INFORMATIONAL THINKING AND SYSTEMS THINKING: A COMPARISON

By
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Abstract

At the 4th International Conference on the Foundations of Information Science in Beijing, August, 2010, Professor Wu Kun of the Xi'an Jiaotong University presented, for the first time in English, the results of some thirty years of research on the theory and philosophy of information. In particular, Wu's theory (Basic Theory of the Philosophy of Information; BTPI) focuses on the ontological properties of information, and their importance for a proper understanding of the function of information in society. Subsequently, Wu and Brenner discovered that the recent extension of logic to real processes (Logic in Reality; LIR), including information, supports and is supported by Wu's approach to the philosophy and natural logic of information, to both of which the same normative principles apply.

In this paper, Wu's philosophy and metaphilosophy of information will also be summarized and the synergy between it and Logic in Reality discussed. Wu's Metaphilosophy of Information positions information as a critical component of all disciplines, beyond the scientific content specific to them. It describes an attitude or stance, which we have termed the Informational Stance, which requires attention to the informational aspects of complex processes as a methodological necessity, an attitude that Wu calls Informational Thinking.

This concept of Informational Thinking as an approach to the science of information will be compared here with the more familiar one of Systems Thinking, first suggested by Forrester, based on complex systems theory. Early in his work, Wu saw the importance of systems theory, as it emerged from the work of von Bertalanffy, and its relation to information. In (English) summaries of this and more recent work, Wu shows how informational concepts deepen and go beyond the sometimes nebulous foundations of systems science. The work discussed today can also be seen as an extension of the pioneering work of Hofkirchner on the relation of systems theory to information.

Wu's meta-philosophical view of the central role of information in the reform and naturalization of philosophy itself is supported by the recent work of Deacon on the dynamics of informational processes. Brenner has discussed this elsewhere as a further contribution to the understanding of what information *is*. The focus of this Wu – Brenner paper is on a new foundational *role* for information in science and philosophy.

The theories described in this paper may thus constitute part of a new informational paradigm, in which information has a central, more fundamental role as compared to other major current approaches from the systems and complexity standpoints. Application of Logic in Reality, together with Wu's concept of Informational Thinking could contribute to the debate on critical outstanding issues in the field of information and provide potential support for an ethical development of the emerging Information Society.

Keywor*ds:* *ethics; dynamics; information; logic; metaphilosophy; process; systems; transdisciplinarity*

1. INTRODUCTION

1.1 What is information?

In the emerging information society, proper understanding of the phenomenon of information is a key problem, and relevant explanations should regard information as a tool for overcoming what Wolfgang Hofkirchner has called the fundamental failures of modern society and aiding its ethical development. Hofkirchner's own theoretical description of the possible nature and role of a unified theory of information (UTI), including contributions for systems theory, is a key step in this direction [Hof09].

Nevertheless, necessary progress in the philosophy and science of information continues to be blocked by the persistence, overt and covert, of an insufficiently complex ontology, dynamics and logic of information processes. There is, unfortunately, a same real predicament, in the domain of information, of misunderstandings about the dynamics and logic of complex processes in general and their dependence on the properties of the energy that constitutes their carrier. Despite the prestige of Norbert Wiener and John Wheeler, it is becoming clear that their – related - statements to the effect that energy is not information and information is primitive to matter-energy (it from bit) have been profoundly misleading.

Brenner has discussed [Bre12] what he considers the major contribution of Terrence Deacon, Head of the Department of Anthropology at the University of California, Berkeley to an understanding of the dynamics of life, mind and of information. Deacon provides a new reading of the relation between Shannon and Boltzmann entropy that reestablishes the link between information and energy exchange in a new "absential" theory of biological and cognitive processes, including information.

In Hofkirchner's approach to a UTI, referred to above, he calls attention to the three ways of thinking that correspond to Capurro's trilemma about the nature of information, and proposes a fourth, integrative way that, again, opens up the possibility of a new conception of information. As many people know, "thinking" in this sense refers to Heidegger's expression of the need to go beyond philosophy toward a more direct understanding of our ontological interaction with nature.

