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Measuring Soft Structures: Their Metric and Topological Dimensions

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Motto:
"…Not all that glitters is gol…"
Bishop. Ignacy Krasicki, Monachomachia

Abstract:

Purpose: *Measurability and metrics are the domain of mathematics. And it is this mathematics that created the branch (discipline) called Measure Theory. Mathematics also created more general fields than the measurable one (linear Euclidean space). These are topology, algebraic topology and category theory, which science tries to apply even to the description, to the grasp of the structures of the humanities. And this is the main dimension of the content of the article.*

Design/Methodology/Approach: *Praxeology is an extremely important field of knowledge, because it is somehow connected with both theory and practice. On the one hand, it examines the invariants (patterns, structures) of all human actions, and on the other hand, it has a utilitarian goal, the goal of using the invariants learned in practice, and perhaps even primarily in the humanities (because mathematics has its own research tools related to it. These are measurable, topological and from the area of category theory, transformation theory). All of them together constitute the methodological dimension of the content of the article.*

Practical Implications: *Generally speaking, in practice we deal with three categories of processes. These are physical, biological, social and mental processes of a human being. The latter are difficult to formalize, i.e. to express their structures in metric terms, and especially mental processes of a human being. And in the text we show what methods of mathematics can be used to capture the processes of the human locus. The praxeological dimension of science combines precision (patterns) with soft structures, because these are also human actions, these everyday ones (you also have to be able to express them scientifically). In addition, there is also a created dimension of science called Pragmatics. All actions are expressed in processes, or rather through them, through their categories. And this dimension of methodology is reflected in the article in the practical dimension indicating the application of the methods presented there.*

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Originality/value: *The originality of the text content is the combination into a whole of the diversity of methods, measures and formal spaces and humanistic content by placing them in the dimension of the contemporary conceptual category called coherence. And it is this (this combination of concepts) that somehow determines the scientific value of the article. Because speech through its language is a coherence (orchestra) of all types of signs (concepts, methods, theories). You just have to be able to show it. And such an attempt is included in the text content.*

Keywords: *Measurability of soft structures, generation of soft processes, mental processes, signs and symbols, catastrophe theory, topological representation of soft structures (archetypes).*

EL codes: *L22, M11, O32, C80.*

Paper type*: Research article.*

1. Introduction

The word *"measure"* in the title means that we know what we are measuring and we have an adequate metric for it. We can ask what metric we have, because one and the same object can be measured in many ways. Measurability and metrics are the domain of mathematics. And it is this mathematics that created the field (discipline) called *Measurement Theory*. Mathematics has also created more general fields than the measurable one (linear Euclid space). These are topology, algebraic topology and category theory, which science tries to apply even to the description, grasping of the structures of the humanities (Lewin, 1936; Thom, 1970; 1973; 1975; Piaget, 1981).

But there is also a discipline of science created by Tadeusz Kotarbiński, which has the name: *Praxeology* (Kotarbiński, 1965; 1982). This is an extremely important field of knowledge, because it is somehow connected with both theory and practice. On the one hand, it examines the invariants (patterns, structures, etc.) of all human actions, and on the other hand, it has a utilitarian goal, the goal of using the invariants learned in practice, and perhaps even primarily in the humanities (because mathematics has its own research tools related to it – measurable, topological and from the area of category theory, transformation theory).

The praxeological dimension of science combines precision (patterns) with soft structures, because these are also human everyday actions (they must also be able to be expressed scientifically). In addition, there is also a dimension of science created by Ch.S. Peirce called *Pragmatics* (Peirce; 1931-35). All actions are expressed in processes, or rather through them, through their categories. And that is why, generally speaking, in practice we deal with three categories of processes. These are physical, biological, social and human mental processes. The latter are difficult to formalize, i.e., to express their structures in metric terms, and especially human mental processes.

Science has been wondering for a long time about creating a theory capable of including all these processes together in its conceptual and operational system. Such science was proposed by Norbert Wiener (Wiener, 1950), and the greatest propagator of his theory was Ashby (1963). A similar paradigm, but as if in relation to scientific theories, was formulated by L. von Bertalanffy (1968). And all this is also about studying the invariants, patterns of Nature (Dröscher, 1971).

Because, as the last author of his book quoted here said, Nature copies its (created by it) schemes wherever it can, and when it cannot apply any of them, only then does it build a new scheme for such a situation. In scientific research and theories, it would be necessary to remember this property of Nature. It should also be noted here that for Nature itself this is also a new situation and it must solve it through some new scheme assigned to it. *It would be good to find out how It does it*. After all, since It exists, It must somehow defend Its existence (stability and order).

On the other hand, *the random factor is also Its factor that tries to disrupt the processes taking place in It*. Scientists call these two categories of Nature, functioning together in It, the fluctuation of reality. Using the concept of analogy, we can say the same about our creativity. We use the research tools we have built to acquire knowledge about Nature. But we encounter a different variety of Nature, in which these cognitive systems are inadequate. Then we create new tools within the framework of new paradigms of science.

In general, it would seem that this is the image of the development of our cognition, of knowing what surrounds us. But man, as we all know, creates things that Nature has not known before. The basis for this is discussed in this text below. Man provides Nature with objects that She does not know, but are created from Her building blocks, components, and the concept is abstract.

1.1 Measurability of Human Social Processes (Communicative, Psychological and Social)

Below we will discuss the measurability of soft structures in relation to social processes, as well as those related to our thinking and speech. All together they constitute one category. These are the so-called soft structures and, like physical and biological processes, they have their *ontology and diversity*. One can ask a philosophical question: which of them are more important? The physical ones, or the biological ones involving humans.

But we must immediately add here the information that without primarily physical processes, the fate of soft structures would be very uncertain. First there was physics, then biology, and only at the end humans. As the eminent French mathematician said: physical space protects against disturbances, because it is in this space that soft structures function (Thom, 1975). It is their carrier and in it that they arise. For this reason, topology influences the content of soft structures and that is why we devote a lot of space to it in this text. Matter creates structures in the dimension of physical space and through its ontology it protects them. But they are also the superstructure of their physical and biological base at the same time.

However, we ask what created soft structures? From the scientific perspective, this is not a clearly explained problem[4]. Philosophically, this question can be expressed as follows: structures, the soft ones, came from the same source where consciousness and the semantics related to it (understanding the space around us and making us aware of it) came from. But this thought does not solve the problem. Every single discussion about the importance of certain objects, speaking mathematically, placed in a certain space, must have a specific context – a spatial reference. We can ask what its role is in this space[5].

1.2 Mathematical Metrics in the Analysis of Social Processes (Selected Issues in the Area of Social Organizations)

Since the time of Plato (427-347 BC), cybernetics (in Greek κυβερνητική) was the science of governing the state[6]. Managing the state, in the most general sense, is the content management of social processes. Because without society there is no state. And since then, Plato's cybernetics has entered the stage of initial development (for almost 2,000 years of development of science, nothing in its content and name has changed). It was not until the 20th century that Norbert Wiener gave this science the form of an independent discipline of knowledge and called cybernetics *the science of control and information in a living organism and a machine* (Wiener, 1950).

One may already ask whether this field of knowledge has found its rightful place in governing contemporary society and in the study of human psychological and social behavior in the dimension of measurable models, i.e. in contemporary science that operates with such measures. No one other than Norbert Wiener himself said that *the humanities are barren soil for doing mathematics. He believed that in most social research we deal with short statistical series and we cannot be sure that a significant part of what we have observed has not been created by ourselves. But he was also aware that we cannot disregard the social sciences, although we should not create exaggerated hopes for significant possibilities of using the tools of mathematics to study there (in them) processes of a static and dynamic nature*

[4] *Physics has no consciousness, biology – here it is a doubtful thing, because can it be assigned to trees, and even when it comes to animals, psychology on this subject speaks differently. But man has consciousness.*

[5] *The heart is the most important organ in the human body, but without blood flowing through it, it does not function. There are many other examples of this type.*

[6] *Plato at some point in his life took up social processes, speaking in modern language. Platonic philosophy focuses on the concept of the "world of ideas" or "material world", where material reality is only a shadow or reflection of perfect, unchanging forms or ideas. Examples of such ideas are justice, beauty, and goodness. Plato's theory of knowledge is based on the belief that true knowledge does not result from sense experience.*

(Wiener, 1965; Wołgin, 1970). From the history of science we know that many great scientists were wrong when they expressed their views on a given subject (they were great, but they were also only human).

