INFORMATION IN THE STRUCTURE OF THE WORLD

Mark Burgin

Abstract*: Finding the place of information in the world is an important philosophical and methodological problem. Some authors relate information only to society. Others also include the level of individual human beings. In contrast to this, many presume that information is everywhere in nature. In this paper, we treat this problem, taking it at a different level of placing information in the structure of the world. Consequently, at first, we describe the global structure of the world and then find the place of information in this structure. In addition, we consider structure of information processes, as well as relations between information and basic constituents of the world, such as matter, energy, mentality and knowledge*

Keywords*: information, logic, operator, natural, society,*

Introduction

Understanding importance of information, researchers began their quest in finding what information is, what the place of information in the world is, how to measure information and many other important theoretical, philosophical and methodological questions related to information. As Wiener wrote, "Information is information, not matter or energy."

Scientists and philosophers suggested dozens of definitions of information, infinite systems of measures of information and a diversity of opinions about the place of information in the world. Some authors relate information only to society. Other researchers also include the level of a separate individual. Some ascribe information only to people, while others relate it also to animals and other living beings. In contrast to this, many presume that information is everywhere in nature. In this paper, we treat this problem, taking it at a different level of placing information in the structure of the world. Consequently, at first, we describe the global structure of the world and then find the place of information in this structure. In addition, we consider structure of information processes, as well as relations between information and basic constituents of the world, such as matter, energy, mentality and knowledge.

In Section 1, we explicate the global structure of the world in the historical perspective, starting with the worldview of Plato and bringing it to our days. Section 2 determines the place of information in the global structure of the world and analyzes structures related to information processes. In Section 3, relations between information and knowledge are explained.

2. The Structure of the World

Plato was the first outstanding philosopher who elaborated and discussed a definite structure of the world. In his dialogues, Plato mostly discusses two worlds: the World of Ideas/Forms, which is perfect unchangeable and eternal, and the Material World, which is not real being an imperfect reflection of the World of Ideas/Forms. However, describing these worlds, he cannot leave without an answer the crucial question asking how people get knowledge about these worlds. Answers inevitably involve the third world - mentality of an individual. In his dialogue *The Republic*, Plato has Socrates explain the literary analogy of a *divided line* to teach basic

philosophical ideas about levels of existence and the corresponding structure of the individual mentality. Going from the lowest part to the highest, the individual mentality contains: *imagination*, *senses*, *intelligence* (as logical thinking) and (philosophical) *intuition*. In such a way, it is possible to conclude that in the worldview of Plato, the world as whole included the Mental World as its constituent.

All three worlds assemble together as the *global world structure*. This triadic structure has an interesting history. In the light of contemporary knowledge, the first was the philosophical tradition that is given in Figure 1.

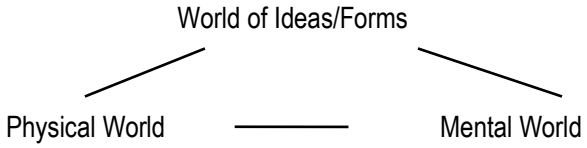

Figure 1. The Plato Triad of the world

According to physics, people live in the *physical* (*material*) *world* and this is the only reality that exists. In contrast to this opinion, subjective philosophies and religious teachings assert that only the mental world is real, while the physical world is just an appearance, a shadow without substance. For instance, Buddhism explains that the whole physical reality is a great illusion and the only reality is the spiritual world. In some forms of Buddhism (e.g., *Yogacara*), it is assumed that all things are created by Mind. At the same time, achievements of physics brought scientists to the edge of physical reality where extremely small physical objects, such as quarks or neutrons, and extremely large physical objects, such as our Universe as a whole, do not allow direct comprehensive observation. As a result, both extremities become more structures than material things. In this context, the outstanding physicist Max Born admits that the notion of reality in the physical world had become, during the last century, rather problematic [Born, 1953].

At the same time, science has enough evidence to admit reality of the *mental world*. As states contemporary psychology, each individual has a specific inner world, which forms mentality of the individual and is based on the psyche. However, there is a controversy whether individual mentality is a product of the person's organism (body), or more exactly, of the brain, or the individual mentality transcends the body. In any case, these individual inner worlds form the lowest level of the mental world, which complements our physical world. On the next level, there are mental worlds of groups of people, communities and the whole society. It is possible to develop this hierarchy of mental worlds but it is done elsewhere demonstrating that the mental world is different from the physical world and constitutes an important part of our reality.

Moreover, our mentality influences the *physical world* and can change it. We can see how ideas change our planet, create many new things and destroy existing ones. Even physicists, who study the very foundation of the physical world, developed the, so-called, observer-created reality interpretation of quantum phenomena. The prominent physicist, John Archibald Wheeler, suggests that in such a way it is possible to change even the past. He stresses [Wheeler, 1977] that phenomena on the level of subatomic particles are unreal until observed. Existence of the *physical world* and *mental world* brings us to a dualistic model of reality.

