

ON THE NOTIONS OF UNDERSTANDING AND INTELLIGENCE

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I. Introduction

In a previous paper I considered that "the condition of *significance* is obligatory for intelligence" [1]. Recently, Roger Penrose considers that intelligence requires *understanding*, and understanding requires *awareness* [2]. Certainly, Penrose is writing about human or natural intelligence. Besides, for him, artificial intelligence is an intelligent computational activity having still some understanding [3].

One of the main ideas of Roger Penrose, with which I fully agree, is that the mind has also non-computational processes. These play a very important role. Regarding the nature of the non-computational processes, in a frame of a structural-phenomenological (orthophysical) philosophy of science [4], one regards the non-computational phenomena as phenomenological. Concerning the denomination of "non-computational", I named it "non-formal". These two denominations, with respect to phenomenological processes, are equivalent. I shall use non-computational as equivalent with non-formal.

In this paper are presented some points of view regarding the notions of understanding and intelligence in the light of the above mentioned structural-phenomenological philosophy of science [4].

The notions of understanding and intelligence are considered with the aim of an enlarged theory of information rather than in the frame of psychology. For psychology, for instance, intelligence is mainly the capacity and ability to adapt to environment (of any type, physical or intellectual), by using mental processes and mental representations (images, propositions) [5]. This is, perhaps, perfectly acceptable with all the details presented by various specialists in psychology. But the problem is, as mentioned, to include the notions of understanding and intelligence in a framework of a general theory of information [6] which takes into consideration both the structural and structural-phenomenological realms of reality [7].

II. Points of Departure

Taking into account the orthophysical (structural-phenomenological) philosophy of science, the following points are to be considered :

1. All what is not living, in the universe, is structural.
2. All what is living, in the universe, is structural-phenomenological.
3. The phenomenological processes are not computational processes. They are non-formal.
4. The phenomenological sense is a fundamental phenomenon of nature.
5. The mental sense is a phenomenological sense.
6. A mental process is a structural-phenomenological interaction in a living object.
7. Understanding may be of three types :
 - a. structural-phenomenological, which is called *meaning*.
 - b. structural, which is called *significance* and is a formal understanding.
 - c. phenomenological, that is a phenomenological understanding, which is a phenomenological sense.
8. Intelligence is mainly an informational processor with memory and some form of understanding (significance or meaning).

Understanding, in its most general form, may be written [8] :

$$\mathbf{M} = \langle \mathbf{G}, \sigma \rangle \quad (1)$$

where,

G is the significance;

σ is the corresponding phenomenological sense.

The understanding (1) is, in fact, a meaning.

The significance is [9],

$$\mathbf{G} = \langle \mathbf{C}, \mathbf{R} \rangle \quad (2)$$

where,

C is the context significance;

R is the reference;

Both **C** and **R** are parts of an informational structure **S** ,

$$\mathbf{C} \subset \mathbf{S} ; \mathbf{R} \subset \mathbf{S} \quad (3)$$

and then,

$$\mathbf{G} \subset \mathbf{S} \quad (4)$$

The phenomenological sense is a physical sensibility of a supposed physical substance, *informatter* [10], which is considered to be a fundamental physical ingredient of nature, without interacting through forces (or by exchange of virtual structural particles) with the structures of the universe, otherwise using other properties. The sensibility of informatter manifests itself a phenomenological information, that is as a phenomenological sense.

A phenomenological sense may be *generated* in informatter by a specific type of physical fluctuation, from itself, or may be *induced* by an interaction with a structure in an organism. These processes are not computational, but physical and informational at the same time.

III. On awareness

The notion of awareness is not well defined. Could it be?

To be aware means to be: 1. informed; 2. conscious; 3. alert. "To be informed" applies both to structural and structural-phenomenological objects. "To be conscious" may be applied to the both above types of objects. A formal consciousness can be presented by a structural artificial intelligence. The humans have a mental consciousness. "To be alert" applies to humans and perhaps to animals. An advanced robot may be prompt, that is to act without delay. Alertness is sooner related to awareness, and in such a case awareness is a property of living objects. Awareness is rather a feeling, a sense related to human consciousness [11]. In general, a structural object cannot have awareness. But awareness is not exactly consciousness. It is a component of human consciousness and of human understanding.