So, in the matter of the thought expressed above by N. Wiener regarding the relationship between social sciences and mathematics, this is also the case. Such a great scientist in this matter, like many of his predecessors, was also wrong. Mathematics found application in the *barren soil* of the humanities, as in linguistics (generative and transformational grammars, fractal theory (Chomsky, 1957; 1959; 1962; 1965; Mandelbrot, 1982; Peters, 1997), in psychology (Category theory – Piaget, 1981) and in social sciences (Game theory – Volgin, 1970).

We will cite a formally simple, but content-speaking example of the application of mathematics in sociology (Wołgin, 1970) in relation to broadly understood *organizations* created by us, with particular emphasis on *political parties*. Because ultimately, it is on them that the possibility of fulfilling our needs as the basic values of our existence depends to a large extent. Because they exercise the constitutional power given to them by us for a certain period of time. They, politicians, shape the legal image of *states* (democratic) with such a system as their electoral programs, as a result of which they gain power[7].

1.2 Mathematics in Sociology (Formal Model of Supporting Socio-Political Organizations by Society)

As a result of the arbitrariness of the sign (Saussure, 1961), a human being can adopt their own individual values (conventions) or values corresponding to them in the social dimension, and even give them an operational dimension (formal, but not necessarily true in relation to what it represents. There are many theories of

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[7]*After all, it must be said in general that every Political Party, every Social Organization should have the idea of statehood included in its program, i.e. the good of the State and the Nation should be taken into account first, and only then the goals of such a Social Organization should be realized. Many examples can be given from States with a democratic system, that it was not always like this and is not always like this. The second important issue concerning the exercise of parliamentary and constitutional power in a democratic system concerns the setting of a time horizon for the development of the State and the Nation for the next 50 years (a very general program), a more detailed program for 20-30 years, then for the next 10 years (clearly outlined accents of supporting investments in profitable sectors of the economy) and finally for 4-5 years (programs of individual political parties for the next elections). Such programs should be set outside the Parliament, through discussions of all significant political parties in the State and organizations that are socially significant on a national scale and in a broad discussion with society. Therefore, it cannot be the case that a Party winning the elections at a certain point significantly reduces its army as part of financial savings, exposing the Nation to the lack of defense of the State against possible foreign aggression. And the same applies to economic processes and other important areas of the life of the Nation and the functioning of the State.*

sociology as a science). This constitutes the power of the arbitrariness of the category of the sign and the symbols associated with it. Below we present one of the possible formal social models of a human being in relation to the role of the electoral programs (electoral ideology) of individual Political Parties fighting (competing with each other) for social support, i.e., for gaining power.

Competition (political struggle) in the dimension of the electoral programs and the way of exercising Power of individual Political Parties, more generally various Social Organizations proclaiming their programs for Society, can be roughly described using one of the analytical models of game theory. This is an example of a very complex game, because its content refers to complex social structures.

EXAMPLE 1:
Let us assume that in a given society there are n groups competing with each other (in general: social organizations, political parties, religions, enterprises, …):

$$D_1, D_2, D_3, \ldots, D_n, \tag{1}$$

each of which uses certain means x_i to proclaim their ideology (program of action, co-financing from taxpayers' money or other financial resources of political parties for their political activities, expenditure on advertising their products by companies, …) I_i. Because the actual content of their various programs of action I_i they are interdependent because they refer to one and the same society, *regardless of their proclaimed form (signs)*[8]. Then the expenses (resultant) y_i incurred by all n groups in society for the programs (ideologies) they proclaim I_i are:

$$y_i = \sum_{i=1}^{n} \rho_{ik} x_k, \ (i = 1,2,\ldots,n). \tag{3}$$

Now we need to consider the (effective) impact of a given program on society. It can be roughly represented by an exponential relationship:

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[8]*Now we need to consider how this interdependence can best be represented. These are correlation coefficients* ρ_{ik} *occurring between couples* (D_i, D_k), *as well as groups of organizations, are best suited to express this relationship.*
The formal model has the following form:

$$\begin{array}{lllccc}
1. & -1 \le \rho_{ik} \le +1, & for & all & I_i & any \\
2. & \rho_{ii} = +1, & for & every & I_i & \rho(I_i, I_i) = 1 \\
3. & \rho_{ik} = -1, & for & opposit & I_i & antagonisttic \\
4. & \rho_{ik} = 0, & for & independent & I_i & indifferent \\
5. & 0 < \rho_{ik} < +1, & for & similar & I_i & coalision \\
6. & -1 < \rho_{ik} < 0. & for & opposit & I_i & hostile
\end{array} \tag{2}$$

$$F(y_i) = 1 - \exp(-\alpha_i y_i), \tag{4}$$

which was obtained from the exponential distribution[9]:

$$f(y_i) = \begin{cases} \alpha_i \exp(-\alpha_i y_i), & y_i \geq 0, \\ 0, & y_i < 0. \end{cases} \tag{5}$$

Factor α_i characterizes society's susceptibility to ideology I_i. The relation (4) is the distribution function of the exponential distribution (5) and takes values from the interval:

$$0 \leq F(y_i) \leq 1 \tag{6}$$

For small input costs, the relationship (4) is approximately linear, i.e. it has the form:

$$F(y_i) \approx \alpha_i y_i. \tag{7}$$

So the susceptibility coefficient α_i determines the increase in program revenues I_i with the unit increase in expenditure on its propaganda (advertising). With very large expenditures (theoretically) on propaganda, such saturation of society with ideology can occur I_i:

$$F(y_i) \to 1 . \tag{8}$$

Then further increases in expenditures have no major impact on the behavior of society. This relationship results from the mathematical property of the exponential distribution. It also expresses social sentiment in a quantitative dimension[10].

The problem of the size of the benefits must now be analyzed a_i what group D_i receives from society (e.g. percentage of support in elections, percentage of sales of

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Integrating expression (5) for $y_i \in [0, y_i]$ *we get the relation (4), that is:*

$$F(y_i) = \alpha_i \int_0^{y_i} \exp(-\alpha_i y_i) dy = 1 - \exp(-\alpha_i y_i).$$

[10]*It is not so rare that social moods (support) change radically (in leaps and bounds). This is explained in a very convincing way by René Thom's theory of catastrophes and his first elementary catastrophe called Casp, which well represents a sudden change in social and political views most often (Thom 1975; Kołwzan 1983, 1984). The experience of recent years shows that this often happens. The society is simply "bored" with a given political party and shows it the red card in elections. It does not reach the required electoral threshold. If the nature of the problem analyzed here has such a formal representation, then we must accept this property (8) as true. Because such facts are reflected in the history of Europe even in recent years.*

its product on the market, ...). Theoretically, it should be proportional to the influence of political programs, quality of supply of products to the market, quality of services, attitude to the customer, etc. on the whole society. This recognition by recipients (society) of the value of offers and presents (this relationship of recognition of this and the offer) the following equation:

$$a_i = c_i F(y_i) \ . \tag{9}$$

To the coefficient c_i the following interpretation can be given. It defines the role (percentage share in quantitative terms) of the organization I_i for the whole society, because of the benefits of the group (political party or any other Organization) D_i are part of the benefit or loss for the whole of society[11].

Therefore, the balance of the group's costs D_i can be expressed by a utility function of the form:

$$U_i = a_i - x_i \ . \ (i = 1,2,\ldots,n) \tag{10}$$

Since each group aims to maximize the benefit (win) function U_i through the appropriate selection of x_i, and different groups have different programs (but also one common goal – gaining power), an n-person game is created in society, the optimal solution of which is given by a system of linear equations (11) defining the optimal expenditures of individual groups on propagating (advertising) their programs.

$$\frac{\partial U_i}{\partial x_i} = 0 \ . \ (i = 1,2,\ldots,n) \tag{11}$$

It has been said that generally it is a type of game. What constitutes winning in this game[12].

[11]*After all, there are social groups, as we know from past history, that act in a hidden way to the detriment of their society.*

[12]*Namely, the win for a given player (ideology Ii) is the percentage of social support for his program (ideology Ii). Any social support for a given ideology in the interpretation of game theory constitutes its win. And its ideology is its strategy of action. Science has also created measures of the utility of some dimensions of social organizations.*

When analyzing any social processes, one cannot avoid interpreting their practical application to managing them in turn. One of such theories is the Utility Theory. It was created to assess the utility of events, for the occurrence of which we only have a given probability of their occurrence. However, the utility theory has also been presented in the form of a system of axioms. In the reality surrounding us, events of a random nature occur. However, a person with the above-mentioned second signaling system, as a thinking being,

1.3 Social Cooperation in Terms of Game Theory (with Constant Payoffs)

A community (any kind) exists and functions as a structure only when there is some cooperation (cooperation, or even valence bonding in the sense of chemical compounds) within it. The contemporary definition of this relationship in the social dimension is nicely captured by the expression *empathy*. In every organized community there are groups, individuals, organizations and the above-mentioned political parties that cooperate with each other in the name of a common idea. They create some social games.