However, having no evidence for and clear understanding of the World of Ideas, many philosophers and scientists, starting with Aristotle, argue that the World of Ideas causes many problems. Where is this world of

ideas and how do we make contact with it? What is an idea in this sense? How is it possible for our mind to have an interaction with the Platonic realm so that our brain state is altered by that experience? Plato and his followers have not provided convincing answers to these questions. Thus, in spite of the attractive character of this idea, the majority of scientists and philosophers believe that the world of ideas does not exist, because nobody has been able to find any positive evidence in support of it. The crucial argument of physicists is that the main methods of verification in modern science are observations and experiments, and nobody has been able to find this world by means of observations and experiments. Nevertheless, there are modern thinkers, such as philosopher Karl Raimund Popper, mathematician Kurt Gödel, and physicist Roger Penrose, who continue to believe that the world of ideas exists.

Starting with ideas of Plato, Popper tried to eliminate the incomprehensible World of Ideas/Forms [Popper, 1974; 1979] building his own triadic ontology of the world based on scientific ideas. It has two forms, which may be called general and pure.

In the pure form, Popper Triad consists of three parts/worlds:

World 1 consists of physical bodies, including microparticles, physical processes, physical energy and physical fields.

World 2 consists of thoughts, feelings, decisions, perceptions, observations, etc.

World 3 consists of abstract or intellectual products of the human mind, such as languages, tales, stories, contents of books and documents, scientific conjectures and theories, mathematical constructions, etc.

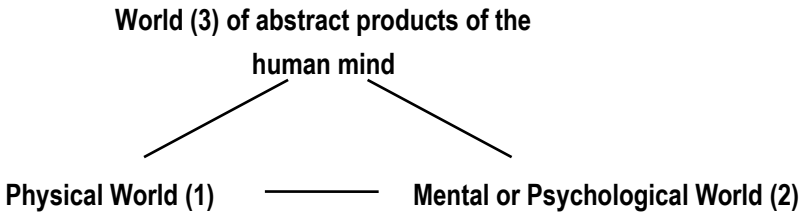

Figure 2. The Pure Popper Triad of the world

To define these worlds, Popper writes [Popper, 1976]:

"If we call the world of "things" or of physical objects - the first world, and the world of subjective experiences (such as thought processes) the second world, we may call the world of statements in themselves the third world. …

It would be easy ... to regard the whole of world 3 as timeless, as Plato suggested of his world of Forms or Ideas.... I propose a different view - one which, I have found, is surprisingly fruitful. I regard world 3 as being essentially the product of the human mind.... More precisely, I regard the world 3 of problems, theories, and critical arguments as one of the results of the evolution of human language, and as acting back on this evolution."

However, such an abstract nature of World 3 caused many questions about it real existence and Popper decided to extend it including other products of the human mind, such as books, paintings, sculptures, aeroplanes and other feats of engineering [Popper, 1978].

Thus, in the general form, Popper Triad consists of three parts/worlds:

World 1 consists of physical bodies, including microparticles, physical processes, physical energy and physical fields.

World 2 consists of thoughts, feelings, decisions, perceptions, observations, etc.

World 3 consists of all products of the human mind, such as books, paintings, sculptures, aeroplanes and other feats of engineering

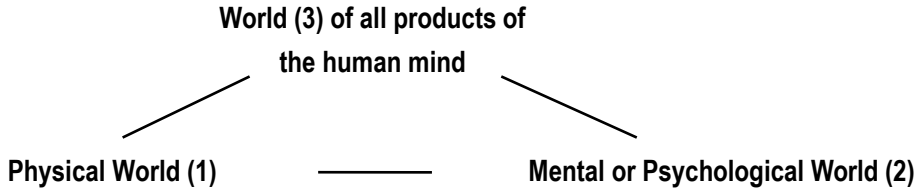

Figure 3. The General Popper Triad of the world

On the one hand, it is much easier to understand Popper Triad than the Plato Triad because products of the human mind are much more tangible than abstract ideas, which exist nobody knows where. On the other hand, there are phenomena related to products of the human mind, such as shapes and other features of physical objects, which are not included in the World 3 of Popper.

Other authors refer World 3 in the Popper Triad to signs in the sense of Charles Saunders Peirce although they do not insists that it consists of objects that Peirce would classify as signs (cf., for example, [Skagestad, 1993; Capuro and Hjorland, 2003]).

However, the progress of science and mathematics brought forth the discovery of the *world of structures* [Burgin, 1991; 1996; 1997], allowing the researchers to solve the mystery of the Plato Forms or Ideas. On the level of ideas, this world may be associated with the Platonic world of ideas or forms in the same way as atoms of modern physics may be related to the atoms of Democritus. In contrast to Plato, science has been able to prove existence of the world of structures, demonstrating by means of observations and experiments, that this world constitutes the structural level of the world as the whole. Each system, phenomenon, or process either in nature, technology or society has some structure. These structures exist like material things, such as tables, chairs, or buildings do, and form the *structural level* of the world. When it is necessary to learn or to create some system or process, it is done, as a rule, by means of knowledge of the corresponding structure. Structures determine the essence of things.

Only recently, modern science came to a new understanding of Plato ideas, representing the global world structure as the *Existential Triad* of the world (cf. Figure 4).

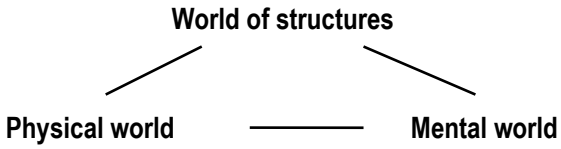

Figure 4. The Existential Triad of the world

In this triad, the Physical (material) World is interpreted as the physical reality studied by natural sciences, the Mental World encompasses different levels of mentality, and the World of Structures consists of various forms and types of structures. Each of these three worlds has a hierarchical structure with several levels or strata. For instance, the hierarchy of the physical world goes from subatomic particles to atoms to molecules to bodies to cells to living beings and so on.