An artificial (formal) consciousness which can be informed and intelligent, but not alert, is a *non-aware form of consciousness*. In fact, this form of consciousness is rather a preconscious or a subconscious form.

For an *aware consciousness*, which today is a natural consciousness, but in the future may be also and an artificial consciousness, it would be better to use, when the

deepest phenomenological sense of a human being is participating in it, a special word, as for instance,

aware **consciousness** -----> **conscousness**.

Now, we are in a situation to analyze more deeply the notion of awareness.

Awareness is a physical-informational phenomenon which sustains consciousness. Awareness is mainly, but not only, a phenomenological sense. It implies informatter, and is partly but mainly a process in informatter. It is non-computational. It is non-formal. But it is always related to the informational structures of consciousness.

Awareness contains a phenomenological sense related strongly to some structures of aware consciousness.

In informatter, not coupled with a structure, there are phenomenological senses from itself. For instance, we can speculate and imagine that there is a general background sense << to exist >> which may be seen as a semantic law [12] that enassures the unity of the entire existence. We can speculate further and imagine that this sense, as a semantic law of existence, has three components, in order to explain the action of existence: << to exist in itself >> , << to exist from itself >> and << to exist into itself >> [13].

In informatter, coupled in a living object with a structure, the degree of coupling may be more or less strong, or more or less weak. The coupling of structures by physical forces may be stronger or weaker. The coupling of specific structures with informatter without implying forces may be stronger in awareness than in the case of the coupling of that structure with the deep sense << to exist from itself >>. Perhaps a coupling of a structure, like that of a man, with the deep sense << to exist in itself >> is not at all possible (we do not take into consideration the mystic experience), but a weak coupling with the deep senses << to exist from itself >> we believe it is possible. I have shown that a "philosophical" experiment of aware consciousness (conscousness) is possible. This phenomenon may be experienced [14]. The result of this experience is, in a way, something deeper than awareness, that I named << beingness >>. This is, of course, a phenomenological sense, not easy to be reached, but fundamental as a mental process. It is a point of reference for all mental processes that constitute the complexity of a mind [15]. The mental sense << beingness >> may be or not related to the deep sense << to exist in itself >>, although we believe it is. But we think that this sense is real.

Beingness is not the awareness for understanding and is not knowledge.

In [4a] I considered awareness (as an English term) to be the same with consceousness. I wrote:

"But awareness (please read aware consciousness or consceousness) experiment showed us that beingness is a psychological contact phenomenon. On the one hand it is unconscious as a physical phenomenon in itself, on the other hand it becomes conscious by the simultaneous triggering of some psychological and surely neuropsychological phenomena. **Consceousness envelops beingness and psychological aspects as a whole...**" [16]

Due to psychological effects, the beingness, which is otherwise unconscious, becomes consceous. But,

"**Beingness** has a specific role, it is neither **thought** nor spirit. Beingness is that giving man properties above machine and automaton" [17].

Beingness with psychological effects is awareness. Therefore, awareness is more complex than beingness. Awareness is consceousness with beingness. *Awareness is structural-phenomenological. Beingness is only phenomenological.* Awareness is essential for mental understanding.

There are more to be said about such phenomena [15] because one may introduce a secondary, or operational beingness

<< **beingness ' >>**

which is also a phenomenological sense which replaces the fundamental sense

<< **beingness >>**

in the usual activities of the mind. One may say that << beingness ' >> is easier to be triggered by the neural structure initially determined by << beingness >>. If awareness is a consequence of <<beingness>>, <<beingness ` >> is a consequence of awareness. And << beingness ` >> is then replacing << beingness >> in the phenomenon of awareness. Beingness is a rare phenomenon, an originator, and is replaced by a more usual operational beingness [15]. Therefore, the following scheme may be presented :

<< to exist in itself >> →→→ << beingness >> in an organism →→→
→→→
→→→ awareness →→→ the consolidated structures involved in this structural-phenomenological process of awareness may generate →→→ << beingness '
>> →→→ used with the above consolidated structures to create again an awareness.

