CHAPTER «PHILOSOPHICAL SCIENCES»

THE SYSTEM STUDY OF CONSCIOUSNESS: THE PROBLEM OF ADEQUACY

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DOI: https://doi.org/10.30525/978-9934-26-151-0-45

Abstract. Given the complex nature of consciousness, many agree that in order to study it properly we need a non-reductive, pluralistic and synthetic (i.e. systemic) approach. Despite the relative popularity of the systems methodology in the vast field of the study of consciousness, system approach (i.e., modeling something as a system) is very well used for a reductive purposes, and there is no consensus on the issue of a clear understanding of the non-reductive use of one or another system approach in area. Hence, the purpose of my research is methodological reflection on the problem of the adequacy of the system approach for the non-reductive deliberation on the problem of consciousness. I formulate criteria of adequacy in a form of three principles that should be followed in any non-reductive (not just systemic) study of consciousness. The principle of structural-ontological (or metaphysical) neutrality is the first one. This principle suspends all metaphysical solutions to the problem of consciousness and plays the role of a necessary precondition. Many pointless disputes in the field could be avoided if the disputing parties adhered to this principle. The second principle of differentiation of ontic modes of experience and epistemic perspectives retains the multifaceted complex structure of consciousness after it is stripped of its metaphysical baggage. The principle of embodiment adds some feedback dynamics to the story. At the next step I implement the principles of adequacy in a particular case of the General parametric systems theory, developed by a philosopher and logician Avenir Uyemov. The conceptual foundations of this theory in relation to its compliance with the criteria of adequacy are revealed. It turns out that two of three principles

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exist at the meta-language of the theory. The principle of neutrality follows by definition of the General system theory – i.e., theory applicable to all kinds of systems. And the principle of embodiment exists as a feedback of the substrate to the structure of a system. The principle of differentiation in this case is the most crucial. If this theory is not enriched at the level of object-language with epistemic perspectives and ontic modes of experience, then we won't get a no-reductive explication of consciousness, even if it remains systemic by definition. In the end I give a systemic definition of consciousness through its basic feature which is (I conjecture) modeling of reality or different kinds of experience through epistemic perspectives, where complex structural ontology of consciousness 'in-forms' or structures its epistemology, which in turn models it in accordance with the needs of a conscious system.

1. Introduction

The variety of views on the nature of consciousness and the lack of consensus impedes with the construction of a comprehensive science of consciousness. Moreover:

"There is unlikely to be any single theoretical perspective that suffices for explaining all the features of consciousness that we wish to understand. Thus a synthetic and pluralistic approach may provide the best road to future progress" [40].

Given a multifaceted nature of consciousness the question arises how to deal with such evasive and complicated object of study in order to understand its different aspects accurately enough for scientific modeling and not to lose it in reduction. One possible answer to this question of where to find such 'synthetic and pluralistic approach' lies in the integrative area of systems science. "Systems science is a way to look at all parts of the world in a way that is unifying and explanatory... [I]t provides a way to integrate the knowledge produced by other sciences…" [22, p. 5].

There are several related notions in the vast area of systems methodology and the concept of *system approach* is one of the most general one. System approach is used whenever something is modeled as a system – i.e., *a set of objects with certain or definite relations between them* [30, p. 73; 36, p. 364–365]. In this sense it's obvious that not just cybernetics or semiotics are instantiations of the notion of system approach but structuralism and functionalism in a certain broad sense too (of course, in many cases it is possible and necessary to point out the differences).

Thus, system approach can allegedly provide us with the needed framework for the integrated study of consciousness. At this point another problem immediately arises. Truth is that not all system approaches are ‘sensitive’ enough to deal with such a delicate issue as the problem of consciousness, and some researchers explicitly use system approach in a reductive mode [16]. So what are the necessary criteria for a non-reductive systems study of consciousness? And how, in particular, are these criteria implemented? And what is consciousness modeled as a system? Thus, my **purpose** here is methodological reflection on the problem of the adequacy of the system approach to the (adequate) study of consciousness. I start with the formulation of the necessary criteria for an adequate (non-reductive) study of consciousness, and then implement them in a particular case of general parametric systems theory. The analysis shows that this theory is adequate to the non-reductive system study of consciousness. In addition, through the implementation of those criteria systems definition of consciousness is formulated.

2. Arguments from *complexity* and *wholeness*

Today we may see varieties of attempts to study consciousness and related questions using implicit or explicit forms of system approach (e.g., [3; 4; 7; 10; 11; 12; 16; 20; 22; 29; 33; 34; 41; 42). The main feature of any system approach is that it puts certain relations (ontological or epistemological structures) before objects [30; 35; 37]. Objects simply do not exist or at least cannot be presented, unless being structured first. If we move from one particular detail to another to another, we aren’t able to understand what is that we are dealing with in the first place. Details can be innumerable and infinite. If we merge into details completely, we are never capable of proper understanding of the subject matter, because understanding presupposes structural or integrative grasp of things [22; 35]. In the area of consciousness study we see mountains of details of all sorts in different disciplines of all kinds, and we can be sure that there will be more and more. What we need is not another detail or another fact – it may be the case that we already have enough facts (or there will never be enough facts). We need a ‘whole’ from which we can begin our real ‘quest for consciousness'. And that is the most powerful feature of any system approach: it explicitly and intentionally begins with the whole, with certain relations with which all numerous details, facts and parts are examined in order to get their meaning.

Thus, explicit arguments in favor of system approach in a field of consciousness study are mainly stressing two following points: the problems of complexity and wholeness of an object of study.