The Plato Triad looks very similar to the Existential Triad as there is a direct correspondence between their vertices:

Material World ↔ Physical World

Mental World ↔ Mental World

World of Ideas/Forms ↔ World of Structures

So, it is important to understand what essential progress has been made from the time of Plato to our time and why these triads are similar and at the same time, fundamentally different.

Comparing the Material World of Plato and the Physical World from the Existential Triad, we see that on the ontological level, they are the same. However, on the epistemological (cognitive) level, they are basically different because due to the advancement of science, now people know much more about physical reality than at the time of Plato. It means that the known physical world from the Existential Triad is many times larger than the known material world from the Plato Triad. In addition, knowledge of the physical reality has become more exact and comprehensive.

Looking at the Mental World, we see that at the time of Plato, it included only individual mentality. Now science extended this picture and studies the Mental World on three levels, which are all included in the Existential Triad:

- The first level treats mentality of separate individuals and is the subject of psychological studies.
- The second level deals with group mentality of separate individuals and is the subject of social psychology.
- The third level encompasses of society as a whole and is the subject of social psychology.

Besides, the Mental World from the Existential Triad comprises higher (than the third) levels of mentality although they are not yet studied by science [Burgin, 1997; 2010].

It is necessary to remark that as physics does not study the physical reality as a whole but explores different parts and aspects of it, psychology also separates and investigates different parts and aspects of the mental reality, such as intelligence, emotions, or unconscious. As in the case of the Physical World, contemporary knowledge about the Mental World exceeds what was known by Plato and its contemporaries.

This is even truer for the World of Structures, which is much more understandable, exact and explored than the World of Ideas/Forms. When Plato and other adherents of the World of Ideas/Forms were asked what an idea or form was, they did not have a satisfactory answer. In contrast to this, many researchers have been analyzing and developing the concept of a structure [Ore, 1935; 1936; Bourbaki, 1948; 1957; 1960; Bucur and Deleanu, 1968; Corry, 1996; Burgin, 1997; Landry, 1999]. It is possible to find the most thorough analysis and the most advanced concept of a structure in [Burgin, 2010].

3 Information as a Basic Component of the World Structure

The place and the role of information in the world are defined by the ontological principles of the General Theory of Information, which is constructed as an axiomatic theory on three levels: *conceptual*, *methodological* (also called *meta-theoretical*) and *theoretical* [Burgin, 2010].

On the conceptual level, the essence of information as a dynamic object playing a pivotal role in all walks of reality is explicated, clarifying a quantity of misconceptions, fallacies and illusions.

Methodological (meta-theoretical) level is based on two classes of principles and their relations. The first class contains ontological principles, which bring to light general properties and regularities of information and its functioning. Principles from the second class explain how to measure information and are called axiological principles.

On the theoretical level, axioms of structures used and axioms reflecting features of information are introduced and utilized for building models of information and related phenomena, e.g., information flow or information processing. These models are used for studies of information and various related systems and phenomena, e.g., information flow in society or information processing systems, such as computers and networks.

To clarify the concept of information, we consider here the basic ontological principles. The first of them separates local and global approaches to information definition, i.e., in what context information is defined.

Ontological Principle O1 (**the *Locality Principle***). It is necessary to separate information in general from information (or a portion of information) for a system *R*.

In other words, empirically, it is possible to speak only about information (or a portion of information) for a system.

The system ***R*** with respect to which some information is considered is called the *receiver*, *receptor* or *recipient* of this information.

Such a receiver/recipient can be a person, community, class of students, audience in a theater, animal, bird, fish, computer, network, database and so on.

The Locality Principle explicates an important property of information, but says nothing what information is. The essence of information is described by the second ontological principle, which has several forms.

Ontological Principle O2 (the *General Transformation Principle*). In a broad sense, *information* for a system *R* is a capacity to cause changes in the system *R*.

Thus, we may understand information in a broad sense as a capacity (ability or potency) of things, both material and abstract, to change other things. Information exists in the form of *portions of information*. Informally, a portion of information is such information that can be separated from other information. Information is, as a rule, about something. What information is about is called the *object* of this information.

The Ontological Principle O2 has several consequences.

- First, it demonstrates that information is closely connected to transformation. Namely, it means that information and transformation are functionally similar because they both point to changes in a system. At the same time, they are different because information is potency for (or in some sense, cause of) change, while transformation is the change itself, or in other words, transformation is an operation, while information is what induces this operation.
- Second, the Ontological Principle O2 explains *why* information influences society and individuals all the time, as well as why this influence grows with the development of society. Namely, reception of information by individuals and social groups induces transformation. In this sense, information is similar to energy. Moreover, according to the Ontological Principle O2, energy is a kind of information in a broad sense. This well correlates with the von Weizsäcker's idea that *energy might in the end turn out to be information* [Weizsäcker, 1974].
- Third, the Ontological Principle O2 makes it possible to separate different kinds of information. For instance, people, as well as any computer, have 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. Thus, 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 might help to understand the interplay between stability and flexibility of mind, in general, and memory, in particular.

In essence, we can see that all kinds and types of information are encompassed by the Ontological Principle O2. In the most concise form, it is demonstrated in [Burgin, 2010].