There are many forms of awareness, all of them containing a beingness. At its turn, awareness is a process that takes part in most of conscious activities of the mind.

IV. On understanding, computability and non-computability

From [13a] and [6a] are derived the following propositions and considerations :

9. Any object (structure, organization [18]) with *understanding* and behaviour is a *psyche* [19].
10. A psyche may be informatic (computational, formal, with significance) [20], or mental (structural-phenomenological, with meaning, and which is partly non-computational).
11. A psyche is a semantic informational processor [21] with input(s) and output(s).
12. The informatic psyche is a semantic automaton [22].
13. The psyche may be with an ego or without an ego.
14. *Ego (self)* is a *privileged understanding*, or a couple informational processor-privileged understanding [23]. It may be informatic or mental.
15. The usual semantic automata (artificial intelligence, expert systems, intelligent robots) have an informatic psyche without an ego(self), and have a form of consciousness that may be named *preconscious* [24].

16. The semantic automaton with an informatic ego(self) has a form of consciousness that may be named subconscious [25].

17. The PSYCHE is, in general,

$$\mathbf{P} = \langle \Pi, \mathbf{M}, \varepsilon \rangle \quad (5)$$

where,

Π - is the informational processor ;

\mathbf{M} - is the understanding ;

ε - is the ego(self) .

The informational processor of a psyche is of the form,

$$\Pi = \langle \mathbf{input/output}, \Pi_{\text{internal}} \rangle \quad (6)$$

18. The mental psyche is [26] ,

$$\mathbf{P} = \langle \Pi, \mathbf{M}, \varepsilon \rangle \quad (7)$$

where,

$$\Pi = \langle \mathbf{S}, \sigma, \Delta, \mathbf{K}, \eta, \gamma, \Theta, \rho \rangle \quad (8)$$

In this expression,

\mathbf{S} - is the structure which has the significance form of understanding;

σ - are the phenomenological senses corresponding to the structure \mathbf{S} ;

Δ - the disposability for new phenomenological senses (it represents, in fact,informatter, as a constituent of Π ;

\mathbf{K} - is a formal heuristic operator (it produces new structures by heuristics, in the frame of some given procedures).

There are also a few purely phenomenological operators (non-computational phenomenological operators) like,

Π - which is an "inductor" (a heuristic phenomenological operator which produces new phenomenological senses by a sort of induction, beginning from the former phenomenological senses);

Υ - a phenomenological "generator" which produces new phenomenological senses by self-generation in informant.

The structural-phenomenological operators Θ and Ψ have the following meanings :

Θ - is an "adequator" which reestablishes the correspondence between the structure and the phenomenological sense of the psyche;

Ψ - is a regulator of the creative activity of the psyche.

The ego ε is a privileged meaning ,

$$\varepsilon = \langle \mathbf{M}_e \rangle \quad (9)$$

or even a privileged couple processor-meaning,

$$\varepsilon = \langle \Pi_e, \mathbf{M}_e \rangle \quad (10)$$

How does awareness participate in understanding? Considering the expression (1) of understanding (meaning, for humans), repeated here,

$$\mathbf{M} = \langle \mathbf{G}, \sigma \rangle \quad (11)$$

and taking into account the notion of awareness exposed in the previous paragraph, a sample of awareness w_k is the couple,

$$\mathbf{w}_k = (\mathbf{G}_k, \sigma_k) \quad (12)$$

where \mathbf{G}_k is the significance and σ_k is the corresponding phenomenological sense.

Awareness \mathbf{w}_k is itself a piece of understanding (meanings, as mentioned above). The set of all awarenesses,

$$\mathbf{w} = \{ \mathbf{w} \} \quad (13)$$

is, in fact, the general understanding,

$$\mathbf{M} = \{ (\mathbf{G}_k, \mathbf{w}_k) \} = \langle \mathbf{G}, \sigma \rangle \quad (14)$$

Awareness and understanding(meaning) may still be not conscious, or, sooner, may be only a form of consciousness, a structural-phenomenological subconsciousness [27].

Although it is objective, the awareness has also a subjective character or qualia. This double subjective-objective quality was denominated as subjectivity (which is different from subjectivity) [28].

