COMMUNITY AND SOCIAL FACTORS FOR THE INTEGRATIVE SCIENCE

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To develop the new paradigm of integrative science focusing on the structural-phenomenological phenomena, it is proposed to incorporate the newly discovered networks (small world, scale-free) by Watts and Strogatz and Barabási as generalized categories to be considered for all domains of reality. The new categorial framework of Struppa, Kato, Drăgănescu, Kafatos, and Roy, and the new network framework, together, may offer an intellectual horizon for fully developing the integrative science which was previously introduced by the authors of this paper. It is shown that the new networks may be as important for the phenomenological domains as for the structural domains.

1. INTRODUCTION

In a previous paper, "Generalized Foundational Principles in the Philosophy of Science" [1], we presented a series of primordial elements for a structural-phenomenological ontology: orthoenergy, fundamental phenomenological information, *cronos* and Fundamental Consciousness of Existence. These are taken to form the first level of existence (Fig. 1). A second level, generated by the first, follows it.

First level	**Orthoenergy,** **Primordial information (informatter),** **Cronos,** **Fundamental Consciousness**
Second level	**Phenomenological categories** **(Clusters of othosenses)**
Third level	**Worlds (in a vast universe)** **quanta (of space and particles)** **time, arrow of time** **energy, information** **bodies and minds**
Fourth level	**Group, community and social networks**

Fig. 1

The second level is formed by phenomenological categories [2]. The third level corresponds to the various worlds which form a vast universe. These "worlds", for example, would consist of isolated regions in space-time with different bulk properties (*e.g.* matter, antimatter worlds; separated and only in contact through black holes, etc.). Our own "local" universe of ~10^{10} light years may be one of these worlds. They contain structural-phenomenological objects. The fourth level corresponds to community and social organizations, for which, perhaps, the most interesting and important configuration is that of network.

These levels are presented here in a separate manner only to designate the main domains of an integrative ontological description of existence. The fourth level, for instance, may comprise networks of phenomenological aspects of the second level, or networks of structural objects of a world in the third level, or of the structural-phenomenological objects, etc.

Social organizations refer to human, animal and perhaps other organisms, in which the living entities are *nodes* and relations between them are *links*. Social organizations are evidently community *structures* if we consider only the structural properties of the component entities and of their relations.

Community structures are also found inside a biological cell (the nodes being biological molecules, mitochondria, etc. and the links chemical reactions between them). The Internet is also a community structure of servers and computers as nodes, and communications lines as links [3].

The most important community structures, y compris for social organizations, are assuming the form of networks. Networks appear in a natural way, and this is a phenomenon of great generality [4], [5], chiefly characterizing self-organization, another specific phenomenon of nature.

2. COMMUNITY AND SOCIAL FACTORS IN THE COGNITIVE PROCESSES

In a previous work on the integrative cognitive science [6], two ways of understanding this new science were described:

a) ways to describe human mind cognition, even if explaining human cognition, one needs models of information processing by computers and of neural electronic networks;
b) a general science of cognition not only for the human mind, but also for animals, for artificial intelligence, for ensembles men-computers-Internet, and also for social organizations like institutions, enterprises and even entire societies at macro-social levels.

It may be observed that both in cases (a) and (b), the cognitive science framework used today is the structural science and not the structural-phenomenological integrative science, or, simply, the integrative science [7]. General cognitive science (b), even in the usual framework of the structural science, has not been sufficiently developed.

It is known today that structural science is insufficient and perhaps fundamentally incomplete to explain all levels of reality, y compris mind and consciousness (John Eccles, David Bohm, Mihai Drăgănescu, Menas Kafatos and others). This assertion became an important scientific truth proven in the last 15 years of the XXth century.

It is important to emphasize that cognitive processes are inherently information processes. Cognition may be a structural process or more likely a structural-phenomenological process. Cognition is a property of objects with *psyche, mind, and consciousness* [7].

Structural objects may have conscious-like processes (or intelligence) (as is the case for artificial intelligence systems) and not only the objects with mind and consciousness. The essential properties of an intelligence (structural or structural-phenomenological) are *understanding* and *behavior* [8], [9]. The intelligence of a mind or consciousness is deeper and requires understanding of its phenomenological properties. Networks of structural intelligence (intelligent agents and intelligent robots) and human minds might become essential for the process of cognition and the constitution of networks of knowledge at the global level of mankind [10].

In [6], cognitive science was defined as the science of intelligence, mental or non-mental, individual or social. The community and social factors of the cognition process, in the most general sense, are fundamental for both individual and social cognition.