However, the common usage of the word information does not imply such wide generalizations as the Ontological Principle O2 implies. Thus, we need a more restricted theoretical meaning because an adequate theory, whether of information or of 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.

Information in a proper sense is defined of structural infological systems. In essence, any subsystem of a system may be considered as its infological system. However, information in a proper sense acts on structural infological systems. An infological system structural is structural if all its elements are structures. For example, systems of knowledge are structures.

To achieve precision in the information definition, we do two conceptual steps. At first, we make the concept of information relative to the chosen infological system IF(R) of the system R and then we select a specific class of infological systems to specify information in the strict sense. That is why it is impossible and, as well as, counterproductive to give an exact and thus, too rigid and restricted definition of an infological system.

Infological system plays the role of a free parameter in the general theory of information, providing for representation of different kinds and types of information in this theory. That is why the concept of *infological system*, in general, should not be limited by boundaries of exact definitions. A free parameter must really be free. Identifying an infological system IF(R) of a system R, we can define information relative to this system. This definition is expressed in the following principle.

Ontological Principle O2g (**the *Relativized Transformation Principle***). *Information* for a system *R relative to the infological system* IF(*R*) is a capacity to cause changes in the system IF(*R*).

As a model example of an infological system IF(*R*) of an intelligent system *R*, we take the system of knowledge of *R*. It is called in cybernetics the *thesaurus* Th(*R*) of the system *R*. 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 and is a complex system of diverse components and processes.

Elements from the infological system IF(*R*) are called *infological elements*. The nature of the infological elements depends on the nature of the infological system IF(*R*).

There is no exact definition of infological elements although there are various entities that are naturally considered as infological elements as they allow one to build theories of information that inherit conventional meanings of the word *information*. For instance, knowledge, data, images, ideas, algorithms, procedures, scenarios, schemas, values, goals, ideals, fantasies, abstractions, beliefs, and similar objects are standard examples of cognitive infological elements.

When we take a physical system *D* as the infological system and allow only for physical changes, information with respect to *D* coincides with energy.

Taking a mental system *B* as the infological system IF(*R*) and considering only mental changes, information with respect to *B* coincides with mental energy. In 1874, the concept of psychic energy, also called *psychological energy*, was developed in the field of psychodynamics by German scientist Ernst Wilhelm von Brücke who proposed that all living organisms are energy-systems governed by the principle of the conservation of energy. Later Sigmund Freud adopted this new idea about energy and suggested that it was possible to apply both the first law of thermodynamics and the second law of thermodynamics to mental processes, describing functioning of a mental or psychic energy (cf. [Freud, 1949]. In *The Ego and the Id*, Freud argued that the Id was the source of the personality's desires, and therefore of the psychic energy that powered the mind. The psychoanalytic approach assumes that the psyche of people needs some kind of energy to make it work. This energy is used in mental work, such as thinking, feeling, and remembering. It is assumed that psychic energy comes from the two main drives: Eros (or libido, the life and sexual instincts) and Thanatos (death instinct). The theory of psychic energy was further developed by Carl Gustav Jung, a student of Freud, who (in 1928) published a seminal essay entitled "On Psychic Energy" (cf. [Jung, 1969]). Later, the theory of psychodynamics and the concept of "psychic energy" was developed further by such well-known psychologists as Alfred Adler and Melanie Klein.

These ideas, which connect concepts of information and energy, are summarized in the following principle which defines information in the strict sense.

Ontological Principle O2a (**the *Special Transformation Principle***). *Information in the strict sense* or *proper information* or, simply, *information* for a system *R*, is a capacity to change structural infological elements from an infological system IF(*R*) of the system *R*.

To better understand how infological system can help to explicate the concept of information in the strict sense, we consider cognitive infological systems.

An infological system IF(*R*) of the system *R* is called *cognitive* if IF(*R*) contains (stores) elements or constituents of cognition, such as knowledge, data, ideas, fantasies, abstractions, beliefs, etc. A cognitive infological system of a system *R* is denoted by CIF(*R*) and is related to cognitive information.

In this case, it looks like it is possible to give an exact definition of a cognitive infological system. However, now cognitive sciences do not know all structural elements involved in cognition. A straightforward definition specifies cognition as activity (process) that gives knowledge. At the same time, we know that knowledge, as a rule, comes through data and with data. So, data are also involved in cognition and thus, have to be included in cognitive infological systems. Besides, cognitive processes utilize such structures as ideas, algorithms, procedures, scenarios, images, beliefs, values, measures, problems, tasks, etc. Thus, to comprehensively represent cognitive information, it is imperative to include all such objects in cognitive infological systems.

In this context, the concept of information is considered on three basic levels of generality:

1. *Information in a broad sense* is considered when there are no restrictions on the infological system (cf. Ontological Principle O2).
2. *Information in the strict sense* is considered when the infological system consists of structural elements (cf. Ontological Principle O2a).
3. *Cognitive information* is considered when the infological system consists of cognitive structures, such as knowledge, beliefs, ideas, images, etc. (cf. Ontological Principle O2c).

As a result, we come to three levels of information understanding:

1. *Information in a broad sense* for a system *R* is a capability (potential) to change (transform) this system in any way.
2. *Information in the strict sense* for a system *R* is a capability (potential) to change (transform) structural components of this system, e.g., cognitive information changes knowledge of the system, affective information changes the state of the system, while effective information changes system orientation.
3. *Cognitive information* for a system *R* is a capability (potential) to change (transform) the cognitive subsystem of this system.