First of all, it is about system approach's ability to work with incredibly complex objects. Usually, it is not about just substrate complexity, i.e., about the quantity of interacting components – it is about structural or organizational complexity, when the issue of the various connections between components is taken into account. For example, our brain (as a possible source of consciousness) is happened to be just one such object of the enormous substrate and structural complexity [10]. There are about one hundred billions of nerve cells in the brain, each of which can have thousands connections with other neurons, and this gives us trillions of synapses. And if we take into account the reconsidered role of glia cells in the brain [9], the amount of which is comparable with that one of neurons, the complexity of a picture becomes even more monstrous. And, as long as you agree that consciousness have something to do with the brain, you cannot just skip the complexity of the 'brain question'.

From this first aspect follows the second one – the ability of system approaches to unite or integrate considered as systems objects of various kinds, especially when we deal with such heterogeneous ones, at least epistemologically, as brains and consciousness. If we picture the possible sources of consciousness revealed and explained by different disciplines, e.g., philosophical, logical, mathematical, physical, biological, biochemical, psychological, psychiatrical, cultural, social, anthropological studies, we can only imagine how should look the eventual framework [40].

3. Three principles helpful for a non-reductive study of consciousness

Despite on the holistic nature of systems methodology it is being non-reductive only to some particular extent. E.g., functionalism of any kind is a realization of a system approach through a reduction of the object of study in relation to its main function (on functionalism in general see

[5, p. 111–112; 30, p. 106–108]). Everything else that does not serve this main function is omitted. Given, that not all realizations of system approach prevent us from slipping into reduction of some kind (from methodological to ontological) I propose to use explicit non-reductive systemic principles in order to study consciousness adequately (presupposing that reductive study of consciousness is not adequate, see [6] on that matter): the principle of structural-ontological neutrality; the principle of differentiation of epistemic perspectives and ontic modes of experience; the principle of embodiment. I believe that these principles can serve as necessary criteria for any (not just systemic) non-reductive study of consciousness.

The principle of structural-ontological neutrality prevents us from pondering on unsolvable (i.e., purely metaphysical) questions. Consider an analogy with physics. Generally speaking, physical theories are not suited for solving the problem derived from the Leibniz's question: Why there is something but not nothing? Physics can tell us how there is something and what it does, but not why. The same must hold for the scientific understanding of consciousness. In order to proceed with the understanding of consciousness, we should leave the questions about its origin and its source stuff out of the scope of scientific consideration (at least temporarily), because those are very interesting and important metaphysical questions, which can be the source of inspiration, but must not impede the scientific research from the start.

So, the neutrality principle is the most important one. We have the same situation with the principle of metaphysical neutrality in phenomenological methodology: you should perform an *epoche* first in order to proceed with further investigation [13, p. 157; 43, p. 30–50].

The next is the principle of differentiation of epistemic perspectives and ontic modes of experience, which helps to distinguish between 1st person data and 3rd person data on consciousness in epistemological and ontological modes. Or, as Searle puts it, that there is an ontological and epistemological objectivity and subjectivity and they should not be confused [28, p. 94–95]. For example, our opinions about quantum theory are epistemologically subjective, but quantum theory itself is epistemologically objective, and our qualitative aspects of these opinions are ontologically subjective when the object of the study of the quantum theory is ontologically objective.

In short, principle of differentiation provides us with that multifaceted structure of consciousness and the neutrality principle deprives it of essentialist metaphysics.

The third criteria, the principle of embodiment puts necessary limitation on the mind and connects it with the substrate (again, according to the first principle, we do not leap to metaphysical presupposition about the nature of that substrate – whether it is carbon-based or made of ectoplasm or the Holy Spirit – is left out of scope of our consideration).

The crucial point is that our three principles must be used in conjunction. The results obtained by disjunctive usage of these principles will not be equally valuable. In this regard, theories (usually mathematically inclined) that rely solely on the principle of neutrality can provide limited (perhaps simply trivial), but nonetheless, quite reliable information about consciousness. Whereas the exclusive use of the principle of differentiation (or conjunctively with the principle of embodiment), without the limitation provided by the principle of neutrality, ends with assuming of some serious ontological commitments as in different types of dualism or in case of ontological interpretation of epistemic perspectives, when we find ourselves talking about far from consensus ontological possibility for atoms to possess some mental (or protomental) ability, albeit at a rudimentary level (e.g., [6, p. 293–310; 42, p. 276–282]). The application of the principle of neutrality without the principle of differentiation will not allow us to grasp the qualitative aspects of consciousness, reducing them to 3rd person explanation in terms of interacting particles, bits of information, synaptic connectedness, systems parameters, etc. And without the principle of embodiment, we won't be able to make a clear distinction between artificial intelligence and 'natural intelligence', thus identifying minds which have different internal and external conditions, as most functionalistic theories tend to do (on embodiment see [14; 41]).

4. Adequacy requirement for the system study of consciousness

4.1. Conditions of adequacy

Adequacy requirement is satisfied when the phenomenon being studied is both relevant and divergent with the research method. Relevance implies the coincidence of the main ideas, concepts, or functions of considered systems; divergence means the difference of substrates (elements) of the systems [35]. For example, if you once again came to the monthly Academic Council of your University while still waiting for the implementation of the 'academic' concept, and instead again have found yourself in the midst of a discussion of nomenclature and business affairs, you feel frustration precisely because of the irrelevance of the concept of expectation to the subject of implementation. Accordingly, you may wish to rename the so-called Academic Council to Bureaucratic or Nomenclature-financial one.

