Three levels of the symbolosphere

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Abstract

This paper attempts to understand the coexistence of the material and nonmaterial aspects of our lives. By synthesizing ideas about structures, physical entities, mental phenomena, and symbolic relations, we argue that the nonmaterial can emerge from the material, and then the nonmaterial may mediate the production of material entities. Finally, this cycle is applied to notions of creativity and invention.

1. Introduction

Scholars have always debated the existence of material and nonmaterial worlds. The nonmaterial realm has generally been referred to as mind or soul. The former generally has referred to psychological or mental domains and the latter to spiritual aspects of life. The nonmaterial is difficult to account for, and therefore, it has been convenient for many scholars to take a reductionist stand that considers the only legitimate reality to be the material.

In this paper, we attempt to reclaim the nonmaterial aspects of our existence. We first present a formulation for the global features of the world (physical, structural, and mental), and then we argue that the nonmaterial domain is located most profoundly in symbolic relationships where signs accrue meaning by reference to other signs. Our point is to assert that, as the symbolic species (Deacon 1997), we inhabit a world that is both material and nonmaterial. The latter emerges from the former and is always related to the former, but nevertheless the nonmaterial constitutes a domain of existence with its own characteristics and with the ability to exert downward influence on the material domain.

Additionally, we will argue that in the creative process there is a progression from ideas or images that are generated in the mental realm

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which then become organized into verbal structures which then can be materialized (e.g., in print or in an electronic medium). These mental and subsequently materialized ideas then have the potential to influence the physical world and to feedback into the mental world to produce additional structure and physical material.

2. The global structure of the world

We live in the physical (material) world, and many perceive that this is the only reality that exists. However, some Eastern philosophical and religious systems, e.g., Buddhism, teach that physical reality is a great illusion and the only reality is the spiritual world. As science does not have enough evidence to accept or reject this idea, we will not discuss it here. Nevertheless, science does have enough evidence to accept the existence of the mental world. As contemporary psychology asserts, each individual has a specific inner world, which is based on the psyche and which forms the mentality of the individual. These individual inner worlds constitute the basic level of the mental world and complement our physical world.

Some thinkers, following Descartes, consider the mental world as independent of the physical world. Others assume that mentality is completely generated by physical systems of the organism, such as the nervous system. However, in any case, 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 research the very foundation of the physical world, developed the, so-called, observer-created reality interpretation of quantum phenomena. A prominent physicist, Wheeler, suggests that in such a way it is possible to change even the past. He stresses (Wheeler and Zurek 1983) that elementary phenomena are unreal until observed. This gives a dualistic model of reality.

However, the dualistic model is not complete. This was prophesized in ancient Greece and demonstrated in modern science. One of the great ideas of ancient Greece is the world of ideas (or forms), the existence of which was postulated by Plato. In spite of the attractive character of this notion, the majority of scientists and philosophers believe that the world of forms does not exist, because nobody has 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, some modern thinkers, including such outstanding scholars as philosopher Karl Popper, mathematician Kurt

Gödel, and physicist Roger Penrose, continued to believe in the world of ideas, giving different interpretations of this world but suggesting no ways for their experimental validation.

However, science is developing, and this development has allowed the recent discovery of the world of structures. This world may be associated with the Platonic world of forms in the same way as atoms of modern physics may be related to the atoms of Democritus. The existence of the world of structures is demonstrated by means of observations and experiments. This world of structures constitutes the structural level of the world as whole. Each system, phenomenon, or process either in nature or in society has some structure. These structures exist as things, such as tables, chairs, or buildings, and form the structural level of the world. When it is necessary to investigate or to create some system or process, it is possible to do this only by means of knowledge of the corresponding structure. Structures determine the essence of things.

In the Platonic tradition, the *global world structure* has the form of three interconnected worlds: *material*, *mental*, and the *world of forms*. However, the existence of the world of forms has been severely criticized. Many argue that taking a long hard look at what the Platonist is asking us to believe, we must have faith in another 'world' stocked with something called forms. Where is this world and how do we make contact with it? 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? Only recently, modern science made it possible to achieve a new understanding of Plato's ideas, representing the *global world structure* in the form of the existential triad of the world. In this triad, the material world is interpreted as the physical reality, while forms might be associated with structures, and the mental world would encompass social and individual conscience (Burgin 1997; Burgin and Milov 1999). Thus, the *existential triad* of the world (the world's global structure) has the form as shown in figure 1.