This information stratification allows us to place information in a broad sense as a pivotal essence in the world as whole and all its components. At the same time, information in a strict sense belongs to the World of Structures, playing there also a pivotal role and having its counterparts in two other Worlds.

This situation is represented by Figure 4. Cognitive information naturally belongs to the domain of cognitive systems.

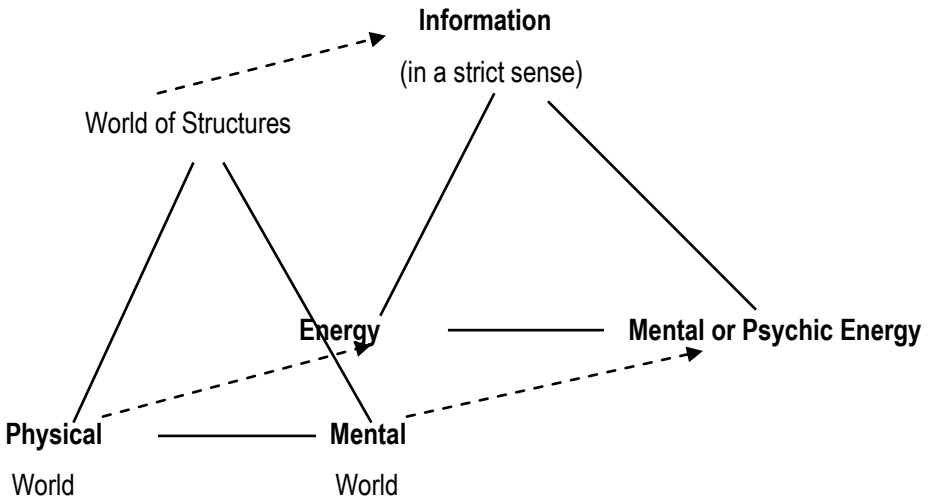

Figure 5. Information in the Structure of the World

It is interesting that defining information as "Information: that which determines form", MacKay also related it to the World of Structures [MacKay, 1969] because *forms* form a special kind of *structures* [Burgin, 2010].

For those who prefer to have a more exact definition of information contrary to a broader perspective, it is possible to define a cognitive infological system as the system of knowledge. This approach was used in [Shreider, 1967] and [Mizzaro, 2001].

Cognitive infological systems are standard examples of infological systems, while their elements, such as knowledge, data, images, ideas, fantasies, abstractions, and beliefs, are standard examples of infological elements. Cognitive infological systems are very important, especially, for intelligent systems as the majority of researchers believe that information is intrinsically connected to knowledge.

Ontological Principle O2c (**the *Cognitive Transformation Principle***). *Cognitive information* for a system *R*, is a capacity to cause changes in the cognitive infological system IFC(*R*) of the system *R*.

As the cognitive infological system contains knowledge of the system it belongs, cognitive information is the source of knowledge changes.

It is useful to understand that in the definition of cognitive information, as well as of other types of information in the strict sense, it is assumed that an infological system IF(*R*) of the system *R* is a part (subsystem) of the system *R*. However, people have always tried to extend their cognitive tools using different things from their environment. In ancient times, people made marks on stones and sticks. Then they used paper. Now they use computers and computer networks.

There are two ways to take this peculiarity into consideration. In one approach, it is suggested to consider *extended infological systems* that do not completely belong to the primary system *R* that receives information. For instance, taking an individual *A*, it is possible to include in the extended cognitive infological system IFC(*A*) of *A*

not only the mind of *A* but also memory of the computer that *A* uses, books that *A* reads and cognitive objects used by *A*.

Another approach extends the primary system *R* as a cognitive object, including all objects used for cognitive purposes. In this case, when we regard an individual *A* as a cognitive system *R*, we have to include (in *R*) all cognitive tools used by *A*. The second approach does not demand to consider extended infological systems. In this case, all infological systems of *R* are parts (subsystems) of the primary system *R*.

Cognitive information belongs to the World of Cognitive Structures, such as knowledge, beliefs, idea, concepts, images, hypotheses, etc.

Information is a dynamic phenomenon. So, it is important to understand how it functions. This is explained by the Ontological Principles O3 – O5 and represented in Figures 6 - 11.

Ontological Principle O3 (**the *Embodiment Principle***). *For any portion of information I, there is always a carrier C of this portion of information for a system R.*

This trait of information is represented in Figure 6.

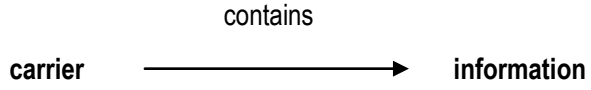

Figure 6. The information carrier triad

There are material carriers of information, such as the memory, DNA or a book, and there are structural carriers of information, such as a text, symbol or idea. A specific type of information carriers is formed by information representations.

Ontological Principle O4 (**the *Representability Principle***). *For any portion of information I, there is always a representation C of this portion of information for a system R.*

As any information representation is, in some sense, its carrier the Ontological Principle O4 implies the Ontological Principle O3.

This trait of information is represented in Figure 7.

