imply that information connects the carrier ***C*** with the system ***R*** and is a component of the following triple structure

$$(\boldsymbol{C}, \boldsymbol{I}, \boldsymbol{R}) \qquad (1)$$

As a rule, there is some channel through which information comes from ***C*** to ***R***. For example, The carrier ***C*** of ***I*** is a piece of paper and ***R*** is a person reading the text written on ***C***. Then the corresponding channel is the space between the paper and the eyes of the person.

The structure (1) is a special case of the following more general structure that is called a named set or a fundamental triad (Burgin, 1990; 1991; 1997):

or

Fig. 3.2. Fundamental triad

In the fundamental triad, Entity 1 (Essence 1) is called the support, the Entity 2 (Essence 2) is called the reflector (or the set of names) and the connection (correspondence) is called the reflection (or the naming relation) of the fundamental triad (named set).

There are many fundamental triads in which Entity 1 is some set, Entity 2 consists of the names of the elements from the Entity 1 and elements are connected with their names by the naming relation. This explains the name "named set" that was for an essential time applied to a triad (Burgin, 1990; 1991). A standard model of this structure is a set of people who constitute the carrier, their names that form the set of names, and the naming relation consists of the correspondences between people and their names.

People meet fundamental triads constantly in their everyday life. An example is given by the traditional scheme of communication.

Communication is extensively studied as process of information transmission and reception. According to Shannon, in order for messages to be transmitted, we need a communication system.

Shannon describes the components of the communication system as follows:

1.The information source (or message source) produces messages or parts of messages intended for a particular destination.

2.On the basis of the message, the transmitter produces a sequence of signals such that they can be transmitted over a channel.

3.The channel is merely the medium used to transmit the signal from transmitter to receiver. During transmission the signals may be perturbed and distorted by a so-called noise source.

4.The receiver usually performs the reverse operation to the transmitter, reconstructing if possible the original message from the signals.

5.The destination is the addressee of the message and can be either a person or a thing. It requires a priori knowledge about the information source, which enables it to understand the message transmitted. In any case, the destination must know the set of signs available to the information source.

Communication process as a total event has been a subject of many studies. Many models or structural descriptions of the communication event have been suggested to aid understanding of the general organization of the total event. This makes possible to classify and to describe the parts of the process and to indicate how they fit together and interact in the process. Models provide clues that permit predictions of behavior and thus stimulate further research.

There are *static* and *dynamic* models. Static models represent the system in which the communication goes on. Dynamic models feature functioning of such a system.

The simplest static model consists of three elements: *sender*, *receiver*, and *channel* (Figure 3.3.a). The simplest dynamic model consists of three elements: *sender*, *receiver*, and *message* (Figure 3.3.b).

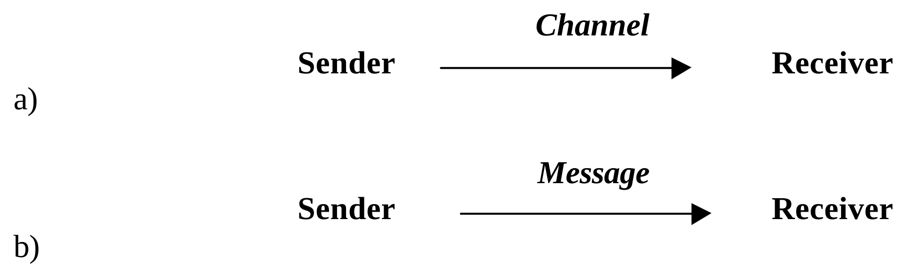

Fig. 3.3. The simplest models of a communication event.

a) The static model; b) The dynamic model.

A more detailed, synthetic model incorporates both static and dynamic features of the process. It is presented in the Figure 3.4. Connection here consists of three components: the *physical communication media* (in particular, a *channel*), *message* as the pragmatic part of communication, and *structural communication means*. The latter include language(s), which is (are) used for coding and decoding the message; emission, transmission, and reception algorithms (software systems) etc. Physical systems that perform emission, transmission, and reception are parts of the physical communication media.

Fig. 3.4. The synthetic model of a communication event.