3. GENERAL PARAMETERS OF THE NETWORKS

There are numerous examples of networks that justify the generality, importance and specificity of this form of reality [4], [3], [5]:

Social:
- acquaintance networks
- partnership networks (for instance, among scientists)
- social webs of innovations

Technical:
- Internet
- World Wide Web
- power grids

Biological:
- metabolic networks (the cell as a network)
- neuronic networks
- ecological food webs

Economic:
- tree networks (hierarchical organizations of organizations)
- web organization in the institutions of the new economy (the value being in ideas and information)
- leaders networks
- the entire economy is a complex network (companies, the government, other economic players are nodes, and various economic and financial ties are links)
- global economic network.

A useful observation at this moment is to consider a network as a mathematical category, and therefore to combine 'network thinking' with 'categorial thinking'. Networks as categories are considered in Lawvere's work [11].

The first model of network was 'the random graph' introduced by Roy Solomonoff and Anatol Rapoport [12] and also by Paul Erdös and Alfréd Rényi [13].

In a random network, or random graph, the nodes are connected at random with other nodes. Although random graph theory was elegant and simple and Erdös believed it corresponded to fundamental truth, reality assumed as a network by present science is not random. The established links between the nodes of various domains of reality are following fundamental laws of nature or psychological or social forces in the case of social communities. It is true, some random links still may be established, and they may play a non-negligible role, but randomness is not the main feature of a network.

For an ensemble of nodes, if each node has an average of one link, the network becomes a cluster. If the nodes have an average less than one link per node, the given ensemble of nodes breaks into tiny nonlinked clusters.

An important parameter to describe a given network is then the *average degree of a node,* that is the average number of links it has with other nodes [3].

Another important parameter is *the average degree of separation,* that is the average number of links from any node to any other node in the network. It is perhaps surprising to notice that, for instance, in the entire human society, the average degree of separation between two persons is, after Milgram [14], equal to 5.5 or roughly 6. Between two persons (nodes) in the society of USA, as demonstrated by Milgram, there are *six degrees of separation.* This seems to be a global social property and it is perhaps interesting to mention that in 1929, the writer Frigyes Karinthy in a story 'Chains' [15] had the insight to write that any two persons, from one and half billion inhabitants of the world at that time, are separated only by five acquaintances (five links).

After Milgram's discovery, it was observed that almost all natural or artificial networks (technological networks) do not have a high average degree of separation (3 for molecules in a cell, 10 for Internet routers, 2 for food webs, 19 in the case of the web (www) nodes in 1998 [16]). *Consequently a general property of networks is to be* ***small worlds****, or that the average distance between nodes is short* [17].

Sometimes, the average distance between nodes is termed the *diameter of the network.*

Barabási comments on this situation as follows:

> "Small worlds' are a generic property of networks in general. Short separation is not a mystery of our society or something peculiar about the Web: most networks around us obey it. It is rooted in their structure – it simply doesn't take many links for me to reach a huge number of Web pages or friends. The resulting small worlds are

> rather different from the Euclidean world to which we are accustomed and in which distances are measured in miles. Our ability to reach people has less and less to do with the physical distance between us. Discovering common acquaintances with perfect strangers on worldwide trips repeatedly reminds us that some people on the other side of the planet are often closer along the social network than people living next door. Navigating this non-Euclidean world repeatedly tricks our intuition and reminds us that there is a new geometry out there that we need to master in order to make sense of the complex world around us." [18]

A third important parameter for a network is the *clustering coefficient* C, first used by Watts and Strogatz [19], [20]. If C=1, the graph is fully connected (every node is connected to every other node). In general [19],

C= {3 x (number of triangles of nodes on the graph)} / (number of connected triples of nodes) (1)

where a triangle of nodes in society means, for instance, that 'two of one's friends are friends themselves' and the denominator expresses the existing connections between triples of nodes. In many real networks, C has values between 0,1 and 0,5 [3].

Following the work of Watts and Strogatz [19],

> "An explosion of further work by other mathematicians, physicists, and computer scientists has turned up profoundly similar structures in many of the world's other networks. Social networks turn out to be nearly identical in their architecture to the World Wide Web, the network of Web pages connected by hypertext links. Each of these networks shares deep structural properties with the food webs of any ecosystem and with the network of business links underlying any nation's economic activity. Incredibly, all these networks possess precisely the same organisation as the network of connected neurones in the human brain and the network of interacting molecules that underlies the living cell." [5, p. 15]

Considering the special properties of small world networks, Barabási observes:

> "The natural question is: Why? How do networks achieve such a uniformly short path despite consisting of millions of nodes? The answer lies in the highly interconnected nature of these networks. In the previous chapter, we saw that random networks require only one link per node to form a giant cluster. The question is, what if, as usually happens in real networks, nodes have many more links than that? At the critical point when the average connectivity is around one per node, the separation between nodes could be rather large. But as we add more links, the distance between the nodes suddenly collapses. Consider a network in which the nodes have on average k links. This means that from a typical node we can reach k other nodes with one step. There are, however, k^2 nodes two links away and roughly k^d nodes exactly d links away.
>
> Therefore, if k is large, for even small values of d the number of nodes you can reach can become very large. Within a few steps you have reached all nodes to be found, which explains why the average separation is so short in most networks.
>
> These arguments can be easily turned into a mathematical formula that predicts the separation in a random network as a function of the number of nodes. (If we have N nodes in the network, k^d must not exceed N. Thus, using $k^d = N$, we obtain a simple

formula that works well for random networks, telling us that the average separation follows the equation d = log N/log k).