When extrapolating to our context, compliance with the relevance requirement means that the system approach used should allow us to grasp various aspects of consciousness without reducing them to something else, which is achieved by the same degree of conceptual generality of the approach to the subject. Divergence requirement in this case is achieved most easily: a system approach or method, on the one hand, and consciousness as an object of study, on the other, by definition are considered as fairly different things. Any approach or method that loses the subject of its research while it is used is not adequate since it is not relevant to the subject matter. I believe that three principles – neutrality, differentiation, and embodiment – provide us with the necessary criteria for the relevant, and hence adequate (system or not) study of consciousness.

4.2. The problem of the adequacy of H. Maturana's systems theory for the study of consciousness

Let's consider briefly, as an example, the compliance of systems theory of H. Maturana with our principles.

Though it is obvious that with the use of the notion of the observer Maturana's theory differentiates perspectives to some extent, it distinguishes, but not concentrates (at least clearly) on qualitative aspects of the mind, providing approximate explication of consciousness where it is reduced to social couplings of systems through linguistic interactions [20, p. 234].

Obviously Maturana distinguishes the principle of embodiment. He uses terms *domains* of *bodyhood* and *behavior*, realized through the *structural coupling* of a system with itself, with its medium or with other systems, for related phenomena [21, p. 26–30]. Consciousness, in the end, has its roots in the biological domain (collective and individual), and it is not some *thing* in the brain (though the nervous system plays an important role here), but is the result of *structurally coupled* internal (biologically) and external *recursive interactions* of a system in some *linguistic domain*, constituted through the network of ongoing *conversations* with other systems in several intersecting *domains of existence*, being detected through the *explanatory domain of the observer* (e.g., [19, p. 63–64; 20, p. 231–235).

The main problem with the adequacy of a Maturana's theory for the study of consciousness is the lack of the neutrality principle. Although the *explanatory path of objectivity-in-parenthesis* [19] in some ways reminds the neutrality principle, Maturana restricts its appliance down to biological substrate. Moreover his theory is adequate only for one particular type of biological systems.

"A system is a network of processes realized by interacting elements that through their preferential interactions and relations establish an operational boundary that separates them as a whole from other elements with which they may also interact" [21, p. 176].

This means that things which do not interact (are not dynamical) are not considered as systems, but there can be found an infinite number of non-interacting systems, even at the biological level (consider the system of two human beings residing at two different places of the planet, which do not interact with each other by no means, but still belong to the same biological class and can be rendered systemically). As for the systems that are not biological by nature, we cannot even begin to discuss them from here (though some theorists use the concept of autopoiesis in a non-conventional meaning, and are able to talk about other options on the problem [4; 17]). Thus, if we follow Maturana's theory, we will restrict ourselves from investigating any kind of mind other than biological (so machines obviously can't have any mental ability if they have no biological history). That is, Maturana's autopoiesis systems theory focuses primarily on ways – structurally different than in most dynamic systems theories – of emergence of consciousness from matter specifically at the level of socially and culturally interacting biological systems. So, it cannot provide us with the *general* theory of consciousness, only with the biologically rooted one.

5. General parametric systems theory's framework

5.1. Categorical foundations of the GPST

As has been already mentioned, the first principle to be followed in constructing a systems theory adequate to the study of consciousness is the principle of neutrality. The easiest way to achieve this condition is to involve lots of mathematics in your theory (because of the metaphysical neutrality of mathematics itself). 'The more mathematics – the more neutrality'. But sometimes there can be inappropriate consequences in such approaches (at least for our purposes). The problem is that some mathematically in-formed systems theories (or approaches) carry within their 'mathematics' extensional ontological commitments with the consequences fraught with the ontologically rendered bottom-up approach that consider a whole as a function of its parts (see [37]). Moreover, when it comes to consciousness, pure quantitative extensional approaches are met with significant limitations, since consciousness turns out to be something very resistant to computational reduction (cf., [25, p. 7–61; 32, p. 281–317; 34, p. 157–172]). For this reason, it should be preferable to use ontologically neutral, but qualitative or intensional system approach for an adequate study of consciousness. The General parametric systems theory (from now on GPST) represents one such approach.

The philosophical basis of the GPST consists of the theory of Avenir Uyemov (1928–2012) on two sets of categories: *things*, *properties,* and *relations* (TPR) and *definite*, *indefinite,* and *arbitrary* [15; 26; 35; 36; 37; 38; 39].

5.1.1. Things, properties, and relations

In the TPR conception, things are understood *qualitatively* (as combinations of properties), and properties and relations are not reducible to things that possess these properties or stand in these relations, but have an equal ontological status along with things. Things, properties, and relations differ from each other not substantially, but functionally depending on the chosen reference system. One and the same phenomenon can be considered both as a thing (a combination of properties or relations, something that is approximately expressed by the use of a noun), as a property (relations of things, or such a thing, that can be attributed to another thing without changing that thing; it is approximately expressed by an adjective), and as a relation (a property of things or, such a thing that, when realized on another thing, changes that thing into another thing; can be expressed by verbs and some other parts of speech). It is important to emphasize that things, properties, and relations can be understood either as something material or as something non-material, that is, these categories are metaphysically neutral to the nature of objects they describe. Consequently, different *things* can be distinguished in one and the same 'body' (cf., scientific and ordinary life understanding of such *thing* as 'water in a bucket'), and one and the same *thing* can be manifested in different bodies (e.g., different exemplars of a book) (for more details see [36]). From here stems the principle of neutrality in GPST (in relation to our topic see [18]).