It is necessary to remark that principles of a theory do not allow one to achieve the necessary exactness. That is why, mathematical structures are utilized and axioms of the general theory of information are introduced. These axioms give an exact mathematical reflection of the main principles and provide for elaboration of a general axiomatic theory of information, which is based on the theory of named sets (fundamental triads). Fundamental triads are used for construction of the mathematical part of the general theory of information. But before doing this we proceed with formulations of the main principles of this theory.

Ontological Principle O4. *A transaction of information goes on only in some interaction of **C** with **R**.*

This interaction may be direct or indirect, i.e. it is realized by means of some other objects.

The property of information explicated in Principle O4 may look evident. However, it has important consequences, For example, if you know that some information has passed from system to another and want to find how it happened, you have to look for a channel of transaction. Although, if it is known only that the second system possesses the same information as the first one, it not necessary that it has been a transmission. It might be possible that the same information has been created by the second system. Existence of a channel makes transmission possible but does not necessitates it.

The next principle is a clarification of Principle O4.

Ontological Principle O4a. *A system **R** receives information **I** only if some carrier **C** of **I** transmits **I** to the system **R** or **R** extracts this information from **C** through some channel ch .*

Here, we have two ways of information transaction: transmission and extraction. Transmission of information is the passive transaction with respect to ***R*** when ***R*** receives information and active transaction with respect to ***C*** when ***C*** transmits information. Extraction of information is the active transaction with respect to ***R*** when ***R*** extracts information and passive transaction with respect to ***C*** when information is taken from ***C***. When the carrier ***C*** is the system ***R*** itself, then we have the third type of information operations – information processing. It includes information transformation and production (Burgin, 1997b).

The two ways of information exchange reflect interesting regularities of education. There is an essential difference between Western and Eastern approaches to education. The main principle of the Western tradition is that a teacher comes to students to teach them. Contrary to this, the main principle of the Eastern tradition is that a student comes to teacher to learn from him. This means that the Western approach is based on information transmission, while the Eastern approach stems from information extraction.

At the same time, the same Western technology has developed means for active participation in entertainment. Computer games represent only the first step in this direction.

Two more principles explicate dynamic properties of information processes.

Ontological Principle O5. *A system **R** accepts information **I** only if the transaction causes corresponding transformations.*

For example, if after reading this paper, your knowledge remains the same, you do not accept cognitive information from this text. That is why, the concern of the people from the entertainment industry how their production influences the intended audience is the greatest importance to the industry. The general theory of information can explain many features of this impact. However, this theory does not solve all problems, and to have a complete picture, it is necessary to include sociologists, psychologists, economists, linguists, and semiologists in the study of entertainment.

Ontological Principle O6. *One and the same carrier **C** can contain different portions of information for one and the same system **R**.*

Really, let us take some person ***A*** as the system ***R*** and a book written in Japanese as the . At first, ***A*** does not know Japanese and ***C*** contains almost no information for ***A***. After some time, ***A*** learns Japanese, reads the book ***C*** and finds in it a lot of valuable information for himself. Note that knowing Japanese ***A*** is, in some sense, another person.

In other words, if you want to convey some information to an audience efficiently, you have to prepare this audience to acceptation of the transferred information. This is essentially important for contemporary entertainment industry based on mass communication.

There are many examples supporting Principle O6 when unprepared community did not accept even the highest achievements of human intellect and creativity. Thus, it is known that contemporaries did not accept many outstanding works of art as well as great discoveries. Only consequent generations understood the greatness of what had been done before. As examples, we can take the great composer Mozart, who died in poverty, the great mathematicians Galois and Abel, who wrote outstanding works but were neglected and died at a very young age as a result of such an attitude.

One more example of misunderstanding gives the life of the great English physicist Paul Dirac. He was well known and respected by physical community when he theoretically discovered a positive "electron", which was later called positron. However, other physicists did not understand Dirac's achievement and even mocked at him.

At the same time, the great German mathematician Gauss made one of the most outstanding discoveries of the 19th century, the discovery of the non-Euclidean geometry. Nevertheless, he did not want to publish his discovery because correctly considered the contemporary mathematical community unprepared to the comprehension of this discovery.

The last three principles reflect only such situations when transformation of an infological system takes place. However, it is important to know and predict properties of these transformations, for example, to evaluate the extent or measure of transformations.

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