All the difficulties related to *n*-person cooperative games concern primarily the concept of cooperation (cooperation) of partners (von Neumann, 1928; 1944; Nash, 1951; Kofler, 1963; Owen, 1975; Dixit and Nalebuff, 2009). One form of cooperative games is the concept of a coalition of players against another in order to reduce their profits in relation to their own. Therefore, cooperation must be directed against someone.

Here is an example of *a cooperative game* with socially controversial features, because this is probably the nature of societies. Some cooperate, and others fight with each other. So how do we put all this in a simple way into a formal, mathematical model, within the framework of game theory. It is not so much about solving this problem, but rather about presenting it in a general and simple formal dimension[13].

EXAMPLE 2 (based on contractual data):
We have three players (partners). Each partner predicts that the other opponents may form a coalition against him. As in two-person zero games, we consider a given player's strategy optimal if it gives him the highest possible payoff for any play by the other partners. Therefore, we must determine the optimal game for each player in anticipation of the worst possible game conditions for him. In other words, in determining (calculating) the optimal strategy for a given partner, we must consider

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professes certain preferences (event valuation) regarding the events occurring around him or her as to their choice. These are innate, primary preferences (given in the same way as the primary concepts accepted in mathematics, for example) or acquired – learned in the course of acquiring knowledge, or social upbringing (education), i.e. generally gaining life experience (this was discussed above and in a very broad scope). Even when a person is dealing with a random process from a scientific point of view, they still try to see some pattern in it in relation to the choice of one of the situations (this problem is widely known from the works of A. Tversky and D. Kahneman). In 1951, the axioms of the so-called social choice were formulated. They are a kind of complement to the utility theory presented in the form of axioms (von Neumann, Morgenstern 1944, Arrow 1951, Peters 1989, Kołwzan et al. 2021).

[13]*An interesting thing is that recently Europe is creating cooperation with other countries against Russia, which is a dangerous player-aggressor - this can be removed. what it did not want to see before. especially some countries in it.*

the zero game that he plays against the coalition of the other partners (for simple calculations and clarity of arguments, we assume that we have three partners and each of them has two strategies of action, choice).

(*)

P_1	P_2	P_3	P_1	P_2	P_3
α_1	β_1	γ_1	a_1	b_1	c_1
α_1	β_1	γ_2	a_2	b_2	c_2
α_1	β_2	γ_1	a_3	b_3	c_3
α_1	β_2	γ_2	a_4	b_4	c_4
α_2	β_1	γ_1	a_5	b_5	c_5
α_2	β_1	γ_2	a_6	b_6	c_6
α_2	β_2	γ_1	a_7	b_7	c_7
α_2	β_2	γ_2	a_8	b_8	c_8

Below we provide the appropriate tables of zero games (why zero? Because each player relates his winnings to the losses of the other players) for individual partners. We arrange them taking into account the data from the table presented above (*).

Numerical example (conventional data). We have three partners with a payout table[14]:

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[14]*PROCEDURE FOR SOLVING THE TASK. We need to find the optimal strategy for each player separately, because each of them (it was mentioned above) assumes that the other players are against him (they play together)! And so, we will find the optimal strategy P_1 by solving the following zero game:*

$$\begin{matrix}\alpha_1\\ \alpha_2\end{matrix}\begin{bmatrix}2 & 3 & 3 & 2\\ 2 & 1 & 2 & 2\end{bmatrix}\Rightarrow\begin{bmatrix}1 & 2\\ 2 & 1\end{bmatrix}\Rightarrow$$

[α_1 = ½, α_2 = ½, and the value of the game $V_1 = 1\frac{1}{2}$ *].*

For partner P_2, in turn, it is necessary to solve a zero game of the form:

$$\begin{matrix}\beta_1\\ \beta_2\end{matrix}\begin{bmatrix}1 & 2 & 2 & 2\\ 2 & 1 & 2 & 2\end{bmatrix}\Rightarrow\begin{bmatrix}2 & 3\\ 2 & 1\end{bmatrix}\Rightarrow$$

[β_1 = ½, β_2 = ½, and the value of the game $V_2 = 2$ *].*

Similarly, we determine the optimal strategy of player P3 from the zero game for him of the form given below:

$$\begin{matrix}\gamma_1\\ \gamma_2\end{matrix}\begin{bmatrix}3 & 2 & 1 & 2\\ 1 & 3 & 2 & 2\end{bmatrix}\Rightarrow\begin{bmatrix}3 & 1\\ 1 & 2\end{bmatrix}\Rightarrow$$

[$\gamma_1 = \frac{1}{3}, \gamma_2 = \frac{2}{3}, V_3 = 1\frac{2}{3}$ *].*

(**)

P_1	P_2	P_3	P_1	P_2	P_3
α_1	β_1	γ_1	1	2	3
α_1	β_1	γ_2	2	3	1
α_1	β_2	γ_1	2	2	2
α_1	β_2	γ_2	2	1	3
α_2	β_1	γ_1	2	3	1
α_2	β_1	γ_2	1	3	2
α_2	β_2	γ_1	2	2	2
α_2	β_2	γ_2	2	2	2

From the numerical data we can see that this is a game with a constant payoff sum of the form: $a_i + b_i + c_i = 6$.

One of the interpretations of the content in relation to the global dimension of social processes may be an example of the competition of three political systems of the modern world represented by their leaders: the USA, the Russian Federation and China for influence (political ($\alpha_1, \beta_1, \gamma_1$), economic ($\alpha_2, \beta_2, \gamma_2$),…) on individual continents [15]:

1. North America - 1
3. Africa -1
4. Asia -1
5. Australia with Oceania -1
6. Europa -1

Σ_= 6.

7. Antarctica - 0

2. Humanistic Measures of Soft Structures

Let us now move on to another dimension of the humanities – to the analysis of its soft structures different from the previous ones (as it were, to their different morphology, i.e. diversity), to the analysis of what they consist of and how they were generated by Nature. Thanks to them, we will better understand the general

Note! The sum of the profits of all three players is not equal to 6, because: (1 +1/2 +2 +1 +2/3)=29/6 < 6.

[15] *Having specific strategies and realistic expected payoffs for each player based on the example provided, one can obtain various scenarios of such a cooperative game in relation to the societies of individual continents. Strategies are a way of gaining the sympathy of the societies of the continents through appropriate positive economic activities for them, or through simple military conquest and subjugation of them through economic advantage (a good example would be the economic situation of present-day Africa – all three powers are fighting for it).*

dimension of communication, the exchange of information in various areas of social life (and not only in the parliamentary benches of a given country, but even – Europe)[16]. Moreover, we may learn what is subject to formalization in Nature and what is beyond its reach (at least in the sense of contemporary Measure Theory), because perhaps it is ontologically subject to another operationalization that we do not know yet, or which already exists but we are not able to apply it significantly in other fields of knowledge.

2.1 Classification of Speech Language Signs (their Origin and Structure)

All soft structure processes are divided into those that can be expressed measurably (not necessarily in numerical terms) and those that are immeasurable (at least in time) or can be expressed with formal symbolism, but not metrically. For example, topology places less importance on measurable relations, and pays special attention to relations between objects or processes studied by it. These relations better show the properties of objects or dynamic processes studied. Such structures include language signs (however, it seems a long way to express their structure presented below in the language of topology.

However, in the language of linguistics there is no major problem, and they participate in the formulation of concepts also from the area of broadly understood topology). According to the linguistic theory of Milewski (1965) on the structure and hierarchy of language signs (because his theory of classification of signs is the most natural and semantically significant among others). First, signs are divided into two main types: *symptoms and signals*. Signals, in turn, are divided into two large groups: *asemantic appeals* and *semantic signals*. In this division, the basic difference between them is the attitude to reality[17].