In the mental world, there are real 'things' and 'phenomena.' For example, there exist happiness and pain, smell and color, love and understanding, impressions and images (of stars, tables, chairs, etc.). In the physical world, there are the real tables and chairs, sun, stars, stones, flowers, butterflies, space and time, molecules and atoms, electrons and photons. It has been demonstrated (Burgin 1997) that the world of structures also exists in reality. For instance, the fundamental triad, as a structure, exists in the same way as tables, chairs, trees, and mountains exist. Knowledge, per se, forms a component of the world of structures. It is an important peculiarity of the world (as a whole) that it exists in such a triadic form, not as a static entity but as a dynamic structure.

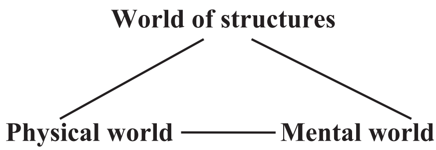

Figure 1. *The existential triad of the world*

It is necessary to understand that these three worlds are not separate realities: they interact and intersect. Thus, individual mentality is based on the brain, which is a material thing. On the other hand, physicists discuss a possibility that mentality influences physical world (cf., for example Herbert 1987), while our knowledge of the physical world to a great extent depends on interaction between mental and material worlds (cf., for example von Baeyer 2001).

Even closer ties exist between structural and material worlds. Actually no material thing exists without structure. Even chaos has its chaotic structure. For instance, it is possible to make a table from various materials: wood, plastics, iron, aluminum, etc. What all these things have in common is not their material; it is the specific peculiarities of their structure. As some physicists argue, physics studies not physical systems as they are but structures of these systems, or physical structures. In some sciences, such as chemistry, and areas of practical activity, such as engineering, structures play a leading role. For instance, the spatial structure of atoms, chemical elements, and molecules determines many properties of these chemical systems. In engineering, structures and structural analysis even form a separate subfield. (cf., for example, Martin 1999).

3. Signs, symbols, and symbolosphere

If we analyze the usage of the word 'symbol,' we come to the conclusion that it has three different but connected meanings. In a broad sense, symbol is the same as sign. For example, the terms 'symbolic system' and 'sign system' are frequently considered synonyms, although the first term is used much more often. A broad understanding identifies symbol with a physical sign.

However, we are interested in the third meaning of the word 'symbol.' Such an understanding has been developed by Peirce in his theory of signs. It is necessary to remark that the French linguist Ferdinand de Saussure understood 'sign' as a category under 'symbol.' Peirce inverted the words 'sign' and 'symbol,' making 'sign' the general word and 'symbol' a special type of sign. The basic property of the sign is that sign

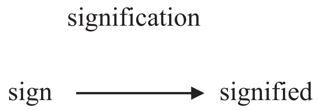

Figure 2. *The sign triad of Saussure*

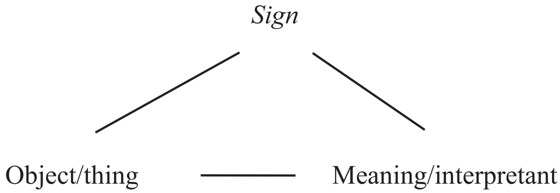

Figure 3. *The sign triad of Peirce*

points to something different than itself, transcendent to it. This relation is represented by the *dyadic sign triad* introduced by Saussure (see figure 2). Note that this triad is a kind of fundamental triad.

This model explicates important properties of sign. However, a sign represents something different than itself, depending on meaning. That is why Peirce developed this diadic model by further splitting the signified into essentially different parts: the sign's object and interpretant, and thus, coming to the triadic model of a sign, the *balanced sign triad* (see figure 3).

This triad is similar to the existential triad of the world with sign corresponding to the structural world as a syntactic system, object/thing corresponding to the physical world, and meaning/interpretant corresponding to the mental world as a semantic system. However, an object can be nonmaterial and thus, beyond the physical world. Nevertheless, an object is always closer to the physical world, implying that the Peircean triad is homomorphic to the existential triad, which has holographic properties. It means that all three parts of the existential triad have complete information about the whole triad.