In this paper, we will discuss another, major and very complex contribution to the philosophy and science of information, that of Wu Kun, at the University of Jiaotong in Xi'an, China. Most people present only became aware of Wu Kun's 30 years of work in the field at the 4th International FIS Conference in Beijing two years ago [Wu10]. Specifically, we will summarize Wu's philosophy and metaphilosophy of information as a fundamentally new concept of the structure and nature of information, including its status and role in philosophy and science in general. We will compare Wu's concept of Informational Thinking as an approach to the science of information with the more familiar one of Systems Thinking, first suggested by Forrester, which emerges from complex systems theory.

It is interesting to note that the conceptions of the properties of information of Hofkirchner, Deacon and Wu all are supported and extended by the dynamic logic of and in reality which Brenner has called Logic in Reality (LIR) [Bre08]. Grounded also in the dialectic properties of energy, LIR provides a logical framework for describing the structure and evolution of the complex energetic processes that we refer to loosely as information.

1.2 Outline of Paper

Because the theories that are critical to the understanding of the approach to information that is the subject of our contributions to this Conference are unfamiliar, Section 2 of this paper

will summarize the Basic Theory of the Philosophy of Information (BTPI) of Wu; Brenner's Logic in Reality and relevant aspects of Deacon's formulations of the role of *absence* in defining the properties of information.

Section 3 of *this* paper will outline some of the problems with the theory of information as a science and what, in the approach of Wu Kun, has been done to solve these problems. In Section 4, we discuss systems theory and its derived approach of Systems Thinking from a logical and informational perspective. In Section 5, we review current concepts of complexity as such, such a those of Morin [Mor08] and show that they also fail to clarify essential aspects of information in any rigorous fashion. In Section 6, we discuss Wu's concept of Information (or Informational) Thinking [Wu10] that is a corollary of what we may call his proposed hypercomplex picture of "Information in Reality" [Bre10] and show its potential for resolution of many outstanding problems in information theory. In conclusion, we will mention Wu's call for the application of Informational Thinking in the social and political sphere, as an attitude which carries an essential ethical component.

2. RELEVANT NEW THEORIES

The major problem with theories of information has perhaps been most succinctly stated by John Collier, as quoted in Deacon's book, *Incomplete Nature*: [Dea12] "The great tragedy of formal information theory is that its very expressive power is gained through abstraction away from the very thing that it has been designed to describe." The first task of any new work in information should thus be to replace, in a rigorously grounded way, what has been removed by a theory of the reality of which information is a part, as a basis for further discussion.

2.1 Deacon's *Incomplete Nature* and the Dynamics of Absence

The key stages in Deacon's approach as (1) a description of the unique characteristics of complex biological and cognitive phenomena and (2) their explanation by an ascent from basic thermodynamic processes through the evolution of form (morphodynamics), to the further complexification of teleodynamics – the emergence of purpose. A few comments about each of these stages are in order.

2.1.1 Ententionality

Information, like other complex biological, cognitive and social processes are all, in Deacon's term *ententional*, that is, they display some form of purpose. If a living organism is involved on the part of a living organism, tending toward something with meaning for that organism. Ententional is a generic adjective proposed to describe all phenomena that are intrinsically incomplete in the sense of being in relationship to, constituted by, or organized to achieve something non-intrinsic, *i.e.*, absent. There is room for meaning, purpose, and value in the fabric of physical explanations, because these phenomena effectively occupy the absences that differentiate and interrelate the world that is physically present.

They are teleological phenomena, evolving in teleological processes. The term is related to that coined by Collier [Col90] of *enformation* to describe the internal informational aspects of such phenomena.

Ententional processes are notoriously recalcitrant to study by the rigorous methods of the experimental sciences. However, yet if it is agreed that they do not take place outside the laws of physics and chemistry, what is or are the still unrecognized characteristics of the precursors to

those processes that enabled them to interact in such a way as to insure the transition from non-living substrates to primitive living systems, and from these to the complex phenomena of human cognition and society?

Deacon deserves the historical credit for showing that that general characteristic is a negative relationship defined with respect to *absence.* The concepts of information, function, purpose, meaning, intention, significance, consciousness, change and human value are intrinsically defined by their fundamental incompleteness.