Therefore, semantic signals are subject to the following further division into: *motivated signals*, also called *images*, and *unmotivated signals*, constituting a group of *signs named* (earlier in this text) *as arbitrary*. Arbitrary semantic signals are divided into two new categories: *single-class signals* opposed by *two-class signals*. In single-class systems, such as traffic lights or the cry of gibbons, the number of signs is closed and strictly limited. Moreover, this is an *unproductive class of signs*, i.e. this system does not create new signs. However, they have value, they can be used in many systems of an informational nature (warning, controlling the informant, and in a conventional but unambiguous way, where STOP means

[16]*We can poetically express the dimension of our analysis in this way: we are, as it were, going from the rain into the gutter.*

[17]*Semantic signals, especially their form, refer the recipient to certain phenomena of the surrounding reality. They evoke a certain image in the sender and the recipient, which, because it is repeated in all members of society, has an objective (supra-individual) character. Appeals, on the other hand, do not refer to the external world, but only evoke certain changes in the psyche and behavior of the recipient (music, paintings, dance, etc.).*

stopping, but only in the convention of the meaning of this sign). Two-class systems, on the other hand, are open and productive, and for example they are: the language of bees, the language of dolphins, and the human language.[18].

2.2 Categories of Human Language Signs

Human language is the only phonemic code and this is what distinguishes it from all other sign systems (soft structures). It is also called the second signal system by science.

Finally, signs were divided into six groups, namely:

1) symptoms,
2) appeals,
3) images,
4) single-class signals,
5) two-class phonemeless signals,
6) two-class phoneme signals (language)[19].

The stages of sign formation can be interpreted formally through the concept of generativity, the morphology of their genesis. These six categories of signs of our language can be captured in the form of generative grammar. Generative grammar is at this time a purely mathematical, formal concept.

Definition. By generative (formal) grammar there is mean 4–touple as $G = \langle V_A, V_T . P, \sigma \rangle$*, where* V_A *and* V_T *are respectively the auxiliary and terminal alphabets* $(V_A \cap V_T = \mathrm{O})$*,* P *is the set of productions in the alphabet* $V_A \cup V_T$ *and* σ *is the axiom (initial symbol of generation* (Blikle, 1971).

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[18]*In general, we have only two kinds of signs. They are simple signs and compound signs, and they form two different classes. Simple signs (e.g. words or expressions of language) correspond to certain classes of phenomena in the world around us, and on the other hand they can be composed according to certain principles (generative rules) into rich sets of complex signs, creating the second category of signs mentioned above, i.e. the class of open and productive signs constituting an important means of linguistic communication.*

[19]*Both from the point of view of the development of the species, i.e. phylogenesis, and of the development of the individual, i.e. ontogeny, language – this two-class semantic and conventional code – is the latest creation. It has been layered on a series of older codes, such as symptoms, appeals and others that appeared during the evolution of the living world and that functioned before it. These old systems of language signs have not ceased to exist, but they cooperate with language within the adult speech, which is an orchestra of all types of signs (Milewski 1965; Hockett 1968).*

In accordance with the definition of formal grammar given above, we create below appropriate sets of symbols and a set of generation rules for the signs of our speech represented by its language.

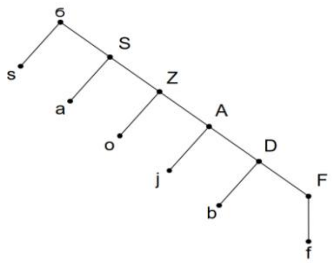
Form of grammars:

$$G = \langle V_A, V_T, P, \sigma \rangle$$

$$V_A = \{A, D, F, S, Z, \sigma\} \qquad V_T = \{a, b, f, j, o, s\}$$

$$P \quad : \quad \left| \begin{array}{ccc} \sigma & \rightarrow & sS \\ S & \rightarrow & aZ \\ Z & \rightarrow & oA \\ A & \rightarrow & jD \\ D & \rightarrow & bF \\ F & \rightarrow & f \end{array} \right|$$

Figure 1. *Grammar and derivation tree of speech signs.*



Note: *The language of grammar is one word L(G) = { x }; x= saojbf.* \

Source: *Own elaboration.*

2.3 The Compactness of the Space of Speech and Thought Signs

The compactness of space in the scientific sense belongs to the concepts of topology. Réne Thom saw the explanation of the processes of the nature of speech and thinking in the dimension of the concepts of this branch of mathematics and included these thoughts in many of his works (Thom, 1968; 1970; 1971; 1972; 1975). Much earlier than R. Thom, Kurt Lewin saw the importance of topology for explaining the ontology of human mental processes (Lewin, 1936).

However, as R.W. Ashby notes, topology was not yet as cognitively and mathematically developed as it was in the second half of the 20th century (Ashby 1963). Réne Thom's approach to understanding the topological connection between Nature and the human mind was met with, to put it mildly, criticism. It is included, among others, in the position of Arnold (1990).

Generally speaking, the main objections (including those of other authors of scientific works cited in this book), the criticism of R. Thom's theory is included in this cited position[20].

3. Classification of Signs and Symbols According to the Thinking Process (Psychological Classification of Signs)

The structure of language signs discussed previously constituted a linguistic classification. But signs and symbols can also be divided into certain categories according to the thinking process taking place in the human mind. This is another way of encoding information, which we mentioned in the previous considerations, when discussing the classification of language signs. Taking this point of view into account, C.R. Morris (Morris 1946) divided signs into four classes that differ in the way they designate our (but basic) thinking processes. These are:

> *1. A defining sign (designator) – designates features, or properties (stimulus) of objects.*
> *2. An evaluative sign (appraisor) – designates the degree of the organism's preference for a given feature.*
> *3. A recommending sign (prescriptor) – designates the degree to which certain sequences of reactions are desirable.*
> *4. A modifying sign (formator) – modifies the way the organism reacts to other signs or symbols that are accompanied by*[21].

The above-presented classic and still recognized classification of signs from the point of view of psychology and the linguistic classification given earlier show how complex and rich in terms of interpretation the sign structure of human signs is[22].

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[20]*Ta ostatnia uwaga ma bardzo skromny wymiar i przypis ten jest jego dopełnieniem. Wielki matematyk W.I. Arnold zarzucał Thomowi irracjonalność jego filozofii, w swojej książce o osobliwościach matematycznych i bifurkacjach, co chwila w tekście napisanym dla nie matematyków przytacza przekroje i inne reprezentacje graficzne matematycznych osobliwości, ale nie odnosi ich do rzeczywistości poza matematycznej (Arnold 1990).*

[21] *Aso see D.E. Berlyne 1969*

[22]*An important methodological problem arises here, how to transform one classification into another, because we are dealing here with two types of diversity, and according to Ashby's philosophy, a given diversity can only be explained through another diversity, i.e. there is always a possibility of expressing one form through another. But for this there is a need to create an appropriate operationalization in the scientific dimension, because perhaps the mind does it spontaneously. It has it, but our consciousness does not know what it consists of. The essence of the motivation for using the sign was emphasized earlier, and this motivation has a more universal dimension, because the process of education and learning in the spontaneous sense also depends on it. Let us add that the human body reacts to the signs or symbols provided to it and therefore, in order to explain the concept of a symbolic reaction, we must first consider the concept of a sign and a symbol and what they are. According to the common view, a sign or a symbol is that which represents or denotes something else. This has already been discussed earlier, although from a different cognitive position. The person*

This is the basic assumption of the Theory of Meaning put forward in 1923 by C.K. Ogden and I.A. Richards[23].

3.1 Classification of Signs in Terms of Semiotics

As can be seen from the above-presented views of the classics in the field of psychology on the origin and understanding of meaning through signs and symbols in comparison to the approach of linguistics on the same subject, it should be noted that the approach to this problem in both of these fields is expressed in different *languages (terminology)*[24].

As part of the analysis and classification of signs and symbols, we will also present an approach from the perspective of *symbolism* expressed in the language of *semiotics*[25]. Jest to nauka zajmująca się wszelkimi znakami, czyli znakiem jako takim (Pelc, 1982). However, the classic representative in this area of science is Ch. Sanders Peirce (1931-1935), who divided signs into the following three classes creating a natural hierarchy (he is considered the founder of modern semiotics).

1. *Images (images) that are faithful – with accuracy to the tolerance relationship – graphic representations of real objects (physical signs).*
2. *Signs – these are objects or living beings associated with the symbolized object. They result from the fact of the existence of these objects (biological signs).*
3. *Symbols – these are any forms whose relationship to the designated object is the result of a social agreement (semantic signs, but also conventional signs).*

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who establishes or uses it has a conscious experience of its meaning and uses the sign or symbol to evoke – for the purpose of communication – a similar experience in the mind of someone else.