A sign is understood as a relation consisting of three elements: Vehicle, Object of the sign, and Meaning. According to Peirce, there are three kinds of signs: *icon*, *index*, and *symbol*. An *icon*, can be the thing itself (e.g., my left index finger is a perfect icon of my left index finger) or it can resemble the thing signified (a drawing of my left index finger). Photographs at the level of direct resemblance or likeness are therefore heavily iconic. We all are familiar with computer icons, as well as with the pictographs such as are used on 'pedestrian crossing' signs. There is no real connection between an object and an icon of it other than the likeness, so the mind (i.e., the interpretant) is required to see the similarity and associate the two. A characteristic of the icon is that by observing it, we can derive information about its signified.

Peirce divides icons further into three kinds. *Images* have the simplest quality, the similarity of aspect. Portraits and computer icons are images. *Diagrams* represent relationships of parts rather than tangible features. Examples of diagrams are algebraic formulae. Finally, *metaphors* possess a similarity of character, representing an object by using a parallelism in some other object. Metaphors are widely used in language (e.g., 'doe-eyed').

An *index* has a sequential and/or causal relationship to its signified. A key to understanding indexes is the verb 'indicate,' of which 'index' is a substantive. For instance, indexes are directly perceivable events that can act as a reference to events that are not directly perceivable, or they are something visible that indicates something out of sight. You may not see a fire, but you do see the smoke and that indicates to you that there is a fire. The words 'this,' 'that,' 'these,' and 'those,' like a pointing finger, are also indexes. The nature of the index can be unrelated to that of the signified, but its connection requires an interpretant that perceives the index as a sign pointing to something else. Indexes are generally non-deliberate, although arrows are just one example of deliberate ones.

A *symbol* is a sign whose object is another sign. The relationship can be completely arbitrary. The connection between signifier and signified depends entirely on the observer, or more exactly, what the observer was taught. Symbols are subjective. Their relation to the signified object (another sign) is dictated either by social and cultural conventions or by habit. Words are a prime example of signs, and when they refer to other words (signs), they are considered, in the Peircean sense, to be symbols. Whether as a group of sounds or a group of characters, words are only linked to their signified because we decide they are, and the connection is neither physical nor logical; words change meaning or objects change names as time goes by. However, often, especially in science, people try to create words so that they show/explicate connections to the signified. For instance, a computer is called computer because it/he/she computes. A teacher is called teacher because she/he teaches. Some class of elementary particles are called neutrons because they are electrically neutral, i.e., their electrical charge is zero.

Peirce divides symbols further into two kinds: a *singular symbol* denotes tangible things, while an *abstract symbol* signifies abstract notions. However, it is not always easy to make this distinction. For example, a symbol such as 'a dog' signifies an abstract notion of a dog as a specific animal. At the same time, this symbol as 'a dog' signifies the set of all dogs. Thus, it is more tangible to introduce one more class of symbols, which we call general symbols. A *general symbol* signifies both an abstract notion and a collection of things encompassed by this notion. For example, 'a lover' is a general symbol, while 'love' is an abstract symbol.

One and the same word can be used as a name for different symbols and even for different types of symbols. For instance, on the social level, the word a 'field' is used as an indexical symbol when it denotes a specific place on the Earth. At the same time, it will be an abstract symbol used in mathematical community and denoting a specific mathematical structure, or more exactly, two kinds of structures — fields in algebra, such as the field of all real numbers, and fields in functional analysis, such as a vector field. On another, wider group level, the same word is used as a name of some system, such as a field of mathematics, field of activity, or field of competence. Important examples of symbols are general concepts and formal expressions.

Monkeys and apes are capable of what is called indexical communication. These animals have calls that refer directly to things in the world, thus indexing objects in the environment. For example, vervet monkeys have calls that index the presence of certain predators. They have specific calls for eagles, snakes, and leopards that unambiguously refer to these animals. However, humans moved from indexical signs to symbols, as they developed language. As they acquired words, these lexical items referred not only to things in the physical world, but also to other words. Frequently, they constituted higher order categories. For example, a hominid might have had specific words for banana, mango, meat, and nut. The development of the word 'food' would then refer to all kinds of edible items. In the same way, words for arrowhead, ax, needle, and hammer specifically referred to individual objects that could be subsumed under a more general term 'tool.' The word 'tool' hence referred to the category 'tool,' to the individual words that named the tools, and to the tools themselves.