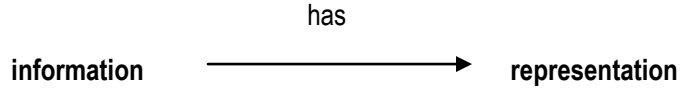

Figure 7. The information representation triad

The process of acquiring a material representation and/or material carrier is called materialization of information. For instance, an example of such materialization is the situation when a scientist has and idea and then writes this idea down or creates a file with a description of this idea. In a similar way, artists and sculptors materialize their vision in paintings and sculptures. Any person sending information finds a material representation or material carrier for this information, in such a way, performing information materialization. A general schema of materialization is studied in [Burgin and Markov, 1991].

People empirically observed that for information to become available, the carrier must interact with a receptor that was capable of detecting information the carrier contained. This empirical fact is represented by the following principle.

Ontological Principle O5 (**the *Interaction Principle***). *A transaction / transition / transmission of information goes on only in some interaction of the carrier with the system*.

Different researchers wrote about this central trait of information (cf., for example, [Shannon, 1948; Ruben, 1992; Burgin, 1993; 1997; Markov, et al, 1993; 2003; 2006; Roederer, 2002]), which is represented in Figure 8.

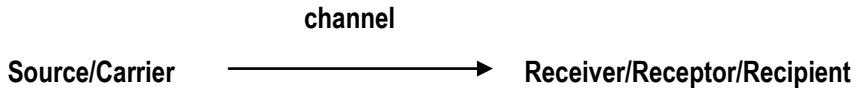

Figure 8. The static communication triad

Interaction is also described by the following triad in the functional way.

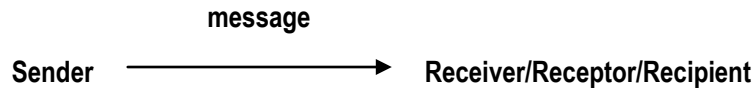

Figure 9. The functional communication triad

It is necessary to remark that interaction is a central trait but a defining property of information. Indeed, the Ontological Principle O2 and all its versions imply existence of three kinds of information: *potential*, *actualizing* and *actual* information. It is interesting that there are also three types of actualizing information: *emerging*, *becoming* and *virtual* information.

While triads from Figures 8 and 9 depict only transition of information or one-way communication, actual communication is an exchange of information and is described by the parallel composition of static or functional communication triads from Figures 8 and 9.

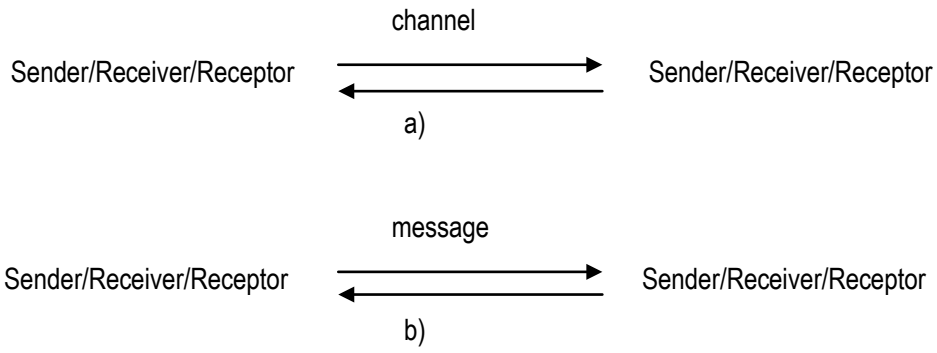

Figure 10. The two-way communication triads

One more communication triad is elaborated by Markov, et al, who write, "We may say that the *reflection* of the first entity in the second one is "*information"* for the first entity if there is corresponded reflection evidence" [Markov et al, 2003]. This gives us the following triad:

(source, recipient; evidence)

An extended form of this triad is given in Figure 11.

Figure 11. The Markov information triad

This triad forms a context for information processes and thus, for information itself. The third component of this triad is connected to a very important philosophical and methodological question in physics about the role of the observer in quantum reality [Wheeler, 1977]. Physicists ask the question whether the world or some events in it exist when nobody observes them. In a similar way, it is possible to ask a question whether information exists when there is no evidence about occurred interaction. Note that according to the general theory of information, information, namely, potential information, exists not only when there is no evidence about occurred interaction but even when there is no interaction at all.

4 Information and Knowledge

The Ontological Principle O2a implies that information is not of the same kind of essences as knowledge and data, which are structures [Burgin, 1997]. Although some researchers announce that information is a kind of data, while others claim that information is a kind of knowledge, from the scientific perspective, it is more efficient to treat information as an essence that has a different nature because other terms represent arious kinds of knowledge and information. Actually, if we take that *matter* is the name for all substances as opposed to *energy* and the *vacuum*, then relations represented in Figure 5 bring us to the Structure-Information-Matter-Energy (SIME) Square given in Figure 12.

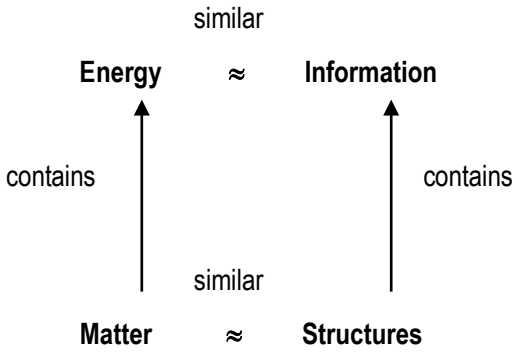

Figure 12. The Structure-Information-Matter-Energy (SIME) Square

In other words, we have the following principle:

Information is related to structures as energy is related to matter.