The origin of the small separation is a logarithmic term present in the formula. Indeed, the logarithm of even a very large number is rather small. The ten-based logarithm of a billion is only nine. For example, if we have two networks, both with an average of ten links per node, but one 100 times larger than the other, the separation of the larger net will be only two degrees higher than the separation of the smaller one. The logarithm shrinks the huge networks, creating the small worlds around us." [21]

4. STATISTICAL LAWS OF THE NETWORKS

Real networks are not random. In a random network, the distribution of the number of nodes n with the number of links k is a bell curve (Fig. 2) which shows that most of the nodes have almost the same number of links. Only very few have a high number of links, and in any case there are no nodes with a very large number of links [4].

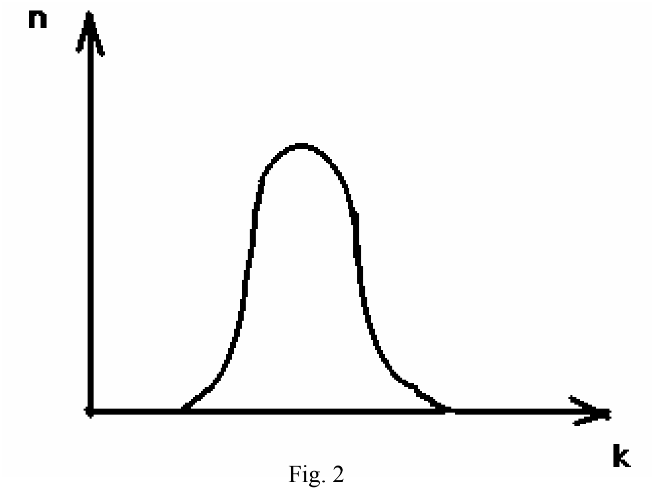


Fig. 2

Another type of network was described by Granovetter [22] in a paper considered "one of the most influential sociology paper ever written" [4, p. 42], in which the social world is seen as formed of *clusters* with internal strong ties (a great number of links among the nodes of the cluster), the clusters being connected by one or a few links (weak ties) as shown in Fig. 3 (after [3]). Strong ties are forming clusters and weak ties are binding different clusters.

The importance of Granovetter's work lies in the discovery of the role of weak ties in a social network. *The crucial links in society are the weak links between people*. Buchanan observed:

> "This link is a social bridge, a crucial connection that binds a portion of the social fabric together. Granovetter's ultimate point is subtle but extremely important. Because bridges are so effective in tying social networks together, we might suppose that they would be strong links – ties between good friends, for example. But as we have seen, strong links are never important in this way. They can be erased without much effect. The truth is just the opposite: bridges *are almost always formed from weak links*. By deftly wielding the knife of elementary logic, Granovetter was able to reach a surprising conclusion: weak links are often of greater importance than strong links because they act as the crucial ties that sew the social network together, These are the social 'shortcuts' that if eliminated, would cause the network to fall to pieces." [5, p. 44]

Such a structure was termed by Girvan and Neumann [3] a ***community structure.*** It is a community of clusters with ties among them:

> "Certainly it is possible that the communities themselves also join together to form metacommunities, and that those metacommunities are themselves joined together, and so on in a hierarchical fashion. [...] The ability to detect community structure in a network could clearly have practical applications. Communities in a social network might represent real social groupings, perhaps by interest or background; communities in a citation network might represent related papers on a single topic; communities in a metabolic network might represent cycles and other functional groupings; communities on the web might represent pages on related topics. Being able to identify these communities could help us to understand and exploit these networks more effectively." [3, p. 7821]

Such networks are found not only in society, but also in biology and other domains. They are very far from being random networks.