Deacon (1997) suggests that when male hominids began to provision food for their mates and their offspring, they may have wanted to be sure that the food they provided actually fed only the children they had sired. The females may also have been concerned that the male provision was only for her and her offspring, not another woman and her children. Such issues may have led to a union more complex than simple mating, one that could be called marriage. A symbolic relationship sanctioned by the community as a whole would be required for such a social construct, since marriage is strictly a symbolic enterprise. This notion of marriage provides for the emergence of and reference to other terms, such as virgin, in-law, fidelity, adultery. In this way, a web of semiotic relations would grow where, in fact, no material relationship existed. We may say that people are married, but, in fact, they are simply mating in the physical world, and the marriage exists only in the symbolic world.

These considerations lead us to argue that language is not essentially *in* the brain or *of* the brain. Instead, it exists as a cultural construct or artifact. There are many other artifacts of the same nature. All of them exist and function in social mentality. We call all these artifacts the symbolosphere. The symbolosphere exists as an invisible and nonmaterial technology that functions in our environment and affects our behavior as profoundly as does the biosphere. Language is a part of this system (Logan and Schumann 2005).

4. Spheres of life and existence

In a complimentary way to the existential triad, the world is stratified into a variety of different spheres, reflecting a variety of world perspectives. The most familiar of them is the biosphere. From the broadest geophysiological point of view, a *biosphere* is the global ecological system integrating all living beings and their relationships, their interaction with the elements of the *lithosphere* (rocks), the *hydrosphere* (water), and the *atmosphere* (air). This understanding makes the term 'biosphere' completely interchangeable with the term 'ecosphere.'

Another approach implies that *biosphere* is that part of a planet's terrestrial system — including air, land, water, and living organisms — in which life develops and where living organisms exist. The Earth's biosphere is generally believed to have evolved about three-and-a-half billion years ago. The biosphere is divided into a number of biomes, inhabited by broadly similar flora and fauna.

The term 'biosphere' has a geological origin and was coined by the geologist Eduard Suess in 1875. The main development of the concept of biosphere is attributed to Vladimir Vernadsky, who stated that a *biosphere* was a stable, adaptive life support system with the potential to be a major geological force on a planet's surface and ecosphere. Under the right conditions, this force can transform the electrical, thermal, chemica, and mechanical energy of the universe to meet its own needs.

On a lower level, in comparison with the biosphere, lies the *physiosphere*, which includes parts such as the lithosphere, hydrosphere, and the atmosphere and such phenomena as weather, climate, etc.

A higher level of world is formed by the *sociosphere*, considered as the part of a planet's terrestrial system in which social relations develop and where social interactions between people happen. It includes political and economic systems. Some researchers introduce an intermediate level between a biosphere and a sociosphere that is called an *ethnosphere*. On higher levels than the sociosphere, such strata as the noosphere, ideosphere, and symbolosphere exist.

Emergence of the *symbolosphere* is related to the development of symbolic relationships among signs, i.e., relationships where signs do not refer to material things, but instead refer to other signs. The first oral or signed languages probably changed form rapidly, leading to a multitude of language systems. Then, about 5,000 years ago, writing developed, essentially as a technology that amplified the oral, nonmaterial, and invisible language component of the symbolosphere. The symbolosphere also includes, of course, mathematics, painting, music, sculpture, and photography, etc. In general, we can define symbolosphere as a component of our world in which symbols emerge, and symbolic relations develop, function, and interact. The symbolosphere is simultaneously a virtual world and real world. It emerges from the physiosphere and biosphere, and it constitutes a stratum that engages all aspects of the existential triad: mental, structural, and physical. In the symbolosphere, words relate to other words to create theories, religions, ideologies, philosophies, laws etc., all of which affect our lives profoundly.