5.1.2. Definite, indefinite, and arbitrary

To explain the categories of definite, indefinite, and arbitrary, Uyemov turns to natural language (e.g., [15; 35; 37]). A common way of expressing definiteness or indefiniteness in many languages is through articles and pronouns. A definite thing is a thing that makes it possible to distinguish this thing from some other thing; this is achieved, for example, with the help of a definite article (implicitly or explicitly present in many languages) or demonstrative pronouns. Indefiniteness is understood as *some* (that which comes across; is well expressed by the indefinite article) thing, the indefiniteness of which is limited by something, in contrast to an arbitrary (*any*) thing.

Now that we have two triples of the basic categories, we can define the concept of a system in GPST. The definition of the system can be put as follows.

(1) *A system is an arbitrary (any) thing, some relations of which are determined by a definite property*.

Or in other form:

(2) *A system is an arbitrary thing, some properties of which are determined by a definite relation.*

From these definitions we can derive the notions of system descriptors: the *concept*, the *structure*, and the *substrate*. System descriptors are terms of the meta-language of GPST, representing a system-forming property or relation (the concept of a system), that has the property of definiteness and determines the structure of a system, which, in turn, structures elements or the substrate of the system (which appears in the definition as an arbitrary thing). Thus, the first of our definitions is called the definition of a system with an attributive concept and a relational structure, and the second is called the definition of a system with a relational concept and an attributive structure. We are dealing with two equal definitions of a system dual and complementary relative to each other in accordance with the principles of duality and complementarity (below we consider these principles in details). Other principles of the GPST that are significant for us include the principles of universality and relativity, according to which *any* thing can be modeled as a system or considered as a non-system relative to the chosen concept (for more details, see [35]).

5.2. Parameters and systems patterns

The path of system modeling in GPST can be considered as a movement of thought through three major steps. First of all, we must represent something as a system, i.e., to distinguish systems descriptors of some particular thing (*thing* in Uyemov's qualitative broad sense [36]). This begins with the choosing of a concept, proceeds through the selection of the structure (as a way of realization of a concept), and ends up with the structuring (organizing) elements of a system. Second, we need to find specific system characteristics (general systems parameters) that are related to second-order relations of systems descriptors. These exist in the attributive and relational modes. Third step consists of finding and formulation of the systems patterns (specific law-like relations between systems parameters).

General systems parameters can be understood as either specific properties of some system, in accordance with the relations between descriptors of that system (attributive parameters), or characteristics that arise when we compare descriptors of different systems (relational parameters). Relational parameters include such well-known properties of related systems as homomorphism and isomorphism (similarity of structures), or less known iso-conceptual, and iso-substrate relations. There are possibilities to compare systems through their different-level descriptors (e.g., concept-substrate or structural-conceptual, etc.) [35; 38]

The attributive general systems parameters mainly include binary (e.g., openness, autonomy) and linear (e.g., wholeness, complexity) parameters. The point is how many values of a parameter of a particular system are to be distinguished: two mutually exclusive (then we are dealing with binary parameters) or several, but no more than some fixed number (parameters with an ordered scale), or an indefinite number of values in the form of degrees or levels (e.g., complexity or wholeness) [35; 38, p. 136–137]. Anyway, parameters should not be understood rigidly. The problem is that sometimes it makes sense to talk about the degrees of autonomy or regeneration (usually considered to be binary), just as linear parameters can be posed in a binary mode. Sometimes, in accordance with the chosen concept, you need to know whether the system is complex or simple, represents some wholeness or appears to be an aggregate of disconnected elements. For example, we can talk about the degree of the completeness of the installed computer program, the degree of the regeneration of nerve cells, the degree of atom divisibility, etc. It follows that linearity or binarity are relative characteristics of system parameters, that is, the same system parameter can exist in several modes (binary, with an ordered scale, or linear).

General systems parameters can be applied to all systems, but there are parameters relevant only for specific types of systems. For example, parameters of cybernetic feedback, homeostasis, adaptability, etc., are applicable to the description of only dynamical systems. It is obviously pointless to talk about the homeostasis of the natural number system. Such parameters can be called low-level-parameters. There is an interesting question whether we can derive low-level-parameters from general ones. To derive, for example, a biological parameter of homeostasis from general parameters of stability or stationarity and obtain a feedback low-level-parameters (in cybernetics or information theory) from some general substrate feedback to structure or a structural feedback to concept parameters. We will return to this topic in relation to our goal.

As the parameters are found, there can be observed (empirically) or derived (analytically) some specific law-like correlations between them. These correlations are called systems patterns. For example, substrate auto-regenerative systems are structurally stable, minimal systems are not fully reliable, chain systems are not stationary, etc. [35; 39] Systems patterns allow predicting the presence of other parameters, based on the already known parameters, which, in turn, expand the possibilities of understanding and explaining the phenomenon under the study.

5.3. The Ternary Description Language

An important feature of the GPST is that it was developed a special formalized language within its framework – the ternary description language (TDL), a non-classical logical language based upon the same philosophical foundations as the GPST (see [15; 35; 37; 38; 39]). Let's consider some notions of the ternary description language in a non-technical way.

In TDL the positional (syntactic) principle of distinguishing things, properties, and relations is accepted. A *thing* is indicated as a single character or by a character in brackets: *A*, *a*, *t*, (*A*), (*t*), (*a*). Things can be arbitrary – *A*, definite – *t,* or indefinite – *a*.

A *property* is designated by a symbol that stands to the right of the brackets, and a *relation* is expressed by a symbol which stands to the left of the brackets, for example, (*A*) *a – an arbitrary thing has some property* and *A* (*t*) *– a certain thing stands in any relation*. The formulae in round brackets are propositional (like in above examples). The formulae in square brackets, e.g.: [(*t*) *a*] *– a definite thing that has some property,* and [*A* (*t*)] *– a definite thing that stands in an arbitrary relation*, are conceptual ones (i.e., equivalent to concepts in traditional logic).