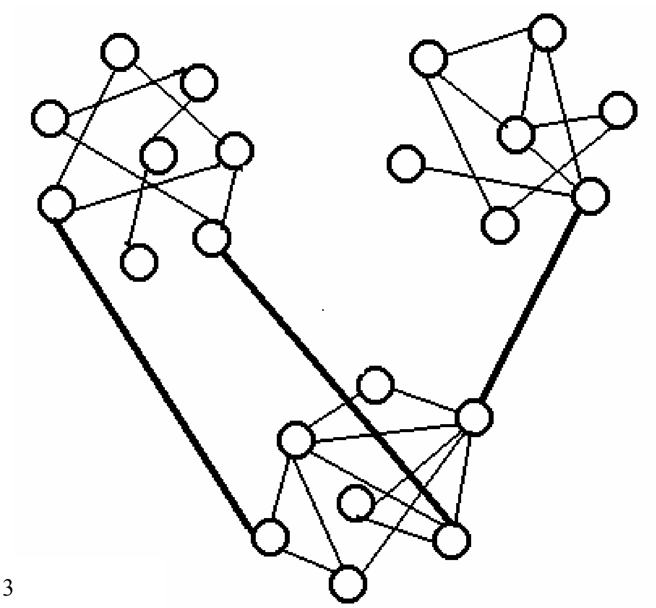


Fig. 3

Another important step in understanding networks was done by studying the World Wide Web. It was discovered that in real networks, there are nodes with an extraordinary number of links. These nodes are called hubs. They are present not only in social networks, but also in many other types of large complex networks. For instance, in the ATP network of chemical reactions of a biological cell, which is a source of energy, it is a hub participating in a huge number of reactions.

Gladwell [23] was the first to observe in social networks the existence of nodes with a very great number of links (he named them 'connectors').

Barabási and his collaborators [24], [25], [26] discovered that

> "Hubs are special. They dominate the structure of all networks in which they are present, making them look like small worlds. Indeed, with links to an unusually large number of nodes, hubs create short paths between any two nodes in the system. Consequently, while the average separation between two randomly selected people on Earth is six, the distance between anybody and a connector is often only one or two. Similarly, while two pages on the Web are nineteen clicks away, Yahoo.com, a giant hub, is reachable from most Webpages in two to three clicks. From the perspective of the hubs the world is indeed very tiny.
>
> The view that networks are random, held for decades under the influence of Erdös and Rényi, has lately been questioned on many fronts. Watts and Strogatz's model offered a simple explanation of clustering, bringing random networks and clustering under the same roof. Hubs, however, again challenge the status quo. They cannot be explained by either of the models we have seen so far. Therefore, hubs force us to reconsider our knowledge of networks and to ask three fundamental questions: How do hubs appear? How many of them are expected in a given network? Why did all previous models fail to account for them?
>
> During the last two years we have answered most of these questions. Indeed, we have found that hubs are not rare accidents of our interlinked universe. Instead, they follow strict mathematical laws whose ubiquity and reach challenge us to think very differently about networks. Uncovering and explaining these laws has been a fascinating roller coaster ride during which we have learned more about our complex, interconnected world than was known in the last hundred years." [27]

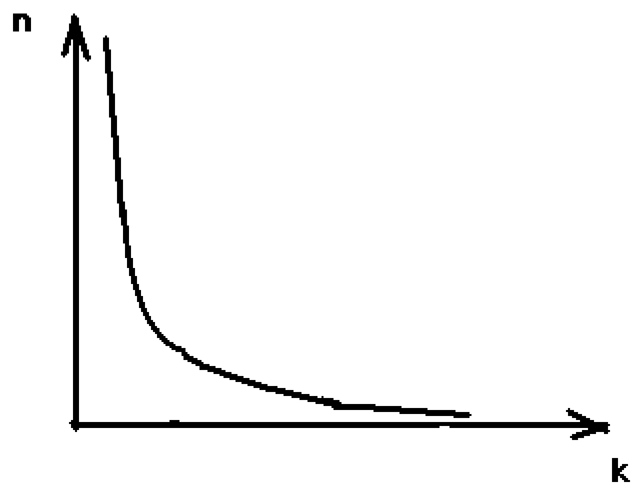
Observing that "hubs appear in most large complex networks that scientists have been able to study so far" [4, p. 63] and that "they are ubiquitous, a generic building block of our complex, interconnected world" [4, p. 63], Barabási and collaborators have shown (1999) that in a network with hubs, the number n of nodes with k links has a power law distribution with k of the form

$$n \sim 1/k^{\gamma} \qquad (2)$$

The representation of this power law in fig.4 shows that the majority of nodes have a few links, but a much smaller number of nodes, namely the hubs, have a very large number of links. *Networks with links following a power law, were termed* ***scale-free networks.***

Barabási observed for these networks:

Fig. 4



"Power laws rarely emerge in systems completely dominated by a roll of the dice. Physicists have learned that most often they signal a transition from disorder to order. Thus the power laws we spotted on the Web indicated, for the first time in precise mathematical terms, that real networks are far from random. Complex networks finally started to speak to us in a language that scientists trained in self-organization and complexity could finally understand. They spoke of order and emerging behavior. We just needed to listen carefully.