[23] *See e.g.: C.K. Ogden, I.A. Richards 1923. Modern psychology, for which signs and symbols are important because of their important role in human behavior, does not fully accept the above-formulated view. See: E.D. Berlyne 1969. A slightly different position from that presented by Odegna and Richard was adopted by the classic psychologist, Skinner, and the already cited Morris and Osgood (Osgood 1952).*

[24] *And here, at least, the theoretical game involves reconciling these two approaches. The problem is solved, in our opinion only, by the Sapir-Whorf hypothesis: do we have two different semantic worlds that are expressed by the same symbols and signs (labels), or is it one semantic world represented by different signs and symbols-concepts, i.e. the way we understand it? (Sapir 2010, Whorf 1982). In the aspect of the cognitive achievements of modern science, we still continue to ask how many worlds there are (one semantic, or many syntactic – formal).*

[25] *Semiotics was already of scientifically established interest in the study of Ancient Greece. See e.g.: I. Dąbska, 1984.*

This chapter concerned, to some extent, the division and use of signs and symbols and their relationships in terms of both their conventions, arbitrariness (Saussure 1961) and content (often symbolic, but meaningful precisely in terms of content (the National Flag and other symbols).

The meaning of real objects and those abstract ones created by us people is approached from the perspective of many dimensions of science, and above all: linguistics, psychology, sociology, physics, biology, logic and mathematics[26]. In contemporary science, one can encounter very different and often different concepts of defining, more generally grasping meaning.

One of them is seeing this category of Nature from the perspective of a very important branch of mathematics today, which is topology. Such a concept of meaning from the perspective of topology was formulated some time ago by the quoted French mathematician René Thom (1971, 1972, 1991). But Jean Piaget also proclaimed the need to study morphisms, transformations occurring in our thinking (during thinking), in order to understand reality and our thinking (Piaget 1981) and was the first to notice this problem (Lewin 1936)[27].

3.2 Speech and Thinking as an Evolutionarily Coherent Topological System

In this part of the text, we will present the fundamental hypotheses formulated in science about the relationship between speech and thinking through their evolution (development) and merging into one system that creates *the human mind*. Generally speaking, science is looking for the structure of the human mind, it is looking for what constitutes its *ontological locus* (Bobryk, 1987).

And in terms of mathematics, it is its topological approach to the compactness of the space of our mind. Here we are addressing a very significant scientific problem – the problem of the relationship between the humanities (psychology) and mathematics in the dimension of such fields as topology, category theory and algebraic topology (Piaget, 1981). These postulates were already expressed early by many philosophers, apart from Réne Thom (1970, 1975) and Jean Piaget (1981). But the forerunner was the aforementioned Kurt Lewin (1936).

After all, the whole difficulty of approaching this problem lies not in the expression of ideas, postulates (correct ones), but in the sensible expression of our mind in the

[26]*Do other fields of knowledge not participate in this process? They do, but to a lesser extent than the above-mentioned fields of science (for example, chemistry also plays an important role in this process, but we are not always able to clearly distinguish a purely chemical reaction in a biological cell related to its metabolism from reactions related to information with a change in metabolism (A.G. Loevy, P. Siekevitz, 1969).*

[27] *We are leaving aside mathematical works on topology here. Because the course lecture for students was introduced in 1929 by Wacław Sierpiński at the University of Warsaw.*

language of these aforementioned sciences. After all, it was human thinking, the human mind that generated these important fields for mathematics (a kind of feedback). So we need to reverse our thinking, because just as there are functions that are inverse to given functions, now we need to transfer concepts such as topological space, category, morphism and others to the mind and explain some forms of our thinking and behavior in their conceptual framework and meaning. Mathematicians – topologists construct spaces called topological, but only some of them point to their important role in the cognitive area of reality. Paradoxically, it is humanists who see more of the need to use these formal tools to learn about our soft structures[28].

4. Understanding the Form and Content of Signs by the Humanities

Three separate classifications of signs and symbols have been presented above. Thus, we have signs and symbols. How they are perceived (their groups, categories, and the relationships between them) by the disciplines of the humanities has been discussed in the presentation above. The reasons for their differences were also mentioned (indicated). However, contemporary philosophy of the humanities (semiotics, linguistics, psychology, and sociology) strongly emphasizes the view that everything related to today's humanities in terms of signs has a single root, a single origin—almost like the primordial seed of symbolic signs. This foundation is rooted in the evolution (development) of speech and thought, followed by the merging and

[28]*Topology (Greek: τόπος (tópos), place, area; λόγος (lógos), word, science) is a branch of higher mathematics that studies topological spaces, i.e. the most general spaces for which the concept of a continuous map can be defined. Topology studies in particular the properties preserved by homeomorphisms (continuous and reversible maps). Properties of this type are called topological invariants. Informally, it is said that topological properties do not change even after radical deformation of objects, e.g. geometric figures such as solids and their equivalents with a different number of dimensions. Deformation here means any deformation – such as bending, stretching or twisting – but without tearing apart different parts or gluing different points together. The deformation process can be imagined by assuming that the object is made of rubber. Pod tym kątem można analizować między innymi obiekty geometryczne jak przestrzenie euklidesowe oraz inne rozmaitości i ich podzbiory. Because it must be added, and even emphasized, that topology grew out of geometry and was sometimes referred to as the theory of location (Latin: analysis situs)[1]. Nevertheless, in general it does not use quantitative concepts such as distance or angle measure, and it does not even take into account some qualitative geometric relations such as parallelism of lines[1]. Such minimalism made it possible to specify concepts of geometric origin, such as a curve or the abstract dimension of a set, without resorting to linear algebra or measure theory. Topology has also entered various areas of mathematics far from its roots. An example is functional analysis[1] – the intuitive notion of connectivity can be generalized to, among others, function spaces such as Hilbert's, Banach's, or even more general linear-topological spaces, which have become the defining topic of this branch of mathematics. The concepts and ideas of topology are even transferred to considerations in the area of soft structures in linguistics (Thom 1970, Kołwzan 1983), psychology (Piaget 1981) and sociology (Levi-Strauss 1970).*

integration of these two paths of human intellectual development into the human mind (semantic cohesion)[29].

Here we will cite an example of understanding the content of the presented object and form from the area of logic, because it also constitutes the basis, the foundation of our thinking. Grzegorczyk (1969) writes that in general, a concept (concerning mathematical theories) is called *syntactic* if the definition of this concept refers only to the shapes of mathematical inscriptions (*form-approach*), and not to their meaning, i.e. whether they concern natural numbers, functions and other such objects of mathematics.

There is no mention of this there. If, however, in defining a concept concerning certain expressions it is impossible to do without talking about the (mathematical) meaning of these expressions, then this concept is called *semantic*[30]. In connection

[29]*However, the fact that each of the mentioned humanities disciplines has its own classification of signs and symbols today also results from the fact that each of them has its own language (terminology and methodology) for the analysis of speech and thinking and social behavior of humans. Although it may seem that each of these fields deals with the pure content of the symbolism of their systems, information about them. However, each of these sciences deals with the concept of information in its available dimension, i.e. in what each of them deals with separately in terms of the content analyzed there and in terms of the research tools available for examining and expressing information related to these fields. Therefore, we can speak of many approaches to information (Shannon 1949; Szroeder 2015). Here we are talking about the meaning (content) of the processes under consideration, or individual objects. The greatest content value for information is its meaning, i.e. what it expresses (represents the content of the object). Semantic theories of information and representative approaches can be found in (Kołwzan 1983). Their approach to information, although semantic in sound, ultimately expresses its form quantitatively. There is no approach to information in the form of what it means. But how to achieve this? Science has not yet been able to do this. Although it should be mentioned that logic is still between form and content. It is worth risking a hypothesis here that logic is between information theory and the aforementioned fields of knowledge, because just as information theory is able to represent different contents through its one and the same schemes, on the other hand its schemes represent certain structures, invariants, and therefore are in themselves a certain content (abstract objects). They constitute the meaning of the represented object. Moreover, logic operates with its own meaning in the sense of logical truth (for example, a linguistic sentence of the form: if (two times two is five), then (Wrocław lies on the Oder) is a true logical sentence). The division of an object into form and content is not a simple procedure, as it may sometimes seem.*

[30]*Here we give examples of formal construction of the syntactic structure and semantic structure of mathematical objects from the domain of predicate calculus. Thus, a construction of the formal form:*

$$\forall x P(x) \equiv \sim \exists x \sim P(x)$$

It is an example of a logical expression with a syntactic approach. These two sides are equivalent, i.e. the whole is a law of logic, or rather a logically true sentence. Moreover, this with the above ideas, we will now consider how the meaning of an object is understood in a general sense.