Formulae can be of direct (as in above examples) or of indirect (inverse) types: (*a**) *a – some property is prescribed to some object, a* (**a*) *– indefinite relation is realized on some objects*. The asterisk (*) symbol in last formulae denotes the inverse direction of predication – from properties and relations toward things.

There are two types of identity in TDL. They are expressed by two different symbols of identification: the iota operator – ι, and the jay operator – j. An iota-operator, ascribed to a symbol of an indefinite or an arbitrary thing, property or relation, designates them as the same ones that have been already mentioned in the framework of the given formula: [ι*a* (ι*A*)] → [ι*a* (*ι*A*)] *– if we have an arbitrary thing that stands in some relations, then we have those relations of that thing*, where → is the symbol of neutral implication (which means '*if…then'* in relation to propositions and concepts). Jay operator identifies different parts of a given formula: j*A* j*a – an arbitrary object is identical to some object.* If we want to emphasize the direction of identification we can use italics and regular jay and iota operators.

Braces {...} are technical or auxiliary symbols with their help sub-formulae in a formula are delimited.

The symbol '•' indicates a linked list. Objects that are not just enumerated (this is a free list, expressed as a comma-separated list), but are in some relation to each other, form a linked list. Other concepts of TDL will be introduced as we use them.

Now we are able to express system definitions in a more formal way. The definition of a system with the attributive concept and the relational structure:

(1) (ι*A*) System = ([*a* (* ι*A*)]) *t*,

and the definition of a system with the relational concept and the attributive structure:

(2) (ι*A*) System = *t* ([(ι*A* *) *a*]).

5.4. The principles of duality and complementarity

Principles of duality and complementarity constitute an important part of the basic assumptions of GPST. Anything can be modeled in two ways: as an attributive system – a system with an attributive concept and a relational structure, or/and as a relational system – a system with a relational concept and an attributive structure.

The history of the duality principle in GPST has its roots in the 'pre-systemic' formulation in the book "Things, Properties, and Relations" [36]. Here Uyemov discusses the principle of duality in relation to the categories (not systems) of properties and relations, based on similar situations which exist in a number of scientific disciplines (projective geometry, mathematical logic, etc.). That is, there are patterns, when by a dual transformation of some concepts or statements, other ones can be obtained, and vice versa. Similarly, Uyemov demonstrates that the categories of properties and relations can be defined through each other in a dual way [36].

Later, this pattern, already at the level of systems definitions, was extrapolated to GPST (e.g., [37]).

Two systems models are obtained from each other in a dual way, not by replacement properties with relations, but by shifting the hierarchy of descriptors location: what is a concept in one system model becomes a structure in another, and vice versa. Thus, in case of a systems rather than categorical duality principle, we can talk not about the duality of properties and relations to each other, but about the duality of systems descriptors relative to each other.

Let us consider some examples. Imagine the usual situation in the road with cars and pedestrians. For a pedestrian, hurrying about his business, a car, left in an uncomfortable for a pedestrian place, acts as an annoying obstacle – it blocks the road. Let's model this situation in TDL syntax as a system with an attributive concept:

([*spatial relations* (* *road, pedestrian, car*)]) *property 'to block the road'*.

Turn the situation around:

spatial relations ([(*road, pedestrian, car* *) *property 'to block the road'*]).

We see that without much effort, in a purely formal way – by shifting the descriptors in the hierarchy, we got a meaningful systems scheme of the situation in question, which complements the dual attributive model. Apparently, the traffic police officer investigating the traffic accident will initially work with the scheme represented by the last formula before formulating a conclusion, which, in turn, would be natural to give in a form of the attributive system model. What exactly will be the attributive concept of the conclusion will be revealed during the investigation, when the police will figure out who has been blocking the road to whom.

Now, let's consider something a little bit more appropriate for our topic, using this dual systems framework. For example, our primary sensory zones of the neocortex work hard constantly processing sensory information about particular features of a perceived object. After some time of processing, patterns of signals go up the cortical hierarchy into association areas, where the integrated inputs construct or awake an invariant patterns, which are then send down the cortical hierarchy, then to thalamus and, eventually, to our senses, so we can perceive what we are dealing with, what kind of the object we are encountered with [12, p. 113–117]. The actual perception can begin only after that invariant model of an object has been sent back by the cortical hierarchy. Perception, especially a conscious one, works through prediction. That is, to perceive *any* thing, it is necessary that some features (properties) of that thing were accessible during some time (i.e., unconsciously adjusted relative to each other). Thus, the process of unconscious constituting of an object can be conveniently grasped by the relational systems model:

time relations ([(*some* '*object'* *) *features of 'something' being constituted*]).

And when, eventually, that information is processed down the cortical (and farther) hierarchy, beginning with association areas, we finally 'recognize' what kind of thing is that and can consciously 'perceive' it (i.e. predict it):

([*time relations* (* *recognized object*)]) *features of a constituted object*.

We can assume that when I unconsciously sense some object, the functioning of my cognitive system can be better described by the relational systems model, when my cognitive system gathers information during some time to eventually give me the invariant of an object that I perceive. In the next step, my cognitive system prescribes to that object the status of being that kind of object, which it has predicted. This step is better described in terms of an attributive systems model. It is interesting that, theoretically speaking, conscious and unconscious work of the cognitive system can be understood as being realized through the switching of dual systems models. And the structure of the complete instant of the process of perception can be described by the formula: $(\iota A)\{\{\iota\iota a\ ([(\iota A\ *)\ \iota a])\rightarrow([\iota\iota a\ (*\ \iota A)])\ \iota a\}\bullet\{\iota a \rightarrow \iota A\}\}$.