It might seem that the discovery that networks obey a simple power law would be exciting only to a few mathematicians or physicists. But power laws are at the heart of some of the most stunning conceptual advances in the second half of the twentieth century, emerging in fields like chaos, fractals, and phase transitions. Spotting them in networks signaled unsuspected links to other natural phenomena and placed networks at the forefront of our understanding of complex systems in general. The fact that the networks behind the Web, Hollywood, scientists, the cell, and many other complex systems all obey a power law allowed us to paraphrase Pareto and claim for the first time that perhaps there were laws behind complex networks." [28]

And further:

"Nature normally hates power laws. In ordinary systems all quantities follow bell curves, and correlations decay rapidly, obeying exponential laws. But all that changes if the system is forced to undergo a phase transition. Then power laws emerge-nature's unmistakable sign that chaos is departing in favor of order. The theory of phase transitions told us loud and clear that the road from disorder to order is maintained by the powerful forces of self-organization and is paved by power laws. It told us that power laws are not just another way of characterising a system's behavior. They are the patent signatures of self-organization in complex systems." [29]

For scale-free networks it was shown that "the degree exponent γ is not universal and depends on the detail of network structure" [30]. For a number of 16 scale-free networks, in various domains, one has following [30],

$$2 < \gamma \leq 3 \tag{3}$$

which appears to indeed be a small range of values (coauthorship 2.2, metabolic processes for eukaryotes and bacteria 2.0–2.4, accelerated growth model 3.0, Internet AS 2.2, WWW 2.1/2.45 etc [30]). The authors of [30] wanted to discover and define a universal parameter to characterise all free-scale networks and they made some progress in this direction, but we will not follow this approach in this paper. Our aim is to extend the concepts of such networks to the phenomenological realms, and then to the structural-phenomenological domains.

There are also other aspects of networks: growth and evolution of networks, preferential attachment (of new nodes to old nodes rich in links), etc.

According to the new theory of networks many aspects of the world are indeed simpler than they appear. Buchanan observes:

> "The small-world idea itself is also remarkably simple. All it takes is a few long-distance links or superconnected hubs, and there you have it-a small world. No doubt this simplicity explains why this kind of network appears in the architecture of everything from the human brain to the web of relationships that bind us into societies, as well as the languages we use to speak and think. Where small-world ideas win lead us in five or ten years is anyone's guess, but they may well reveal something about the way our ideas link up with one another, how discoveries in biology, computer science, sociology, and physics can be so intimately connected… This too is presumably more than mere coincidence." [5]

And further:

> "What is surprising, in fact, is how infrequently we notice the small world, and how often we believe that most others are indeed a long way away. On another level, it is also not a coincidence that the wiring of the human brain turns out to have the very same small-world structure as our social networks, nor that these patterns turn up again in the Internet and the World Wide Web, in the way words link together in human language, or in the food webs that underlie the world's ecosystems." [5, p. 197]

> "As Duncan Watts and Steven Strogatz discovered, a few long-distance links thrown into an otherwise gridlike network will suffice to make a small world. As Albert Barabási and Réka Albert noticed, the simplest of all conceivable patterns of growth-the richest and most popular getting still richer and more popular-leads to small-world networks of a slightly different kind. From two very simple rules follow small worlds of many kinds-this is no coincidence" […] In a world that could conceivably be random and lacking in any discoverable order, scientists have discovered instead that order abounds, even within the context of overwhelming disorder. The very aim of the science of complexity is to discover patterns in complex networks of all kinds and to learn how we might use this understanding to better ourselves and our world. Central to this task is the notion of emergence, the idea that meaningful order can emerge all on its own in complex systems made of many interacting parts. […] Of course, recognising these patterns and understanding their origins is only one step; we also want to know how we might influence them and how to use network properties to our advantage." [5, p. 198]

> "When it comes to network architecture, the small-world network offers obvious advantages because of its intimacy. For a computer network or a nervous system, or for

a company of people who need to organize their efforts, this pattern of connectivity fosters rapid communication between disparate elements-computers, neurones, or employees. Recall, however, that random networks also have only a few degrees of separation. What distinguishes a small-world network is not only that it has a low number of degrees of separation but also that it remains highly clustered. We might say that the fabric of the network is densely weaved, so that any element remains comfortably and tightly enmeshed within a local web of connections. Consequently, the net work overall can be viewed as a collection of clusters, within which the elements are intimately linked, as in a group of friends. A few "weak" links between clusters serve to keep the whole world small." [5, p. 199]

5. CATEGORIES AND NETWORKS

Networks in the new integrative science are structural, phenomenological and structural-phenomenological. In the integrative science framework, a network is, perhaps, needed to be considered as a category.