5. Object Permanence as its Meaning

The concept of meaning is inextricably linked to another important concept in science, which is *structure*. After all, it is only one of the features defining meaning[31]. But man creates various thought constructs that we do not see, but they are important to us and sometimes have great value in the cognitive, emotional or many other value-related dimensions (Kacenelinbojgen 1977)[32].

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law can be considered a definition of a general quantifier by means of an existential one. Moreover, it is very intuitive.

EXAMPLE IN THE FIELD OF PEOPLE: for the predicate P(x) – (x is mortal) – we get:

(All men are mortal) $\equiv$ *(there is no immortal man).*

In turn, for example, an expression of the form: $\exists x \forall z (x \leq z)$ *it is a semantic construction because it contains a specific name of a predicate in the form of some relation between numbers. Relation* $x \leq z$ *with respect to the domain of natural numbers, it states (together with quantifiers) that there is a smallest natural number. And this expression of the predicate calculus is true in the domain of natural numbers, but is no longer true in the domain of integers. The content represented by symbols sometimes has a different logical value.*

[31]*However, the concept of object constancy was questioned at one time in the area of elementary particle physics (currently physicists have even supposedly come to the conclusion that the World came from nothing...), for which an object exists as such (has a macro dimension, unlike a wave) only when it is possible to localize it (Piaget 1977).*

[32]*We can therefore ask about the genesis of the creation of an object (subject) and the consolidation of its understanding, or rather its meaning, in our human mind (the mind is also invisible, but a person feels its functioning through their senses, because the mind is largely Us). As shown by Jean Piaget's experimental research conducted on children, as mentioned above, the constancy of an object is related to its location in space and time, and the location in turn depends on the system creating the so-called group of displacements (transformations), which the French mathematician René Poincaré treated as the source of generation (creation) of human sensory-motor space. But this group of displacements, although it appears as necessary for the organization of space, is not necessary (sufficient) from the very beginning of the creation of meaning; it is not given a priori. This is one of the conclusions of the results of research on children's behavior in the sense of their understanding of time and space, and even quantity. J. Piaget wrote: "...I always recall Einstein's joy when we told him at Princeton about the fact that children aged 4-6 did not recognize that a liquid conserves its quantity poured into a container of a different shape, and also how significant he considered this late understanding of the conservation of quantity. Indeed, since the most basic concepts, those that seem the most obvious, require such a long and difficult elaboration, it is better to understand that experimental sciences were historically created later than strictly logical-mathematical disciplines. ..." (Piaget 1977). Thus, the concept of meaning is created in the process of the individual development of an individual (child). The dynamics of the structure of objects (environment) present in it play an important role in this process. But these objects are inseparably accompanied by human language and its signs. As we already know, the environment in which it occurs is*

Speech, through its language (form as a carrier of content), maps continuous and discrete processes in the form appropriate to its structure. It was created through evolution and reality is mapped in its structure. Meaning is continuous (it is represented, for example, by a certain thought as a whole – coherence (e.g. *I am thinking*, *I am learning*, these are continuous content processes), but it is represented syntactically, i.e., in a discrete way[33].

Mathematics can also represent many discrete processes in the form of a continuous function[34]. Or conversely, a continuous function can be expressed, for example, by a series (a discrete mathematical structure).

How to reconcile or explain the distinctiveness of language (coding) of linguistic *parts of speech*, psychological *cognitive schemas* and Peirce's semiotic signs corresponding to both of these dimensions and find their equivalents within *ontological categories*? Therefore, we need to search for invariant forms, mind and reality in the dimensions of *mathematics*, *praxeology* and *pragmatics*, the fields mentioned in our discourse on the role of processes in human actions.

A partial answer to this question was given a long time ago by two outstanding psychologists, the already cited J. Piaget and the Russian psychologist L.S. Vygotsky, and the French mathematician R. Thom, already cited many times. The reasoning of these scholars on the subject of the connections between speech and

also important for signs. It is therefore worth considering our understanding of signs and symbols in the psychological dimension and the representation of this understanding by psychology, i.e., analyzing their structure, with regard to the thinking process itself. In psychology, this problem has been and continues to be analyzed. See also: Berlyne E.D. 1969.

[33]*L.A. Zadeh created fuzzy logic – an intermediate link between continuity and discreteness, but logic does not always reflect reality (Zadeh 1965). However, it must be admitted that the essence of fuzziness is the possibility of its meaningful interpretation. Many types of multi-valued logics have been created, which do not have any content interpretation. However, there are also such logics that find interpretation even in the field of physics. Such a construction in relation to the mentioned field of knowledge is Reichenbach's logic, see: Zinowiew 1963.*

[34]*As an example, we can cite the central Lindeberg–Lévy theorem in the field of probability theory (the binomial distribution, being discrete, can be replaced by the continuous normal distribution, more on for* $n = \infty$ *transforms into a normal distribution. In relation to language, the elementary semiotic structure – discrete expressed symbolically in the form of Z. Harris's SAO chain [S - subject, O - complement (object of action) and A - predicate (action of action)]. Content-wise (semantically) it can represent some continuous process, as for example expressed by the sentence: John goes home in opposition to the perfective (discrete) form: John entered the house (at a given moment) Anatomical data and psychological research indicate a significant difference in the way information is processed by the so-called human cerebral hemispheres. One is responsible for discrete (generally syntactic) information, the other – semantic (continuous).*

thought was similar. Piaget's views have already been presented in many ways related to this topic. We will present the views of L.S. Vygotsky and R. Thom.

Here, the general problem of the structure of the language of thought and speech and their relations emerges for consideration - the connections of a genetic nature (the origin of structures), as well as in relation to the use of these forms in everyday life, i.e., the pragmatic dimension of this connection.

Vygotsky (1989; 1971) put forward the hypothesis that thinking and speech genetically developed independently, but at some point their independent lines of development crossed and from then on thinking was based on the word (inner speech), and speech became an intellectual activity, it represents thinking externally, and in reference to R. Thom this connection consists in the resonance (reproduction) of speech and thinking through reality. But in what way, i.e. through what elements of this reality this connection is realized. Modern science has not developed a unified theory of ontological meaning.

This has been shown on the example of various classifications of signs. A promising attempt of this nature was made at one time by R. Thom (1975). Within the framework of the formulated *Elementary Theory of Catastrophes*, he proclaimed a direction of research in relation to fields focused on practicing science of a qualitative (semantic) nature, opposed only to quantitative approaches to science. He called this line of research *the dynamic theory of morphogenesis* or, in other words, *the theory of development of forms*.

In this concept of Thom, first of all, the concept of form, previously understood more intuitively, gained a formalized representation. The main task of the theory of morphogenesis is the classification of forms and their development (genesis, formation and preservation of structure). The simplest theory of morphogenesis is the above-mentioned *Elementary Theory of Catastrophes* (ETC). Based on *the theorem of universal expansion*, it was possible to classify forms within this theory and distinguish elementary catastrophes[35].

The elementary catastrophe theory distinguishes only seven topologically distinct classes of forms (topological types) also called *universal morphologies* by R. Thom. After all, this theory, although it contains phrases related to universality, is not universal in itself. Its scope is local. It applies to small environments of space-time points. It is therefore difficult to say unequivocally (to know through the nature of

[35]*The word catastrophe itself is a mathematical concept (in this theory) and is used to represent a qualitative type of form. However, in the philosophical aspect it means a process of a sudden, abrupt change in the behavior of a form (e.g. leaving the forest for an open field). As W.I. Arnold points out, E.C. Zeeman proposed to call the mathematical theory of singularities and bifurcations and their examples and other related topological objects the Theory of Catastrophes (Arnold 1990).*

morphology) how a given form will behave outside its space-time scope, whether it will maintain its type, its structure constituting the stability of its behavior. In relation to the mind, there is evidence that it changes its attitude to the environment, changes to a different type of thinking, etc.

However, according to the author of *the Theory of Catastrophes*, the long-term goal of science should be to create *the General Theory of Catastrophes*, which in the future would aspire to be called the General Theory of Analogy[36], as if a formal theory of cognition, a theory operating with a universal language (Thom 1975, 1991). In a different approach, this idea was propagated by W. Ross Ashby (Ashby 1963) and Jean Piaget (Piaget 1973, 1981).

5.1 Catastrophe Theory as a Modern Precursor of the General Theory of Meaning

It was said above that something that is constant, unchanging in time, generates its meaning in relation to other objects because it occupies some place in space-time.