Deacon's argument is that the existence of anything requires the imposition of some force that separates it from other things – a constraint; this constraint reduces the number of possible states of the entity which is, accordingly, defined by what it is not, or what it is not yet. The absence (sic!) of any serious literature about absence as a physical and metaphysical principle that is causally efficient is, negative, evidence of the resistance to or lack of interest in it. Only in *some* theories of deontic (judicial) logic is negative evidence given appropriate attention. Apophatic philosophy is about the importance of things that are not *said*, but not about things that are not *there.*

2.1.2 Spontaneity and Constraint. Homeodynamic Processes

The existence of spontaneity and spontaneous processes is an expression of the role of the 2nd Law of Thermodynamics that describes the energy gradient in which the world has existed since the Big Bang (or its equivalent in a cyclic model of the universe). Spontaneity refers to the familiar phenomena of "water running downhill" or of chemical reactions taking place if the free energy of the products is lower than that of the reactants. In other words, spontaneous processes are those described by Newton's 1st Law of Inertia, also designated by Deacon as homeodynamic processes.

The concept of constraint provides a negative approach to realism, determined by discrete interaction effects that don't occur. Constraint is in effect, a complementary concept to order, habit, and organization, because it determines a similarity class by exclusion. Paying attention to the critical role played by constraints in the determination of causal processes offers us a figure/background reversal is critical in developing a scientific theory of emergence, evolution and information. Constraints are what is not there but could have been, irrespective of whether this is registered by any act of observation.

2.1.3 Orthograde and Contragrade Processes

Orthograde processes are Deacon's term for changes in the state of a system that are consistent with the spontaneous, "natural" tendency to change without external interference. Contragrade processes are changes that must be extrinsically forced because they run counter to orthograde tendencies. As noted in Brenner's paper, the assumption of spontaneity is fraught with problems, but these will not be discussed here. It remains true that the 'spontaneous' tendency of molecules with the potential for interaction to wander into each other's spatial positions and dynamical values is responsible for the orthograde dynamic that characterizes global change toward equilibrium. In this way, contragrade dynamics at one level produce orthograde dynamics at the higher level. Another merit of describing change in these complementary terms is that it gives new meaning to the defining property of matter—a resistance to change—and the defining property of energy—that which is required to overcome resistance to change. (The equivalent Lupascian formulation is one of potentiality overcoming an energy barrier to become actual.) A contragrade change must therefore derive from two or more

orthograde processes, each in some way opposing the other's effects. Each must constrain the other in a reciprocal way, again as described by LIR. Thus the evolution of increasingly complex forms of constraints — absences, has given rise to increasingly varied ways to impose constraints on the world with respect to these internal constraints. In this sense, the source of agency can be described as the generation of interactive constraints which do work to perpetuate the reciprocal maintenance of the constraints that maintain an organism or a self.

We now summarize very rapidly the further stages in Deacon's construction.

2.1.4 Morphodynamic Processes

Morphodynamic organization emerges due to the interaction of opposed thermodynamic processes (e.g., perturbation and equilibration), and it results in constraint amplification rather than constraint dissipation (*i.e.*, increase in entropy). In this respect, formation of primitive systems capable of self-replication (autogens) exemplifies the defining feature of an emergent phase transition—the appearance of a new form of orthograde organization.

2.1.5 Teleodynamic Processes

Teleodynamics refers to a form of dynamical organization of real processes that exhibit purpose or end-directedness and consequence-oriented features that is constituted by the co-creation, complementary constraint and reciprocal synergy of two or more strongly coupled morphodynamic processes. It results in constraint stabilization rather than constraint amplification, and entropy "ratcheting" rather than entropy production.

2.1.6 Work. Teleodynamic Work

A key innovation made by Deacon is to emphasize the role of work in the explication of the evolution of complex processes the ability of orthograde and contragrade processes to change the state of things, that is, to do work. Teleodynamic work can be defined as the production of contragrade teleodynamic processes. Since this must be understood in terms of orthograde teleodynamic processes, the first step in describing this level of work is to define and identify examples of orthograde teleodynamics.