The classical structural theory of mathematical categories and functors deals in the case of presheaves and sheaves with sequences of nodes and arrows (directed links) between nodes (Fig. 5) defined as cohomological objects [31]–[40]. In the usual cohomology theories, there are no links with two arrows (as in fig.6) between nodes, and there are not direct links between two distant nodes

Fig. 5

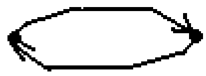


Fig. 6

(as are in Fig. 7). Also, there are no hubs that are essential in real networks (as in Fig. 8) as we have seen in the previous chapter.

It follows that the theory of network categories has to be further developed. The combination of categorial thinking and network thinking may, therefore, prove fruitful for developing the new integrative science.

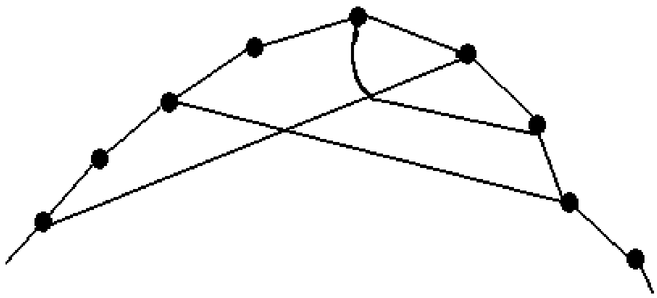


Fig. 7

It has been suggested by our team that structural-phenomenological categories (Drăgănescu, Kafatos and Roy), and of using presheaves,

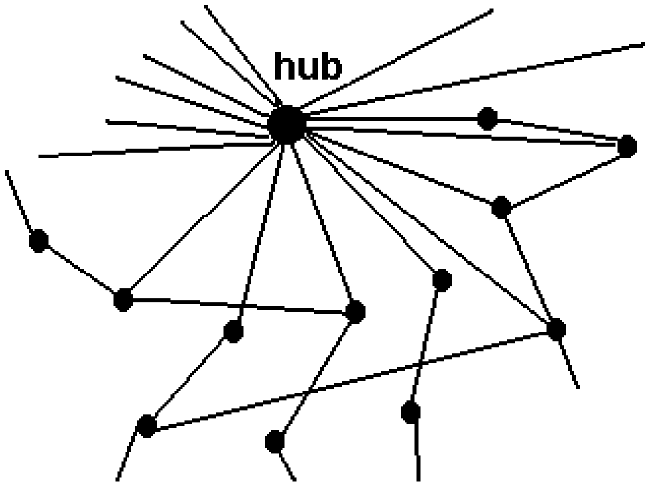


Fig. 8

sheaves and cohomologies (Kato) are needed in explaining both consciousness (mind) and physical phenomena. Some considerations on the Kato approach were presented in [40] suggesting perhaps a way of connection between the two above lines of dealing with reality in the general frame of category theory.

Network formalism may enter into the arena of integrative science:

> "Network thinking is poised to invade all domains of human activity and most fields of human inquiry. It is more than another perspective or helpful tool. Networks are by their very nature the fabric of most complex systems, and nodes and links deeply infuse all strategies aimed at approaching our interlocked universe." [41]

For Barabási, "real networks are self-organized. They offer vivid example how the independent actions of millions of nodes and links lead to spectacular emergent behaviour" [42].

Of course, there are also organized networks as it is the case of many technical systems and the 'old' organizational style of companies and institutions with hierarchical levels, such entities being organized in an artificial way. Self-organization is natural, from itself, being more efficient, more flexible and more tolerant to internal failures. Perhaps there are networks partly (externally) organized, partly self-organized.

Consequently, categorial and network formalisms have to go hand in hand for the development of integrative science.

In integrative science, all fundamental factors mentioned in this work are new in philosophy and science, namely:

– the ontological structural-phenomenological integrative model of reality developed in the last 23 years;
– the theory of categories and functors extended to the phenomenological domains and to the problems of mind, consciousness and deep physical reality, beginning to be developed in the last 4 years;
– the theory of real networks developed in the last 5 years.

The aim of integrative science is to set up framework to explain the nature and dynamics of diverse phenomena. Which processes give birth to a world, what laws or rules are followed in the phenomenological category of a world, what are the laws or rules in the structural category of the same world, and how these laws are acting together? Which are the processes that give birth to a mind in a world and how is a mind functioning in both its parts, the phenomenological and the structural, and in their mutual connection?

6. NETWORKS OF IDEAS AND THOUGHTS IN A MIND

Some properties of the phenomenological category of a mind were examined in [2]. In Fig. 9 [2], we represent the structural category of a mind $C_{str.m}$ in connection with its phenomenological category $C_{phe.m}$ through the functors F and H.