As knowledge and data are specific structures, Figure 12 is specialized into the Knowledge-Information-Matter-Energy (KIME) Square given in Figure 13.

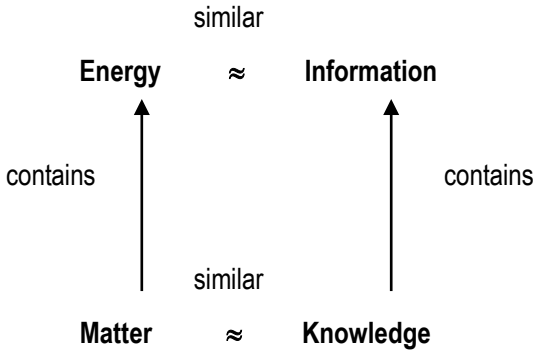

Figure 13. The Knowledge-Information-Matter-Energy (KIME) Square

Information also allows explications of relations between the physical reality and mental world. Indeed, all people, including scientists, get their knowledge about the physical reality only based on information that comes (is obtained) from physical objects. Even theoretical and philosophical considerations become knowledge the physical reality only when they are correlated with information that comes (is obtained) from physical objects. As a result, information becomes an intermediary, a connecting link between physical and mental. Consequently, we have the following Cartesian Triad, which shows how the physical reality is reflected in mental world (cf. Figure 14). It is called the Cartesian Triad because Descartes was the main proponent of the dualistic approach to reality, separating it into the Material World and the Mental World.

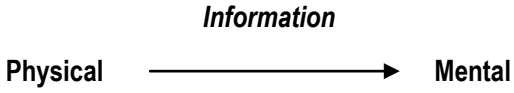

Figure 14. The Cartesian Triad

At the same time, the lower levels of mentality [Burgin, 1997; 2010] are based on physical systems: on the brain in the case of the individual mentality and people in the case of the group and social mentality. This results in following Materialistic Triad. It is called the Materialistic Triad because it reduces mentality to the physical level of nature. It is necessary to remark that many people assume that mentality is a virtually independent from the physical reality.

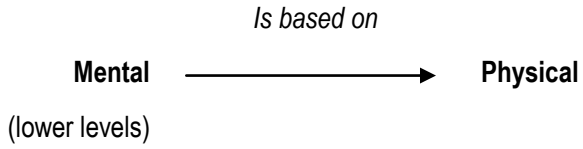

Figure 15. The Materialistic Triad

Including the SIME square into the global structure of the world, we come to the following structure of the Basic Components of the World. This structure is called the BC Prism and display the key structure of each of these components.

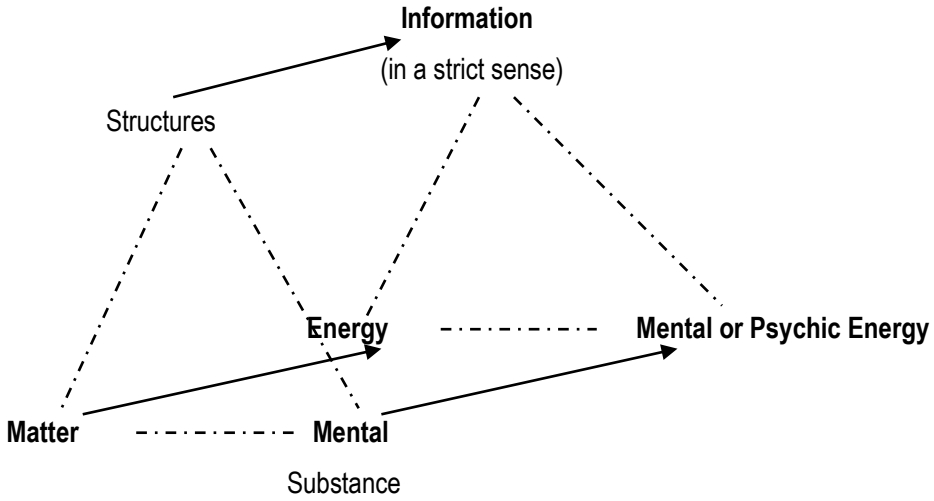

Figure 16. The Basic Components of the World in the form of the BC Prism

This shows that all three basic components of the world, the Physical World, Mental World and World of Structures, have a similar key structure, which is presented in Figure 17.

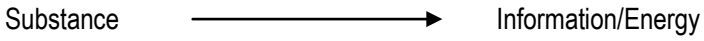

Figure 17. The Key Structure of the World Components

5 Conclusion

The discussed description of relations between information and other basic entities places information the global structure of the world. At the same time, we know that there are different levels of reality (cf., for example, [Burgin, 1997; 2010]). For instance, there are levels of reality organized according to their dimensions, such as the level of subatomic particles, the level of atoms, the level of molecules, the level of physical objects in the same scale as a human being, the level of celestial bodies such as the Earth and other planets, the level of stars, the level of galaxies, etc. There are also organizational levels, such as the level of subatomic particles, the level of atoms, the level of molecules, the level of cells in a living organism, the level of organs in a living organism, the level of living organisms, the level of human beings, the level of society. Thus, the next step in the direction discussed in this paper is finding the place of information on different levels of reality.