Mathematics provides an advanced example of a domain of the symbolosphere because in it symbolism is made explicit, achieving very high levels of abstraction. Formalism is its most extreme manifestation. The main thesis of formalism is that mathematical statements are not about anything material, but are rather to be regarded as meaningless marks. The formalists are interested in the rules that govern how these marks are manipulated. Mathematics, in other words is the manipulation of symbols. The fact that $(a + b) + c = a + (b + c)$ is simply a rule of the system. The principle protagonist of this philosophy was David Hilbert.

However, many mathematicians disputed this approach. For instance, Gödel (1981 [1961]) wrote that the certainty of mathematics is to be secured not by proving certain properties by a projection onto material systems — namely, the manipulation of physical symbols — but rather by cultivating (deepening) knowledge of the abstract concepts themselves which lead to the setting up of these mechanical systems, and further by seeking, according to the same procedures, to gain insights into the solvability, and the actual methods for the solution, of all meaningful mathematical problems. Being a Platonist, Gödel represents another extremity in philosophy of mathematics, postulating independent existence of abstract mathematical objects.

In more recent times, electronic technologies have been developed that further amplify the symbolosphere: the telephone, the telegraph, radio, television, fax, the Internet. All these technologies mediate the symbolosphere and maintain it is an open system in far-from-equilibrium states.

A storm in the symbolosphere can have the same personal consequences as a storm in physiosphere. This world has a life of its own and cannot be controlled by 'operationalizing our definitions,' 'using language carefully,' or attempting to wall off language from 'dangerous outside influences.' The symbolosphere is subject to manipulation, but all attempts to control it eventually fail.

This realm of our existence must be viewed as part of an ecology that also includes the biological and physical world. Language is but one part of the symbolosphere, and grammar is an even smaller part. Humans inhabit the symbolosphere as much as the physiosphere and the biosphere. These spheres of human existence are not separate: they intersect and interact. We must know how to deal with the vagaries of the symbolosphere, just as we deal with the vagaries of the physiosphere (i.e., weather, climate, radiation, tornados, typhoons, earthquakes, etc.).

5. The generic stratification of the symbolosphere

The existential triad of the world implies that all components of the world are structured by means of three constituents: physical, structural, and mental. This shows that the existential triad is a fractal. It means that taking some large-scale sphere of the world, we can find that this sphere has the same structure of the existential triad. Consequently, applying this to the symbolosphere, we obtain its three constituents: physical, structural, and mental symbolosphere. We call this structure the *existential triad of the symbolosphere*.

If we consider some symbol (a sign-sign relationship), and the corresponding means to see, hear, and/or feel this symbol, we encounter the *physical representation* of this symbol. Symbols on paper and symbols in computer have different material nature, but all of them are physical embodiments of mental symbols and corresponding symbolic structures. In their essence, symbols exist only within developed symbolic structures (e.g., language, music, mathematics) and each symbol has a definite structure of its own. This structure is the structural representation of the symbol. Taking a system of symbols, for example, mathematical formulas, we come upon the same situation; that is, these formulas have physical, mental, and structural representations.

Nonmaterial strata of the symbolosphere has been developing parallel to their material counterpart. For instance, scientific, or philosophical, instruments, such as telescopes and microscopes, have been used to obtain and create knowledge by observation and experimentation (Ackerman 1985). Analytical instruments, such as compass and radar, have been used for a long time for various practical purposes. However, in addition to those two types of devices, analytical and philosophical, humankind in its development created the third type of instruments, namely, a system of intellectual 'devices' for dealing with complicated phenomena. This system is called science and its 'devices' are theories.

When people want to see what they cannot see with their naked eyes, they build and use various magnifying devices. To visualize what is situated very far from them, people use telescopes. To discern very small things, such as microbes or cells of living organisms, people use microscopes. In a similar way, theories are 'magnifying devices' for mind (Burgin 2001). They may be utilized both as microscopes and telescopes. Being very complex these 'theoretical devices' have to be used by experts. Theoretical 'devices' from the structural and mental domains of the symbolosphere start, control, and direct physical processes of cognition and practical activity. This reflects a shift of emphasis in the existential triad of the symbolosphere that goes with the development of the human civilization.