It can be said that almost the entire attention of modern science, whatever it deals with, is focused on finding the answer to the question of what *meaning* is (how to understand scientific results, what they are, etc.) and how humans came to be aware

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[36]*As we already know from the previous arguments we have drawn, a similar position in the aspect of the theory of cognition, the theory of analogy was expressed by (Ashby 1963, Piaget 1972). Elementary catastrophes are often used to interpret or present the structures of objects and processes in numerous sciences and with different paradigms of their cultivation. They are used to model discontinuous phenomena. They explain what the process of a sudden change in the behavior of an object or process, i.e. a given form, consists in. At the same time, it is a theory of the qualitative nature of the description of forms. It does not require precise quantitative data representing the described form. Hence its numerous applications in the humanities, because R. Thom himself attempted to describe the semantics of natural language in numerous works (Thom 1972, 1973, 1975, 1991). Moreover, and this is a very important reference cognitively, various forms of creative thinking could be interpreted as a process of abrupt change occurring in human thinking. But there are trends of thought (Berlyne 1969) among psychologists from the cognitive science group, which tend to perceive the mental processes of the mind as computational forms. The aforementioned Bobryk (Bobryk 1987) referred to such an approach to the mind with some caution in his work. One may ask what new thing the catastrophe theory brings to science. The most important result of this line of research is the finiteness of forms in space-time, i.e. those occurring in our environment. In a pragmatic sense, this means that the human mind is able to capture the continuous (continuous) external world in a finite number of concepts and signs representing them, i.e. forms. These forms must therefore be present in speech and thought (together in the mind) and constitute the most general semantic universals – linguistic and mental. Within psychology, they may be the semantic networks, scripts, frames, and generally certain cognitive patterns distinguished by it (Kołwzan 1983, 1992; Bobryk 1987; Nosal 1992). The need to create such a language was also postulated by (Ashby 1963, Piaget 1972), and in relation to the general structure of our thinking by C.E. Berlyne (1969).*

of the content contained in messages and, above all, to understand them through the reception of information in general. And how does R. Thom, a supporter of seeing us through the language of our communication (speech and thinking as forms of acquired consciousness) see it all in terms of the language of topology, an important field of mathematics.

5.2 The Topological Dimension of Form as the Content of its Meaning

The starting point in building a general theory of meaning for the author of the catastrophe theory, F. de Saussure (de Saussure 1961), is the theory of the sign (relation: the signifier – the signified). The signifier is given in language and is available for research, it is the formal side of the sign (often established by us and often arbitrary).

However, it is more difficult to understand what is signified, the conceptual side of the sign. It can be either reality itself (*R1*), or the conceptual reality (*R2*), which is in truth conscious, but is not fully available for research, which is basically what is being talked about all the time[37]. It is therefore necessary to explain (understand the ontology of the mechanism) how the human mind (of the entire world community) creates ideas about the external world and what is the internal structure of these ideas, i.e., the geometry (topology) specific to the mind. It can be called the internal semantic code (Kołwzan, 1983).

Thom understands this structure as a kind of internal resonance between the mind and external stimuli acting on it. Natural language is the most characteristic distinguishing feature of this kind of resonance. The significant side of language is therefore images, or geometric forms, mapped in the mind as signified[38] .

It can be assumed that they are somehow connected with elementary catastrophes, because the classification theorem, by means of which the classification of forms is obtained, can be understood in such a way that when in every natural process there is a dependence of a certain variable on one, two, three or four other arbitrary variables, then the course of such a process (e.g., the creation of an idea, the appearance of some analogy initiating a creative thought process) must have the shape of one of the seven types of universal morphologies.

According to ETC, universal morphologies are space-time forms. We as humans perceive only a part of the form, the space-time one (because we have such senses), and the inner space, i.e., *R2*, is not more familiar to it, as mentioned above. The perceived part of the form is a submorphology of both of these spaces and is the

[37] *Freud's Id is not accessible to scientific study. According to this scientist's conception, our consciousness has no access to this area of the mind (Freud 1923).*

[38] *The representation of the reality-mind connection as a relation in the form of resonance was also seen by other researchers investigating the influence of reality on us (Lorenz 1977).*

result of mapping – projection of the elementary catastrophe in *R1*. Nazywa się ona *morfologią archetypową (archetypem)*. It is a set of points constituting the boundary of areas of fluid and abrupt behavior of form. In the geometric sense, the shape of this boundary determines the topological structure of the mutual influence of these areas. The essential thing about the content interpretation of these areas is that the existence of this boundary in them causes a *conflict*. Something new, a different situation, arises[39].

5.3 Translating Continuous Forms into Discrete Forms (The Phenomenon of Nature in the Human Mind)

In natural language, every process (action), especially a simple one, is represented by a verb. A verb concentrates the dynamics of what it represents (an event, a process, a message, ...). Therefore, each archetype can be assigned a verb, and additionally, objects included in the archetype can be assigned nouns. It turned out that the most complex archetype contains four elements, which R. Thom, following L. Tesnière (1959), called *actants*.

Also the most complex chain of the Universal Semantic Code (USC) theory created by V.V. Martynov (1974) contains four elements. In the publications (Kołwzan, 1983; Kołwzan and Święcki, 1983) continuous archetypal forms were translated into their discrete equivalents represented by semiotic chains of UCS. In this translation, continuity (Thoma-topological ideas) was combined with the discreteness (generativity) of Martynov's ideas. The principle of translation refers to the hypothesis of Guiraud (Guiraud 1976), who statistically investigated hypothetical semantic universals put forward in linguistics[40].

And these are precisely the units that archetypes and semiotic chains are[41]. The basic unit of the semiotic chain is the above-mentioned Harris structure (*SAO*)[42].

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[39]*Exiting the dense forest into the open field, here the conflict is the edge of the forest and the field. Therefore, it is a physically visible conflict of the morphology of both different spaces (topological types).*

[40] *These units are also called semes (semem; Gołąb et al., 1968); a semantic unit that can be formally expressed in various ways, does not have an unambiguous representation, unlike a semanteme. A seme has therefore a very general meaning).*

[41]*After all, P. Guiraud, as a result of his statistical analyses (based on Zipf's law) came to the conclusion that the number of these semes comes down to sixteen, but he was unable to name them, to give them some form - an internal structure. It can be assumed that they can be established through the analysis of perceptual-existential universals, those common to all communities, because there is only one Man on our R3 (as a category). And he has invariant macro-situations in common, and that is, those that repeat themselves particularly often, because they occur in the dynamics of our behavior. The structure of semantemes in general was given by V.V. Martynov - a sign structure and R. Thom – a topological structure..*

[42]*But V.V. Martynov went deeper into this problem of semantic units represented by the SAO structure. This structure is a link between the material world, the one we already know R1*

6. Philosophy of the Concept of the Logos of Form and the Locus of the Human Mind as a Whole

Philosophy, only the above outlined approach to speech and thinking as a whole indicates that the semantic structures of language participate in thinking and vice

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(material objects are placed in it), and the world of signs – R2. Signs exist in human mental states (and incidentally, how to formalize them, since they are abstract), i.e. in this reality R2. It has already been mentioned that these two realities cannot be so easily transformed mutually and unambiguously one into the other. This problem was very strongly emphasized by Jean Piaget (Piaget 1981). It creates in its sign space a separate world and probably a separate geometry of its own (as if separate to mathematical measures of distances between signs) encompassing semantic relations that occur in the world of human semantics, but which relations cannot differ too much from the relations occurring between the processes of matter in R1 (due to the adopted concept of resonance of these two spaces of reality). This geometry, however, does not operate with numerical scales, metrics: Euclid's, Minkowski's, or Manhattan's metrics, because it is a content representation of various material situations. A simple situation of a sign (semiotic) chain is an example of a chain: subject - S1 (subject), action - A (predicate), object - O1 (complement), or structure S1AO1. Language uses a wealth of stylistic forms for one and the same real situation. But such that they do not change its meaning. So how can this be expressed formally in the language of semiotics, not mathematics? This function of changing the semiotic form without changing the content (meaning) is obtained by having a second subject S2 (the instrument of action) and a second object O2 (the object of action) next to S1 for the purpose of the action (O1) - Janek (S1) sends a letter O2) by post (S2) to Marek (O1). This structure has the record S1S2AO2O1. In short, it is assumed that S1S2 AO2O1=SSOO. In this way, we obtain the so-called full structure, in which each of the four elements can be active (without a line in the symbolic notation, or inactive (hidden), with a line above the symbol.