Bibliography

[Born, 1953] Born, M. (1953) Physical Reality, The Philosophical Quarterly, v. 3, No. 11, pp. 139-149

[Bourbaki, 1948] Bourbaki, N. (1948) L'architecture des mathématiques, Legrands courants de la pensée mathématiques, Cahiers Sud, pp.35-47

[Bourbaki, 1957] Bourbaki, N. Structures, Hermann, Paris, 1957

[Bourbaki, 1960] Bourbaki, N. Theorie des Ensembles, Hermann, Paris, 1960

[Bucur and Deleanu, 1968] Bucur, I. and Deleanu, A. Introduction to the theory of categories and functors, John Wiley, London, 1968

[Burgin, 1991] Burgin, M. (1991) What the Surrounding World is Build of, Philosophical and Sociological Thought, No. 8, pp.54-67 (in Russian and Ukrainian)

[Burgin, 1993] Burgin, M. (1993) Information triads, Philosophical and Sociological Thought, No. 7/8, pp. 243-246 (in Russian and Ukrainian)

[Burgin, 1996] Burgin, M. (1996) The Structural Level of Nature, Kiev, Znannya (in Russian)

[Burgin, 1997] Burgin, M. Fundamental Structures of Knowledge and Information, Ukrainian Academy of Information Sciences, Kiev, 1997 (in Russian)

[Burgin, 2004] Burgin, M. (2004) Data, Information, and Knowledge, Information, v. 7, pp. 47-57

[Burgin, 2009] Burgin, M. (2009) Structures in mathematics and beyond, in Proceedings of the 8-th Annual International Conference on Statistics, Mathematics and Related Fields, Honolulu, Hawaii, pp. 449-469

[Burgin, 2010] Burgin, M. Theory of Information: Fundamentality, Diversity and Unification, World Scientific, New York/London/Singapore, 2010

[Burgin and Markov, 1991] Burgin, M. and Markov, K. A formal definition of materialization, in "Mathematics and Education in Mathematics", Sofia, 1991, pp. 175-179 (in Russian)

[Capuro and Hjorland, 2003] Capuro, R., and Hjorland, B. (2003) The Concept of Information, Annual Review of Information Science and Technology, v. 37, No. 8, pp. 343-411

[Corry, 1996] Corry, L. (1996) Modern Algebra and the Rise Mathematical Structures, Birkhäuser, Basel/Boston/Berlin

[Freud, 1949] Freud, S. (1949) The Ego and the Id, The Hogarth Press Ltd., London

[Jung, 1969] Jung, C.G. (1969) On Psychic Energy, in On the Nature of the Psyche, Princeton University Press, Princeton

[Landry, 1999] Landry, E. (1999) Category Theory as a Framework for Mathematical Structuralism, in The 1998 Annual Proceedings of the Canadian Society for the History and Philosophy of Mathematics, pp. 133-142

[MacKay, 1969] MacKay, D. M. Information, Mechanism, and Meaning, MIT Press, Cambridge, MA 1969

[Markov, et al, 1993] Markov, Kr., Ivanova, Kr., and Mitov, I. Basic Concepts of a General Information Theory, IJ "Information Theories and Applications". FOI ITHEA, Sofia, 1993, v.1, No. 10, pp.3-10

[Markov, et al, 2003] Markov, Kr., Mitov, I., and Velikova-Bandova, E.The Information, IJ "Information Theories and Applications", FOI ITHEA, Sofia, 1993, v.10, No.1, pp.5-9

[Markov, et al, 2006] Markov, Kr., Ivanova, Kr., and Mitov, I. Basic Structure of the General Information Theory. IJ ITA, Vol.14, No.: 1, pp.5-19

[Mizzaro, 2001] Mizzaro, S. Towards a theory of epistemic information. Information Modelling and Knowledge Bases, IOS Press, Amsterdam, 2001, 12, 1–20

[Ruben, 1992] Ruben, B.D. (1992) The Communication-Information Relationship in System-Theoretic Perspective, Journ. Amer Society for Information Science, v. 43, No. 1, pp. 15-27

[Shannon, 1948] Shannon, C.E. (1948) The Mathematical Theory of Communication, Bell System Technical Journal, v. 27, No. 1, pp. 379-423; No. 3, pp.623-656

[Shreider, 1967] Shreider, Y. A. On Semantic Aspects of Information Theory, Information and Cybernetics, Moscow, Radio, 1967, 15-47 (in Russian)

[Skagestad, 1993] Skagestad, P. (1993) Thinking with machines: Intelligence augmentation, evolutionary epistemology, and semiotics, Journal of Social and Evolutionary Systems, v. 16, pp. 157-180

[Wheeler, 1977] Wheeler, J. A. (1977) Include the Observer in the Wave Function? in Quantum Mechanics, a Half Century Later (Lopes, J.L. and M. Paty M., Eds.), Riedel, Dordrecht, pp. 1-18

[Weizsäcker, 1974] von Weizsäcker, C.F. Die Einheit der Natur, Deutscher Taschenbuch Verlag, Munich, Germany, 1974

Authors' Information

Mark Burgin *– UCLA, Information Editor-in-Chief, Department of Mathematics, UCLA, 405 Hilgard Ave, Los Angeles, California 90095, USA*

Areas of interest: Information, Complexity, Algorithms, Mathematics, Technology