However, the existential stratification of the symbolosphere is not unique. Taking into consideration dynamics of symbols, we find a different structure, which is called the *generic stratification* of the symbolosphere (cf. figure 4).

Basic Level

in the

Mental world

↓

Cardinal Level

spans into the

World of structures & Mental world

↓

Comprehensive Level

spans into the

Physical world & World of structures & Mental world

Figure 4. *The generic stratification of the symbolosphere*

Symbols are initially conceived as vague ideas in the Mental World, which becomes the first and basic generic stratum of the symbolosphere. Very often symbols appear in the form of names where names are considered in an extended sense, for instance, a text can be a name.

They become systemic symbols only by being organized and acquiring some structure. From this structure they derive additional meaning. At the same time, symbols may become incorporated into another system/structure of symbols. In such a way, symbols expand to the World of Structures. As a result, the symbolosphere comes into existence on the second generic stratum, which spans into two worlds — the Mental World and World of Structures. We call this stratum the cardinal level of the symbolosphere.

There are two fundamental processes in the cardinal level (second stratum): inner and outer structuring. The first one is an endowment of a symbol with an inner structure, while the second one is integration of the symbol into a diverse net of other symbols. These processes go in the Mental World on three distinct levels: individual, group, and social. The group level has its sublevels. Sometimes results on all three levels, as well as on the group sublevels, are different. For instance, love symbolizes a positive feeling on the social level, a neutral emotion in a group of bureaucrats, and a negative passion for a person (individual level) who was ruined by his/her fatal love.

To become stable and continue to live, symbols have to become materialized. There are different ways of materialization: in a static form, as an action, and as a process. Being pronounced, symbols appear in a form of a sound, which is, as we know, a process of air vibration. Being drawn or written, symbols acquire a static form. In such a way, symbols expand further to the Physical World. As a result, the symbolosphere comes into existence on the third generic stratum, which spans into three worlds — the Mental World, World of Structures, and Physical World. We call this stratum the comprehensive level of the symbolosphere.

For instance, having a notion of quantity (a *mental representation* of symbols representing quantity, such as numbers) is far from the intricate abstract reasoning that today goes by the name of mathematics (Barrow 1994). Thousands of years passed in the ancient world with comparatively little progress in mathematics. The reason is that simply having the notion of quantity in a symbolic form is insufficient. One must develop an efficient method of recording numbers and operating on them. Thus, more crucially still, the adaptation of a place value system (a *structural representation* of numbers) with a symbol for zero was a watershed. The aim of structurization is recording numbers and operating with them. A good notation permits an efficient extension to the ideas of fractions and the operations of multiplication and division. However, these discoveries are deep and difficult (Barrow 1994). After such notation was developed, means for recording numbers and operating with them (a *material representation* of numbers) were invented and improved. According to Burton, 'the earliest and most immediate technique for visibly expressing the idea of number is tallying [a kind of the *material representation* of numbers]. The idea in tallying is to match the collection to be counted with some easily employed set of objects — in the case of our early forbears, these were fingers, shells, or stones. Sheep, for instance, could be counted by driving them one by one through a narrow passage while dropping a pebble for each' (Burton 1997: 2).

Other ways of counting were by making scratches on stones, by cutting notches in wooden sticks or pieces of bone, or by tying knots in strings of different colors or lengths. However, it was in those societies that that rose to power some 6,000 years ago in the river valleys of the Nile, the Tigris-Euphrates, the Indus, and the Yangtze that special symbols for numbers first appeared (Burton 1997). To record and operate on numbers, they were written on papyrus, rocks, clay, bark, bamboo, paper, etc.

As symbolic numbering lumbered forward, the invention of a counting tool called an abacus, which simplified addition and subtraction of numbers, made life easier for traders, merchants, and others. For a long time, it was the only information-processing device for operating with numbers. Later, more developed instruments for the same purpose appeared. In the early 1600s, an English clergyman William Oughtred invented the slide rule for dividing and mutiplying numbers. It was an ancestor of an analog computer. The first ancestor of a digital computer, later called Pascaline, was produced by the outstanding French mathematician Blaise Pascal around 1642. This was the dawn of the computer era.