The philosophical experiment of aware consciousness (conscience) [16] has three moments. The first was described in the previous paragraph : <<beingness>> as a phenomenological sense. To this will correspond a neural structure "to be" in the

brain. This a second moment. Together, << beingness >> and "to be" constitute an awareness of this experiment, an awareness of self-existence. The third moment fulfills a *self-consciousness* and is a result of an automatic comparison of <<beingness>> and "to be", comparison that produces a neural structure "to know". These three components constitutes the primary self-consciousness,

$$\Phi = \langle \textcircled{1}, \textcircled{2}, \textcircled{3} \rangle \quad (15)$$

where,

①- is the phenomenological sense <<beingness>> ;

②- is the neural structure "to be" ;

③- is the neural structure "to know".

Without the phenomenological sense, theoretically, $\langle \textcircled{2}, \textcircled{3} \rangle$ is a form of structural consciousness, a formal non-aware consciousness. But there is more. The neural structure, as was shown in the previous paragraph, may produce a secondary phenomenological sense <<beingness'>> (①') which is more operational. And "to know" naturally will produce a phenomenological sense << to know >> (④). Then, self-consciousness may also have the following organizations :

$$\Phi' = \langle \textcircled{1}', \textcircled{2}, \textcircled{3} \rangle \quad (16)$$

$$\Phi'' = \langle \textcircled{1}', \textcircled{2}, \textcircled{3}, \textcircled{4} \rangle \quad (17)$$

All these are possible modes of functioning of self-consciousness. These are also forms of awareness. Indeed, self-consciousness is a form of awareness, but awareness is not (only) consciousness. Awareness is more general.

All these modes of manifestations of self-consciousness are essentially non-computational phenomena. Self-consciousness is almost a non-computational process.

V. Intelligence, significance and meaning

Intelligence, shortly defined, is an informational processor with understanding, and mainly and always with significance, that produces new information to adapt the object in which it is a part to the environment.

For intelligence the most important aspect is understanding, and specifically, significance. Awareness is participating in intelligence only in the case of structural-phenomenological processors, that is in the case of mental processors.

Not all the structural-phenomenological processors are intelligent. Only those which have significance, i.e. enough informational structures to accommodate significance.

A living molecule may have structural-phenomenological processes, but not intelligence because it has not sufficient and convenient structures to process (compute) information. Intelligence is not possible without computation, and intelligence is not possible without signification. A living molecule may still have a form of consciousness, but this is another problem.

A biological cell may have some intelligence if one considers after Hameroff [29] [30] that the microfibers of tubuline in a cell constitute an intracellular nervous system, or a computing system.

Structural intelligence, like artificial non-alive intelligence (AI) is an informational processor with significance.

The general expression (6) of an informational processor is also applicable to an intelligent informational processor, therefore intelligence \mathfrak{I} may be written,

$$\mathfrak{I} = \langle \text{input/output} , \Pi_{\text{intern}} \rangle \quad (18)$$

In this expression, both input/output and Π_{intern} may be intelligent. For simplicity we shall consider that only Π_{intern} is intelligent.

A structural intelligent informational processor is a semantic automaton [31]. If the information of a syntactic automaton is $N = \langle S \rangle$ where S is the structural information. The information of a semantic automaton may be written,

$$N = \langle S , G \rangle \quad (19)$$

where G is the significance ($G \subset S$). N comprises both memory and programs of algorithmic processing (computing). The structural intelligence may be written as,

$$\mathfrak{I} = \langle \text{input/output} , S , G , \tau \rangle \quad (20)$$

where τ is the time or the clock of the computing processor.