Thus, dual systems modeling can provide us with the heuristic method of system interpretation of the work of our cognitive system. Given that it works by switching from relational to attributive model (and vice versa) and it can be modeled formally, we can assume some far reaching consequences for consciousness study, e.g., finding system differences between conscious and unconscious perception, or, to paraphrase famous NCC, – systems correlates of consciousness (SCC).

6. The problem of the adequacy of GPST to the study of consciousness

6.1. The principle embodiment in GPST

Let us recall that adequacy of a method to an object of study is realized when one system (method) is relevant (i.e., is iso-conceptual) and divergent (substrate difference) from the other. Our three necessary principles delineate the concept's level, i.e. – the relevance. Having examined the essential features of Uyemov's system approach, we can, at first glance, state that this approach does not fully meet the requirements of the adequacy. That is, of the three necessary conditions (neutrality, differentiation, embodiment), only two are directly fulfilled: the principles of neutrality and embodiment.

The first one is explicitly formulated at a metaphysical basis of GPST as a principle of indifference to metaphysical choice, when the nature of things (material or ideal), considered as a system, is of no importance.

The embodiment principle in GPST is realized through the combined interaction of two systems descriptors of three. To build a system model of an object you should pick up a concept, choose the appropriate structure which, in turn, will affect the substrate. But what can be said about the feedback from the substrate to the structure?

As there cannot be a system without a concept, in the same way there is no one without two others descriptors. For example, pure structural approach can proceed without explicitly stated elements [30]. This cannot be said about GPST. Nevertheless, the substrate descriptor alone doesn't have enough power to represent the principle of embodiment, because it is too 'passive' due to the double 'weight' of two other descriptors.

Let's consider an example with functionalism. Functionally speaking, the fact is that a given body (and the brain as a part of it, if it is present) is just another device for consciousness to function (on functionalism and its problems see [5, p. 111–12; 6; 28, p. 43–52]). From our point of view, functionalistic approach in general meets the requirement of neutrality, but fails to satisfy the embodiment principle, because the substrate plays the role of passive elements here, and only the relationship between them matters. To put it formally, if t stands for a human consciousness, A stands for any set of objects, and a – for some specific relations responsible for the emergence of human consciousness, then: $[a\ (*\iota A)] \rightarrow (\iota A)\ t$ – *some relations, realized on/in the brain, give us human-like conscious brain*.

From here functionalism takes its next step: $[\iota a\ (*A)] \rightarrow ([\iota a\ (A)])\ t$. This means that if we manage to realize some specific kind of relations on *any* thing A (from neurons to beer cans to silicon chips), we will get as its *definite* outcome t the same kind of consciousness on different substrates (A's in antecedent and in consequent aren't *ioted* and can differ from each other). This is one reason why functionalism is the metaphysical foundation of AI studies.

If take into account the principle of embodiment, the same relations, realized on different substrates are not likely to give us the same result, because matter matters (at least structurally). To put it symbolically: $[\iota a\ (*A)] \rightarrow ([\iota a\ (A)])\ a$, which means that some specific set of relations ιa, realized on any object A, gives as its outcome an object A in specific relations ιa, which have an indefinite property a (e.g., relations corresponding to the neural correlates of consciousness transferred to beer cans give us 'beer cans correlates of something', but doubtfully (if at all) consciousness).

There is much evidence that our body shapes our mind to the core by its form, structure or organization, and not just influences it by its material content (see, e.g., [14; 20; 24; 33; 41]). So, let's preliminary disclose the structure of the idea of the embodiment using TDL: $\{[\iota\iota a\ (*\iota A)]\rightarrow([\iota\iota a\ (\iota A)])\ t\}\bullet$

$\{ t \rightarrow (t) \{[(t)[\iota a(\iota A)]]\}\}\}$, where ι*A* represents some particular substrate that is organized by the structure ι*a*, which in turn, being realized on that substrate, is responsible for the emergence of a human-mind-like property *t*, that has as its *internal property* that substrate ι*A* with those relations ι*a* (on internal properties and relations in Uyemov's theory see [26; 36]). E.g., if we have some specific relations ι*a* between human brain-body and human eco-socio-cultural context ι*A*, then that brain-body in that context [ι*a* (ι*A*)] can generate human-like consciousness *t*, and if there is that consciousness *t*, then it is internally influenced by those specific elements and their relations to each other $(t)\{[(t)[\iota a(\iota A)]]\}$. With different body structures we would have different relations with our environmental context, and would have different minds, and of course, the brain alone is never enough for consciousness understood systemically [24].

So, for the proper realization of the embodiment principle in GPST we should use a twofold relation of the structure and the substrate of the system. Figuratively speaking, we are dealing not just with an 'in-formed matter' here, but more with a 'mattered form'. Thus, the principle of embodiment is expressible through the second order relation of systems descriptors, i.e., as an attributive system parameter that differentiates *substrate feedback systems* from those, which do not possess such property.