A powerful mechanism in symbolosphere development is a process of metaphoric mapping. Metaphors provide a creative response to cognitive problems, especially valuable for generating new symbols. Through linguistic metaphor, what was impossible, inconceivable, and incoherent based on literal vocabulary becomes possible, conceivable, and coherent.

We can consider such a symbol relationship as a 'physical field,' an example of a process of metaphoric mapping. Field in physics began as a convenient representation of action-at-a-distance forces and was later elevated to the status of a physical entity in its own right. The field concept initiated the complete overthrow of Newton's mechanical model of the universe and paved the way for quantum field theory, the mathematical language underpinning contemporary understanding of the universe. Many think that quantum field theory is by far the most accurate and successful model of nature that human beings have ever constructed.

At first, two physical fields, electric and magnetic, were considered. Such fields are represented by a mathematical construction called a vector field. In mathematics a vector field is a structure in which a vector is associated with every point in some manifold or Euclidean space. In physical fields, these vectors may vary in time.

James Clerk Maxwell, one of the world's greatest physicists, combined the fields of electricity and magnetism and introduced the concept of the electromagnetic field. For some time, this concept was considered an abstract construction invented to give means for calculation of 'real' physical quantities. However, the discovery of electromagnetic waves by the great German physicist Heinrich Hertz in 1888 endowed the status of a physical phenomenon to the electromagnetic field. Activity of people involves deeper and deeper immersion into the symbolosphere and it proceeds in cycles. The existence of these cycles is explained by the Generalized Poincaré Recurrence Theorem (Burgin 2005). Scientific cognition, for instance, emerged in works of Aristotle and other Greek philosophers as mostly symbolic activity with only weak ties to physical and social reality. Later, the transition to modern science placed emphasis on physical phenomena comprehended and evaluated through observation and experiment. However, the development of science, in general and in any of its subareas, has been always characterized by the level of its theoretical component, which always belongs to symbolosphere. Now importance of theories grows completing the cycle of going from symbolic operation to experimentation and back. Many discoveries in physics (e.g., discoveries of electromagnetic field or of positron) were made at first in the corresponding theory and only later validated by experiments. Now such a fundamental system as string theory exists only in the symbolosphere without real experimental evidence.

Analyzing the creative process, we see that, at first, ideas are conceived in the mind of a researcher. Thus, the beginning of the creative process takes place in the mental world. Then to work on these ideas, the researcher puts then into words. As the great French mathematician Poincaré wrote (1908), without a name, no object exists either in science or mathematics. To 'put into words' means to ascribe to the idea a linguistic structure. Thus, the continuation of the creative process brings us to the world of structures. Then, after some deliberation, the researcher writes her/his ideas on paper or, using contemporary technology, puts them into a computer. The result of these procedures is the materialization of ideas in the physical world. This explicates the *creative cycle* where the symbolosphere is manifest in the verbal structures and their print or electronic transformations.

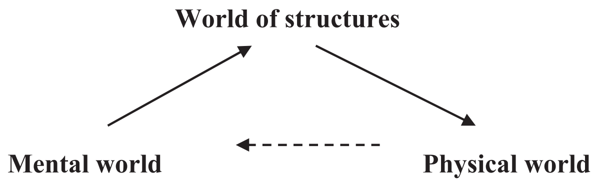

Figure 5. *The creative cycle*

This is a real cycle because after the ideas become materialized, the creative process continues, repeating the creative cycle. The researcher works with these ideas in her/his mind, developing new ideas, hypotheses, theorems, laws, symbolic models, theories, etc. Then these mental entities acquire linguistic structures and are embodied as spoken words (aloud or to oneself), words on paper, and words in a computer.

Even such material activity as engineering acquired its counterpart in the symbolosphere when software engineering came of age. According to the IEEE Standard Computer Dictionary (1990), software engineering is the application of a systematic, disciplined, quantifiable approach to development, operation, and maintenance of software; that is, the application of engineering to software. Software, at the same time, is a part of the symbolosphere embodied in written texts and states of computer memory. On the other hand (Fairley 1985), software engineering is the technological and managerial discipline concerned with systematic production and maintenance of software products that are developed and modified on time and within cost estimates. Software engineering covers not only the technical aspects of building software systems, but also management issues, such as directing programming teams, scheduling, and budgeting.