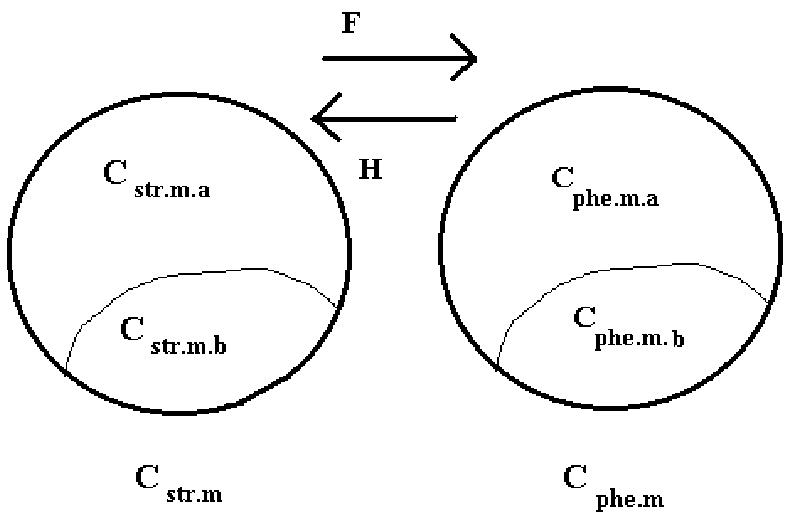


Fig. 9

An idea is a structural-phenomenological object. The brain is the structural category $C_{str.m}$. The structural part of an idea belongs to the subcategory $C_{str.m.b}$ of the brain, which carries structural information in the brain. The structural information of an idea is an object of $C_{str.m.b}$ and carries the *significance* component of that idea.

The phenomenological part of an idea is an object of $C_{phe.m.b}$ and carries the *phenomenological meaning* of that idea (orthosense = qualia = experience).

A thought is an ensemble of ideas connected in some way. If a thought of a written text as a proposition or a phrase is analysed through linguistics means (as in a text), it may be presented as a tree, a semantic web, a neural network etc. The structural part of a thought has a structural representation in the brain, in the subcategory $C_{str.m.b}$ in some form of network.

The phenomenological component of a thought is a community of phenomenological meanings of ideas, a community organized perhaps in a network (phenomenological objects with morphisms-links among them) in $C_{phe.m.b}$.

Also, a thought is a community of interconnected ideas. What is important in the phenomenological realm $C_{phe.m.b}$ is that the entire thought will have (generate) a general phenomenological meaning of that thought.

To this thought corresponds a phenomenological structure in $C_{phe.m.b}$ (Fig. 10) – a structure of phenomenological senses with a hub - and also a structure in the brain, in $C_{str.m.b}$.

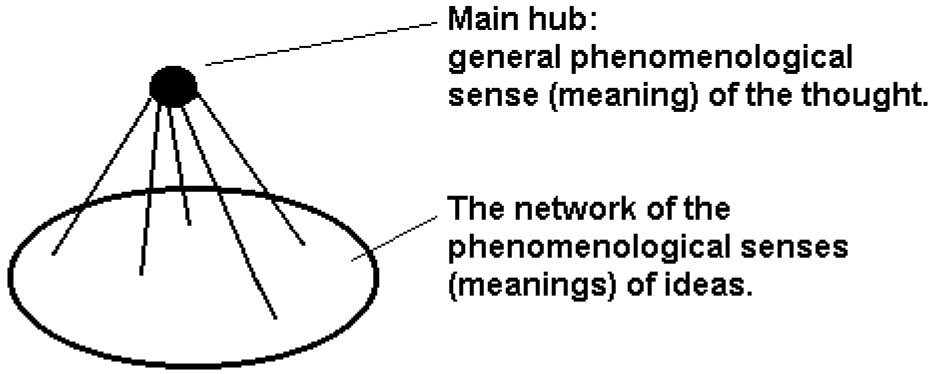


Fig. 10. – A thought in the phenomenological category $C_{phe.m.b}$ of the mind.

The generation of a general phenomenological meaning of a thought is due to information phenomenological processing in the phenomenological category of the mind. The general phenomenological sense (meaning) of a thought, has links (at least through strong neighbourhoods) with all the objects (nodes) of the thought, becoming the main hub of the network of that thought.

Thoughts may be connected between themselves. In such a case, in the phenomenological domain, a community of phenomenological thoughts may be represented like in Fig. 11. This is a community of an **extended act of thinking**. Such an extended act of thinking may use the main hubs of the thoughts as shown in Fig. 11. A thought is then not isolated, it is acting in a context of many thoughts, with reciprocal influences represented by the links of the main hubs. Such phenomena will have a correspondence in $C_{str.m.b}$, although it primarily seems to belong to the phenomenological realm in most cases.

These considerations are, of course, only preliminary ideas for the possibility of using the concepts of the integrative science together with the concepts of networks with hubs for the study of mind.