Because [32],

$$\text{input/output} = \langle \lambda , \psi \rangle \quad (21)$$

where,

λ - is an input word or text,
 Ψ - is the output word or text,
(20) becomes,

$$\mathfrak{S} = \langle \lambda, \Psi, \mathbf{S}, \mathbf{G}, \tau \rangle \quad (22)$$

If

$$\lambda \in \Sigma^* \text{ and } \Psi \in \Gamma^* \quad (23)$$

where Σ^* and Γ^* are all the words and texts on the input and output alphabets Σ and Γ , then the semantic automaton produces at least the function (for more structural details and functions see [31]),

$$\mathbf{D} : \Sigma^* \rightarrow \Gamma^* \quad (24)$$

If λ is a word or text with significance and Ψ is also a word or text with significance, then the function \mathbf{D} is an *intelligent function*. Of course, in order to produce an intelligent answer, to solve a problem, for instance, the expression (22) of the structural intelligence must be detailed to comprise changes of the internal memory, the resolutive system and others [31]. What is important is that the semantic automaton admits an input language with significance $\mathbf{A} \subset \Sigma^*$, and an output language with significance $\mathbf{B} \subset \Gamma^*$, and the languages A and B with significance are *intelligent languages*. Sometimes, $\mathbf{A} = \mathbf{B}$, as may be the case for a formal restriction of the natural language. The natural language is structural-phenomenological, it is a mental processor, and it is intelligent.

An intelligent structural (formal) language can be recognized by a semantic automaton. A semantic automaton (intelligent automaton) manipulates intelligent languages, that is languages with signification.

A formal language is a set, therefore an intelligent structural language is an intelligent set.

A structural-phenomenological informational processor, as we have seen, must have significance in order to be intelligent. In such a case its intelligence may be written,

$$\mathfrak{S}_h = \langle \mathfrak{S}, \sigma, \eta, \theta, \dots \rangle \quad (25)$$

where \mathfrak{S} is the structural part of the intelligence, as above, and σ are the phenomenological senses, η is the "inductor" operator, and θ is the "adequator" operator. *The functioning of this intelligence depends mainly and mostly on \mathfrak{S}* , but

still η and θ may intervene in some important ways in the process of intelligence \mathfrak{S}_h which is partly non-computational.

It may be shown that mental(structural-phenomenological) intelligence has to deal also with the continuum, having also an intelligence of the continuum. This is possible only by using phenomenological senses [33] together with the rest of the "machinery" of intelligence.

VI. Final Remarks

Related to the notion of intelligence are those of intellect and reason. To the author of this paper, the difference between structural and structural-phenomenological objects (informational processors) seems to be relevant for a better description of these notions.

In which frame to put, for instance, intuition and creativity? In the frame of intelligence? Of course, not. In the frame of reason? May be, because reason has a connection with intelligence, being at the same time larger than intelligence.

Intuition may be a part of creativity, or a form of creativity. Reason may be then creativity + intelligence (or a part of intelligence).

Perception is related to sensation, but also to intelligence. Is perception a part of intelligence ? Partly it seems that it is.

I would like to mention that a strong structural-phenomenological tendency to explain mind and consciousness is also manifested in a recent work of David Chalmers [34] [35]. Will a structural-phenomenological theory be a way for a future science of mind and consciousness, and perhaps for the entire science? I am not quite sure, although I do not see, for the time being, other promising solution than a structural-phenomenological one.

Notes and References

1. Mihai Drăgănescu, *Information, Heuristics, Creation*, Artificial Intelligence and information-Control Systems of Robots, I. Plander(editor),Elsevier Science Publishers B.V. (North Holland),1984,p.25-29.

2. Roger Penrose, *Shadows of the mind-search for the missing science of consciousness*, New York, Oxford University Press, 1994, p.37-39 (paperback edition 1996).

3. Idem.

4. Mihai Drăgănescu, Profunzimele lumii materiale (in Romanian), Bucharest, Editura Politica, 1979, with an English translation (a) *The Depths of Existence*, preprint 1992, to be published on the Web*, 1997.

Other books of the same author:

-(b) *Ortofizica* (in Romanian), Bucuresti, Editura stiintifica si enciclopedica, 456 p., 1985**;

-(c) *Informatia materiei* (in Romanian), Bucuresti, Editura Academiei, 253 pag., 1990;

-(d) *Eseuri* (in Romanian), Bucuresti, Editura Academiei, 302 pag., 1993;

-(e) *L'Universalité ontologique de l'information* (Ontological Universality of Information), Préface et notes par Yves Kodratoff, prof., Université de Paris-Sud, Bucharest, Editura Academiei, 1996* (also on the INTERNET, <http://www.racai.ro/books/draganescu>).