6.2. The principle of differentiation in GPST

As for the principle of differentiation, for obvious reasons (General (!) systems theory), it doesn't exist explicitly within the framework of GPST as a part of its meta-language. Nevertheless, the notion of concept as a system's descriptor can be traced back to different epistemological perspectives, because the concept always presupposes the point of view, the system of reference, but there is nothing about experiential modes here. And without the differentiation principle, experiential (qualitative) aspects of the mind cannot be distinguished in GPST framework from the very beginning. But actually, we don't need them from the very beginning. Because of its neutrality to metaphysical choice and of its intensional (qualitative) nature, GPST could be adequately enriched by some phenomenological or similar perspectivist interpretation from other frameworks. And with this understanding in mind, we can fulfill the requirement of all three necessary principles for a non-reductive study of consciousness at the object-language level. This can be demonstrated by a tentative systemic definition of consciousness.

6.3. Systemic definition of consciousness

How to define consciousness as a system? First of all, we need a main and general feature of it. What could it be? I hypothesize that the term *perspective modeling of reality or experience* can do the job. But let's consider it in an appropriate order.

We should begin with the intuitive explication of consciousness as *experience*. Here we can ask about the subject matter of this experience. Is it an experience of objective reality, or the experience of subjective 'reality', or maybe both of them? According to the principle of differentiation, we are to choose the third variant, i.e., the experience of subjective or/and objective reality. Principles of differentiation and embodiment lead us into distinguishing not just subjective and objective, but along with them the intersubjective (dialogical, cultural) perspectives which stem from corresponding ontic modes of experiences (cf., [4, p. 297–315; 7; 8; 20, p. 180–235; 25, p. 411–420; 27, p. 263–281; 32, p. 233–242; 42]).

To anticipate accusations of ontological dualism, ternarism, or even quadrolism of some sort, we should remember that here we act strictly under the regulative power of the principle of structural-ontological neutrality. Thus, these 'realities' or ontic modes of experience should be considered simply as structural modes of either one Reality, or, if you wish, three-four realities – it doesn't matter for now. We are not dealing with some sort of substances or essences of any kind, neither accept, nor deny the substantial aspects of essentialist views, if at all, we are looking at structural coherence of those views.

Anyway, the point is that there are many facts about consciousness mined from all these so called 'realities' (or different modes of the single Reality). For example, neuroscience, evolutionary biology, cognitive linguistics, philosophy of mind, cultural anthropology, logic, mathematics, cybernetics, psychology and psychiatry, computer science, physics, spiritual traditions of all sorts – to name just few – all of them give us more than enough empirical and theoretical data from different 'realities' to proceed with the definition.

Thus, the application of the principle of differentiation to the intuitive rendering of consciousness as experience tells us that the necessary condition for the emergence of consciousness is the ability of a system to make a distinction (create a perspective) between itself and everything else (cf., [19, p. 56–57; 27, p. 296]. Adding here the principle of embodiment, we get that this difference arises through different ways of experiencing: subjective (e.g., qualia, intentionality), intersubjective (e.g., language, cultural meaning, collective intentionality), objective (e.g., body, brain, material world); from which correlative epistemological points of view ultimately arise.

It is interesting in this context, that one of the main criteria of mental process, formulated by Gregory Bateson, was the ability of a system to draw the difference between its parts and between itself and other systems [1, p. 89–93]. What do conscious beings need this difference for? This differentiation is the basic instrument of their efficient functioning and/or survival, especially when the situation has some unknown variables in it. The differentiation is a necessary (but not sufficient) condition for *modeling*. Using the difference, a conscious system can explain or predict something in *reality*, i.e. to model it.

As evolutionary biology and neuroscience tell us, we need consciousness for modeling of possible exterior outcomes in a safe virtual mode of existence – in experiential subjectivity of our consciousness (see, [27; 31]). This subjective modeling of objective is needed for a prediction of what is about to happen, so that we can function in adequacy with our own survival. But as mathematics and logic, psychology and psychiatry, Husserl's phenomenology tell us (directly or indirectly), modeling can be not of only objective outcomes – it can involve higher-order modeling of modeling (ad infinitum) sometimes without direct connection to objective at all (e.g., mathematical or philosophical, or any pure theoretical reflection, introspection, meditation, imagination, hallucinations, dreaming) [21, p. 189–195]. In case of subjective aspect of consciousness, we are dealing both: with subjective modeling of something objective or with a higher-order subjective modeling of something subjective. There are others logical possibilities, e.g., objective modeling of subjective or even objective modeling of objective (as proposed by speculative realism).

Thus, we have a set of different approaches to consciousness from different disciplines from which we take our concept – *t*: subjective, objective, intersubjective epistemic structures of various sorts. The corresponding structure is expressed by relation of modeling, for example, objective experience through subjective experience. At last, the elements of a system (the substrate) are those objective and/or subjective experiences where, or through which consciousness as a whole is constituted or structured. Thus, we can define consciousness as a system with attributive concept and relational structure:

(4) ([*modeling* (**ontic experiences*)]) *epistemic perspectives*

Let's use the principle of duality to convert the attributive form into the relational one:

(5) *modeling* ([(*ontic experiences**) epistemic *perspectives*])

In our definitions, for the brevity sake, we do not include the feedback from the substrate.

The basic feature of consciousness is the property of modeling of ontic modes of experience in or through different epistemic perspectives. The formula with the relational concept represents, to some extent, a case of a complex (many-featured) approach to consciousness. We are dealing with almost 'raw' empirical data from different disciplines through which experience is modeled. These data must be organized in a proper systemic way. To do that, we assume that the basic property of consciousness is perspective modeling of experience. Using the principle of duality, we are able to give a systems non-reductive definition of consciousness *as modeling of ontic experiences (subjective, objective, intersubjective) through different epistemic perspectives (subjective, objective, intersubjective), which in turn are formed and structured by those ontic experiences*. Obviously, the last definition can be enlarged very quickly if we bother to use more structural details.