EXAMPLE. The situation represented by the sentence I'm going home is expressed by the semiotic chain $\overline{S}(SAO)\overline{O}$ *, which should be read: I (S) with my own feet (* $\overline{S}$ *) I move (A) my body (* $\overline{O}$ *) home (O).*

We get sixteen semiotic chains, or a complete list of all possible variants of the SSOO sequence. It looks like this:

$$\begin{array}{llll} \overline{S}\,\overline{S}\,\overline{O}\,\overline{O} & \overline{S}S\overline{O}\,\overline{O} & S\overline{S}\,\overline{O}\,\overline{O} & SS\overline{O}\,\overline{O} \\ \overline{S}\,\overline{S}\,\overline{O}O & \overline{S}S\overline{O}O & \overline{S}S\overline{O}O & SS\overline{O}O \\ \overline{S}\,\overline{S}O\overline{O} & \overline{S}SO\overline{O} & \overline{S}SO\overline{O} & SSO\overline{O} \\ \overline{S}\,\overline{S}OO & \overline{S}SOO & \overline{S}SOO & SSOO \end{array}$$

It can be assumed that the semiotic chains obtained in this way constitute (can represent) certain elementary meanings that are part of complex meanings, just as words and expressions are elements of complex sentences and utterances. Therefore, there is a need to operate with the rules of assembling these chains into larger wholes. However, the most important thing would be to demonstrate that the combinatorics of chains does not generate new units, i.e. it is finite. These units are, as it were, modules of our thinking, which consists in our abilities to transfer these modules from one domain of thinking to another. They play a fundamental role in thinking by analogy. This was and is the basic postulate in R. Thom's Elementary Theory of Catastrophes.

versa, thinking is expressed through language (speech). A simple formal relation, but how is it realized in the real domain. Here it is not a simple relation, but only a collision in the concept of R. Thom, the thinking of Man vs. Nature. Who resolves this collision. The answer is trivially simple, if it is resolved, it is only through our Mind. Therefore, the category of analogy (resonance of Nature and Mind) comes into play here. So the appearance of *the symbol* marked an important evolutionary leap in thinking.

Thus, the *semantic space* born of evolution, also called by some the *social space*, created a different quality of the language of thought, that is, the expression of thoughts through speech in language (an external form of thinking). In addition to ordinary communication, the creativity of language appeared[43]. These situations also required new symbols (two-class signs) to describe them. Syntactic structures appeared, i.e. language (*a discrete form as an external medium of speech and thinking*).

Globalization of space, thanks to the emergence of a symbol (imagination-a compact topological space), probably also gave birth to a human cognitive passion, and its maintenance is one of the goals of education, and the highest form of this process is creativity (the abstractness of the symbol allowed the creation of mathematics, for example, or rather its language, because many forms of nature have a structure of mathematical relations (connections))[44]. Creativity is directly connected with meaning. Hence, it is worth quoting here once again R. Thom's view on semantics

[43]*It began to serve not only for simple communication, but from that moment on it played a role, and an important one at that, in human creativity. The fundamental difference between biological sign space and semantic (symbolic) space is that in relation to the former, the number of basic signals telling about biologically important events is small. Social organization (social organizational structures) has limited many dangerous situations in human life. His life dynamics could be directed towards representing new situations, less frequent, but more complex, and therefore artificial in relation to the former. Man has noticed other needs besides obtaining food, these higher, intellectual ones. Thanks to this, a uniform geometry of the world surrounding man has been created, but the dimension of this geometry is difficult to describe mathematically. R. Thom suggests that the essence of meaning, or the understanding of semantic space by man, consists in the fact that a human thought giving rise to a single sentence is a form of dynamic behavior describing the functioning of the human nervous system. Individual paths (attractors) of the system are represented by nouns, while the surfaces separating their outlets (basins) are represented by verbs. Speech is then interpreted as a mechanism gradually transmitting the components of thought processes. Speech reception consists of the reverse mechanism. It is stimulated by a thought analogous to the original thought of the sender. The communication process takes place in the environment-subject system (Thom 1970, 1971).*

[44]*Scientific literature contains many interesting studies on mathematical symbolism, the origins of concepts, as well as analyses of where mathematics came from, generally speaking, and views on our human limitations in learning about reality. We cite a few from a rich list of very interesting studies on this subject: Kulczycki 1973, Bourbaki 1980, Kordos 1994, Spengler 2001, Wodzicki 2005, Dubos 1973.*

itself: *All natural languages have the same universal morphologies in their deep structure. They are common (compare the views of J. Piaget and L.S. Vygotsky and Noam Chomsky) to the structure of speech and thought. They probably also form the basic elements of the rules of grammar of speech and thought*. These rules are derived from the sign structure of man, as accepted by Ch.S. Peirce (1931; 1935; 1958), expressed through *images*, *signs* and *symbols*. Each class of signs can be assigned an appropriate space.

Images are associated with physical space, signs with biological space, and symbols should be naturally associated with semantic space (speech and thought). And since these signs are arranged hierarchically, there is no semantic process that could be realized without the participation of the other two types of sign space.

Our mind is simply placed in physical and biological space, but in its semantic space *R2* it creates topological structures that go beyond the system *R1*. The reverse relation does not have to hold, for example: *a human shadow* (a physical process) does not have to (but can) automatically trigger the remaining processes, i.e. the biological and semantic ones. In each of the three spaces there are stable forms to which a certain meaning can be assigned (this value expressed by Kacenelinbojgen)[45].

But there are three categories of meaning: meanings generated in physical space, biological space, and the most creative space – semantic space. In many places in our considerations, in addition to the concept of structure, the importance of the concept of *process* in its formation and subsequent functioning was also mentioned. What is a process? Well, as Tony Plummer says (Plummer 1995), in order to understand how the behaviour of systems (collectives) changes, we need to focus on *processes* rather than structures. But both of these approaches are the basis for studying and understanding the behavior of nature and constitute the philosophy of its cognition within *the Systems Theory* formulated by Ludwig von Bertalanffy (von Bertalanffy 1968)[46], L. Lévy-Strauss's *Structural Anthropology* (Lévy-Strauss 1970), R. Thom's *Elementary Catastrophe Theory* (Thom 1975), and currently the processes of Nature are studied within the framework of *Dynamical Complexity Theory* (Peters 1997).

7. Conclusions

Conclusions and postulates for further research resulting from the content of the above text will begin with recalling Norbert Wiener's view on the possibility of

[45]*Poglądy te i cytowane w poprzednich punktach naszych wywodów wiele innych jego myśli opisane są w wielu jego publikacjach i z wielu z nich korzystaliśmy, i tu je cytujemy (Thom 1968, 1970, 1971, 1972, 1973, 1975, 1991).*

[46]*Choć przed L. von Bertalanffy'm prekursorem w dziedzinie tej był Polak B.B. Bogdanov vel. Malinowski (Bogdanov 1912).*

formalizing (generally speaking) the humanities. He, the creator of operationalized cybernetics, believed that the humanities constituted barren soil for practicing mathematics. The examples presented in the text indicate that this is not entirely true. However, all types of processes of the three disciplines of the humanities, namely linguistics, psychology and sociology, constitute dynamically complex objects and processes.

Theoretically, the matter is simple, if we want to operationalize and measure something from soft structures, we must first learn the ontology of such a process or object. Only then can we apply adequate mathematical theories to their formalization (apply knowledge of social processes to manage people in production processes). In mathematics, somewhere in the last few decades, a new paradigm appeared under the name: Dynamic Complexity Theory. Réne Thom wrote that there are many indications that in the coming decades, linguistics is the science that will make a significant contribution to the development of science as a whole.

Based on the analyses conducted in the text, we assume that now, in turn, in the coming decades, the dynamic theory of complexity will change our knowledge of the nature of processes and their diversity in the humanities, in turn. In the applications of mathematics and logic in the humanities, the following motto must be borne in mind: Using only pure tools of logic and mathematics is useful and interesting from the operational point of view, i.e.. using the tools of mathematics to find (obtain) a solution to a certain problem of a non-mathematical nature. Because human activities are related to specific areas of life in terms of content, and only then formally (mathematically).

There was no mathematics, and man was already building houses and producing various tools. So, first of all, one must be able to formulate problems requiring solutions using mathematical methods well (logically). Both sides must understand a given problem for mathematical solution well in terms of content, i.e. as a soft structure. Mathematics solves problems, and the humanities interpret them. In the future, we should study the approach to our thinking in the dimension of topological spaces, because topology measures less and places more importance on the relations between real and abstract processes.

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