5. Robert J. Sternberg, *Human Intelligence*, The New Encyclopaedia Britannica, 1994, vol.21, p.775-781.

6. Elements for such a general theory of information are presented in [1], [4b], and in the volume [6a] Mihai Drăgănescu a.o., *Electronica Functionala* (in Romanian **), Bucuresti, Editura Tehnica, 1991.

7. Mihai Drăgănescu, *Sur la notion et le domaine de la Vie Artificielle* (On the notion and the domain of artificial life), Bulletin de la Classe des Sciences, Academie Royale de Belgique, 6e serie, Tome VI, No. 7-12, 1995, 13 pages.

8. See [1], p. 26.

9. The theoretical elements presented in this paragraph are an extension [1] of a semantic theory of Mario Bunge (*Treatise on basic philosophy*, vol.I and II, D. Reidel Publishing Company, Dordrecht-Holland, 1974). The extension was necessary because of the structural-phenomenological nature of human semantic phenomena in comparison with only a structural vision of these processes.

10. See [4a] and [4b].

11. See [4a], Ch. 8.

12. The idea of semantic laws was taken from Robert Rosen (1988) from Dalhousie University, Canada. This idea is compatible with the points of view of the author [4] and, in fact, many deep phenomenological senses of informmatter are semantic laws.

13. See [4b], Ch. 3, **Orthosenses**, or in the volume [13a] Mihai Drăgănescu, *Inelul lumii materiale* (in Romanian, a second edition of the volumes [4a] and [4b]), Bucharest, Editura Stiintifica si Enciclopedica, 1989.

14. See [4a].

15. See [4d] and also Mihai Drăgănescu, *The philosophical tension and the cosmic feeling* (In English), Bucuresti, Editura Academiei, 32 pag., 1991.

16. Mihai Drăgănescu, *The Depths of Existence*, preprint 1992, p.113 (Also on the web*). It is an English translation with minor changes of [4a].

17. Idem, p.130.

18. In the frame of the structural science, structure and organization are identical, but not for a structural-phenomenological vision. In the latter case, an organization may contain structural and phenomenological elements ([6a] p.91). Organization is more general than structure. It can be structural-phenomenological. The structure is formal, or computational. The organization is formal-nonformal, containing a noncomputational part. Without phenomenological elements the organization is a structure.

19. See [13a], p.410 and [6a], p.333.

20. N.A.Schmajuk, *The psychology of robots*, Proceedings of the I.E.E.E., Vol. 84, No. 10, october 1996, p.1553-1561.

21. The informational processors may be of some types: a) algorithmic (computational); b) mental (computational and non-computational at the same time); c) phenomenological (non-computational).

22. See [6a], p.327-333.

23. See [13a], p.409.

24. See [6a], p.333 and also [4e], ch.8 (**La pensée et la conscience des automates**).

25. Idem.

26. See [13a], p.408-410.

27. See [6a], p.401.

28. The term subjectivity was introduced by the romanian philosopher Constantin Noica in a paper about the volume [4b]. After C. Noica, subjectivity means the general objectivity of the subject.

29. Stuart R. Hameroff, Steen Rasmussen, *Information Processing in Microtubules: Biomolecular Automata and Nanocomputers*, Preprint, Advanced Biotechnology, University of Arizona Health Sciences Center, 1988; and Stuart R. Hameroff, Steen Rasmussen, Bengt Mansson, *Molecular Automata in Microtubules, Basic Computational Logic of the Living State?* Preprint, 1988.

30. In [4e],Ch.7, **Ingénierie moléculaire et intelligence artificielle.**

31. See in [13a], p.327-333.

32. Idem.

33. See [13a], p.334-340.

34. David J. Chalmers, *The Puzzle of Conscious Experience*, Scientific American, December 1995, p.62-68.

35. David J. Chalmers, *The Conscious Mind: In Search of a Fundamental Theory*, Oxford University Press, New York, Oxford, 1996.

*The author's URL on the web is

<http://www.racai.ro/~ncristin/MD-Web/mdraganescu.html>

where this book or paper may be read.

** The contents (in English) may be seen ,as above, on the web.

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