6.3.1. Two types of modeling and the system of consciousness

The appropriate question can be asked: what do I mean by 'modeling'? For the brevity sake, let's consider two wide types of modeling. There is an epistemic or E-modeling, and there is the ontic or O-modeling. The basis of the epistemological modeling is the analogy method, and it is needed when we have a target system which is more conveniently to study through its substitute (a model). The substitute represents the target system in some or other aspect. O-modeling happens when we are concerned more with the constitution or development or using of a model, then with the target system.

We can for a moment (for all time needed) forget that a model substitutes a target system, and deal with it as if it were the target system. O-modeling happens everywhere through our life, both ordinary and scientific. The simplest example is the use of language (e.g., natural or mathematical). Language models reality. It would suffice to say that we model or represent objects or situations with words, usually without thinking where a model or a target system is and how to gain information of one from another by an appropriate analogy; it would be very inconvenient to live without ontic mode of modeling.

Let's show what the definition of consciousness has to do with two types of modeling with the help of simple examples. First goes E-modeling. Everyone is familiar with the situation when one wants to know the other person's mind. What is she thinking about? Why is he so sad? Such and related questions mean that we want to have the access to the content of the person's subjective experience, subjective consciousness. How do we do that? We usually do it by analogy, or – as Husserl would put it – by "appresentative mirroring" [13, p. 149]. There are some objective facts, e.g., behavior (which is modeled in this case), and there is a subjective experience of a person (a target system), and we are modeling the latter with the former, i.e., we represent one with another. And we are doing this modeling by analogy with our own subjective experience, had we express it in such and such behavior. Schematically, the case when we encounter person's behavior can be put in this way:

modeling ([(*objective behavior, subjective experience**) *subjectivist analogy*])

And the case when we have made our mind about our interlocutor's inner life is described by an attributive systems model:

([*modeling* (**objective behavior, subjective experience*)]) *subjectivist analogy*

Imagine another situation when you need to predict what would happen if you encounter Mike Tyson in the ring. What are the odds of a victorious or at least not harmful outcome? Maybe it'd better not to meet at all? I.e., it's rather convenient to be able to 'rehearse' the harmful situation without any harm for the health in order to avoid it. The process of modeling in this example is slightly different regarding to the previous one: we are modeling or substituting objective situation by the subjective experience, using objectivistic epistemic perspective (how it would *really* happen):

modeling ([(*objective experience, subjective experience**) *objectivistic perspective*]), or in a dual systems form

([*modeling* (**objective experience, subjective experience*)]) *objectivistic perspective.*

Let's give two simple examples of O-modeling of a system of consciousness. First goes the concept of consciousness as a subjective experience. The attributive concept is *consciousness as subjective experience* is modeled through the specific relational structuring of intersubjective, objective and subjective experiences. I.e., the system's structure models the substrate (ontic experiences) in particular order in accordance with the given epistemic perspective. That particular order can be represented as the structure of epistemic perspectives that organizes ontic experiences into a cortege: <*basic subjective experience*, *intersubjective experience, objective experience, consciousness as subjectivity*>. Loosely speaking, this means that consciousness as subjectivity is a result of modeling of the primary ability to have subjective experience by the socio-cultural impacts on the brain-body within some eco-niche. In comparison, *consciousness as the objective experience* (e.g., neural correlates of consciousness) could be described as a result of modeling of objective ontic experience by an objective, intersubjective, and subjective experiences e.g.,: <*brain-body-eco-niche, population-culture, subjective experience, neural correlates of consciousness*>. And so on.

It is obvious, that in order to have a non-reductive definition of consciousness, we should not lose it conceptually, in the first place. In a non-reductive approach to consciousness we are not producing it from nothing, we assume some non-reducible conscious experience from the start [5; 6]; hence the category of primary experience (subjective, objective, intersubjective experiential modes), of which consciousness – in its different modes – is a higher level of systemic modeling.

6.4. Resume on the adequacy of TDL for the consciousness study

As we have seen, the embodiment principle or the 'voice of the substrate', represented through the attributive systems parameter of substrate feedback systems, shows us that epistemic perspectives stem from the structural aspects of ontic modes of experience (the substrate), in order to form or structure those modes of experience in accordance with the concept. As for the principle of differentiation, it can be used at the object language level, i.e., at the level of the interpretation of GPST framework. The latter is possible, first of all, due to the principle of neutrality and to the qualitative nature of GPST categorical framework. It turns out that even the meta-language lack of the principle of differentiation does not restrict GPST from an adequate non-reductive study of consciousness. GPST can be enriched with methodologies which have the principle of differentiation (or alike) in their framework from the beginning and are consistent with GPST. We assume that that role can be played by an approach based on the Husserl's transcendental phenomenology or some other possible frameworks (e.g., [8; 42]).

After completion of the systems definition of consciousness, we can proceed with the development of the 'logic' of system research by building a parametric model of consciousness, and continue with the search for systems patterns as a necessary part of the constituting of the non-reductive systems theory of consciousness.

7. Conclusion

The science of consciousness still waits for its hour to emerge from the 'metaphysical soil'. A possible way to start the development of such a science is to assume a system-theoretic framework for its construction, governed by several non-reductive principles. Three criteria or principles outlined in this work, I believe, will be helpful for those theoreticians who try to study consciousness non-reductively (without or with the use of any type or form of system approach). Question remains how far we can move in this direction and will it be enough to rely on the metatheoretic nature of systems science alone in order to create a science of consciousness. Without a doubt is that an adequate system approach, at least, can help make first comprehensive steps towards the goal without falling into one or other popular metaphysical trend.

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