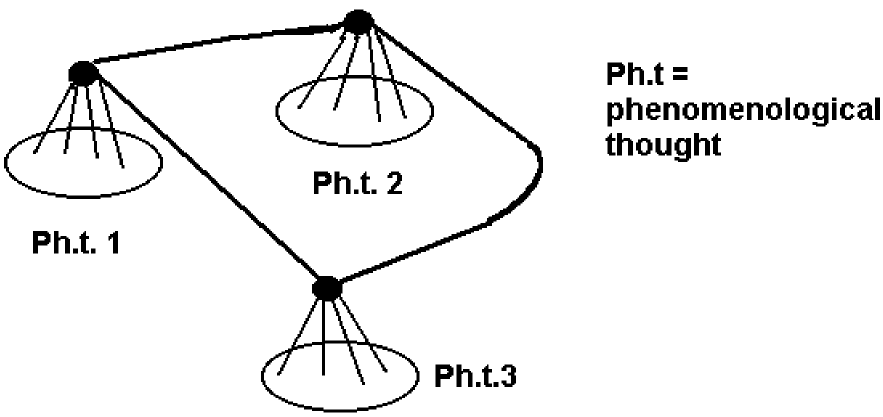


Fig. 11

The social aspects refer to a community of minds (or of consciousness). Perhaps a first attempt to take into account together the structural, phenomenological and social phenomena was done in 1985, [43]. Then it was observed [44] that society is also an information processor, with both formal and non-formal processes (non-formal processing is specific in the phenomenological categories of minds). The social information processor Psoc may be considered to be formed of two parts,

$$P_{soc} = \langle P_{soc.f}, G_{soc.nf} \rangle \tag{4}$$

where $P_{soc.f}$ is the formal social processor functioning by the formal processing of the brain-minds of the social subjects, as well as the systems of artificial intelligence used by society and of the formal processing of the social networks as such.

$G_{soc.nf}$ represents what is generated by phenomenological processing in the minds of social subjects (from one or some minds or more minds) and is accepted on the social plane as new systems of thoughts, ideas and concepts.

Something new may be obtained not only from phenomenological sources, but also by heuristic restructuring of the structure of society, or of a part of it.

The social structural information processor may be written

$$P_{soc.f} = \langle S_{soc}, h_{soc} \rangle \tag{5}$$

where S_{soc} is the structure of society and h_{soc} is an operator that represents the structural heuristic occurrence in the structure of society, and may change, after every one of its actions, the structure of society S_{soc}. In fact, S_{soc} is a category, the structural category of a society, which is evidently a dynamic network. In such a category, many phenomena of self-organization are taking place that may be seen as an important class of structural heuristics.

Concerning $G_{soc.nf}$, it has an important phenomenological part. If the minds have, each one of them, a phenomenological category, and all these categories are in the greater phenomenological category of the society, they may establish phenomenological connections (neighborhoods) and, therefore, some forms of phenomenological social activity (or phenomenological networks), more or less limited, could also take place. The social phenomena, in totality, may indeed be very rich.

7. FINAL REMARKS

The works of Milgram, Watts and Strogatz, Granovetter, Barabási and others established a new science of networks in the framework of the structural science. The generality of properties of such networks, which are independent of the domain of reality, confers to them an ontological status. In this paper this ontological position is added to the philosophy of integrative science, proposed first by Menas Kafatos and Mihai Drăgănescu. It is suggested that:

- the same types of networks, and maybe others alike, have a role in the phenomenological domains of reality, for the entire existence, of a world, for a mind and the phenomenological parts of the thoughts of the mind, for the phenomenological components of the thoughts of a community of minds, etc.
- a network, structural or phenomenological, to be considered as a category, and to combine categorial formalism with network formalism to enable us to develop a structural-phenomenological integrative science.

Recently, Stephen Wolfram published his book ‘A New Kind of Science’ [46] with new insights on the structural science and on many fundamental topics of science. The consequences of this book might be extremely important, but science is seen only in the framework of structural science, which, by definition, is incomplete and insufficient [1]. The problem for the integrative science is to find a bridge, if possible, of Wolfram’s science, based on cellular automata with simple rules and initial conditions for the description of the entire structural reality, with the phenomenological domains of reality. We believe this to be possible because in the phenomenological category of existence, or of a world, or of a mind, there are ‘cells’ with phenomenological senses and some types of rules for their interaction [42], [44].

We postulated – Fig. 1 – a Fundamental Consciousness [1], in fact in the framework of the structural-phenomenological philosophy it was demonstrated that such a Consciousness, referred to many as God, is possible in a natural way. Could, at last, the proposed integrative science provide answers to some primary questions concerning this entity? For instance, might the category of Fundamental Consciousness be the hub in the network of phenomenological entities, *i.e.* is Consciousness the main hub of all existence? And so on.

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