Software development starts in the mental world with decision-making concerning what we need the program to do. The process transits to the world of structures when the problem is broken down into functional blocks — pieces that can be turned into functions or classes in a programming language. The next stage takes the process to the physical world where developed structures of functional blocks are materialized in texts of specifications.

Then the creative cycle is repeated when the software designer starts (in the mental world) an investigation process, trying to determine what needs to be done and how, in theory, it could be done. The next step brings the design process into the world of structures where the designer determines the functional blocks of the system, decides on the details of internal processing for each functional block, and defines their interfaces. In this way, software architecture is developed.

The software architecture of a program or computing system is the structure or structures of the system, which comprise software elements, the externally visible properties of those elements, and the relationships among them (Bass et al. 2003). This definition makes clear that *software systems can and do comprise more than one structure* and that no one structure holds the claim of being *the* architecture. For example, all non-trivial projects are partitioned into implementation units; these units are given specific responsibilities, and are the basis of work assignments for programming teams. These kind of elements will comprise programs and data that software in other implementation units can call or access, and programs and data that are private. In large projects, implementation units are almost certainly subdivided for assignment to subteams. This is one kind of structure often used to describe a system. It is a very static structure, in that it focuses on the way the system's functionality is divided up and assigned to implementation teams.

Other structures are much more focused on the way the elements interact with each other at runtime to carry out the system's function. Suppose the system is to be built as a set of parallel processes. The set of processes that will exist at runtime, the programs in the various implementation units described previously that are strung together sequentially to form each process, and the synchronization relations among the processes form another kind of structure often used to describe a system. As Garlan and Shaw (1993) write, 'beyond the algorithms and data structures of the computation; designing and specifying the overall system structure emerges as a new kind of problem. Structural issues include gross organization and global control structure; protocols for communication, synchronization, and data access; assignment of functionality to design elements; physical distribution; composition of design elements; scaling and performance; and selection among design alternative' (Garlan and Shaw 1993: 2).

A set of architectural elements has a particular form. Perry and Wolf (1992) distinguish between processing elements, data elements, and connecting elements, and this taxonomy by and large persists through most other definitions and approaches. Besides, the definition implies that *every software system has an architecture* because every system can be shown to be composed of elements and relations among them. In the most trivial case, a system is itself a single element — an uninteresting and probably non-useful architecture, but an architecture nevertheless. This gives additional supportive evidence to objective existence of the world of structures. Even though every system always has an architecture, it does not necessarily follow that the architecture is known to anyone. Moreover, as Bass et al. (2003) state, an architecture can exist independently of its description or specification, that is, of its embodiment in texts. This raises the importance of architecture documentation and architecture reconstruction.

A complimentary structural representation of a software system is given by algorithms, which are usually designed before a software engineer (a programmer, a team of software engineers/programmers) goes to the first embodiment of these structures in the source code. Physical embodiment of software goes through several stages: writing source code, which contains text in the utilized programming language; compiling, which transforms source code into object code — a translation of the instructions written in the utilized programming language into the native language of the computer; linking all the object code files for the program together to create an executable, and debugging.

Thus, we can see that software engineering exists in the symbolosphere and is realized in a sequence of creative cycles. Many general regularities discovered in software engineering are true in a much more general context. For instance, we can formulate following laws of system science:

Every system has a structure.
Systems, as a rule, can and do comprise more than one structure.

These laws give additional evidence for existence of the World of structures, as well as for the existential triad of the world and existential stratification of the symbolosphere.

6. Conclusion

The econiche that humans inhabit is both *physical + structural and mental*. It consists of *objects + signs and interpretants*. The physical/material world is objective and is the domain of the natural and, in particular, the physical sciences. Some scholars would have this domain be the only realm worthy of consideration. This attitude may exist because it is the domain that is most amenable to scientific investigation. It is generally assumed that the nonmaterial realm is by nature relativistic and subjective because traditional scientific technologies have been developed to understand physical reality. This has been a reason to think that no account can adequately treat the nonmaterial realm. The main point that our account makes is that, as humans, we inhabit both structured material and structured nonmaterial worlds, and the latter cannot be dismissed when we find this world complex, conceptually difficult, or experimentally intractable.

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