2.1.7 Information

In Deacon's theory [Dea12], a complete account of the nature of information that is adequate to distinguish it from more simple material or energetic relationships requires a basic inversion of perspective, a figure/background shift, which is fundamental and counterintuitive. This is because what matters is not an account of only its physical properties, or even its formal properties. What matters in the case of information, and produces its distinctive physical consequences, is a relationship to something not there. Information is the archetypical absential concept [Dea10].

Deacon's key concept is that information is a relational property that emerges from nested layers of constraint: constraints of signal probability (Shannon), constraints of the dynamics of signal generation (Boltzmann), and the constraints required for self-maintaining, far-from-equilibrium, end-directed dynamics (Darwin). Because information is a relationship among levels of constraint generated by intrinsically unstable physical processes, it is also normative with respect to those processes. As above, constraint is a negative property, and thus neither something intrinsic nor determinate; it is intrinsically incomplete and fallible, or in LIR terms characterized by its potentialities. The nested dependencies of the three levels of entropy

reduction— characterized by Shannon's, Boltzmann's, and Darwin's variations on this theme of entropy reduction—define a recursive architecture that demonstrates three hierarchically nested notions of information. These three very roughly parallel the classic hierarchic distinctions between syntax (Shannon), semantics (add Boltzmann), and pragmatics (add Darwin). They also roughly parallel the relationship between data, content, and significance. As we show in the first paper, LIR provides a way of understanding how these semiotic levels are interrelated dynamically.

2.2 Wu Kun and an Informational Ontology

2.2.1 The Existential Field

The basic insight of Wu Kun's Philosophy of Information is that the concept of objective reality = objective existence is too poor to describe the informational world. A proper new ontology and worldview is needed to describe a basic field of that existence. The approach of Wu to information is to start from an ontological, rather than a purely phenomenological, standpoint, which is not just to view the existential field so constituted as objective and subjective in the standard sense. He then places the critical terms of existence, objective and subjective, reality and unreality, and direct and indirect in one framework or partition diagram in which each combination of terms defines a path leading to matter-energy on the one hand and information on the other. Restating his key conclusions, information then has the following characteristics:

- Information is an indirect existence that has both objective and subjective characteristics.
- Subjective indirect existence refers to the subjective unreality that is part of subjective existence (the mental world).
- Objective indirect existence refers to the objective unreality that is nevertheless part of objective existence.

Existence is constituted in this picture, then, by *both* matter-energy and information from a physical perspective. We thus establish the essence of information, namely that it is "tied" to existence and reality through its objective and subjective aspects. It *is* part of the existential field. Hence all things are characterized as dualities of matter-energy and information. The complexification that occurs in moving from one informational form to the next is readily interpreted in terms of grades or levels. The concept of information as indirect but still objective existence enables Wu to show that any object has its directly and indirectly existing meaning and value, and that any object's present structure encodes the information of its history, present property and future development which taken together constitute an informational entity or in Wu's term an "informosome". This descriptive resegmentation theory of the field of existence (the real world) of Wu, when applied to informational processes or 'activities' benefits from the principles of LIR that further explicate their normative and qualitative properties in logical terms.

2.2.2 The Classification and Structure of Information

Wu then classifies information into three independent forms and one dependent form:

- In-itself information

In-itself information has an objective indirect existence not mediated by any subject. Within the Informational Field (IF; see next Section), the assimilation/dissimilation of information are two basic forms of In-itself information. The Informational Field (IF) is carried by the movements of basic particles of matter-energy and their fluctuations, which contains the information (relationship of difference) of those objects constituting them. The IF is also a material field, commonly called physical field, which has a direct existence and an indirect existential unity. The interactions taking place in the IF produce the change between objects, and therefore change is the assimilation/dissimilation of information, where all objects become the informosome and have their material and informational, direct and indirect meaning and value as a unified dual-existence. In-itself informational activities are the most fundamental from which all others are derived. The informational activities described by Wu include, but are not limited to, information as well-formed, meaningful data in the view of Floridi.

- For-itself information

  For-itself information is the primary level of the recognition and storing of in-itself information by a subject with cognitive and memory capacities, giving it subjective indirect existence. Wu designates this knowing subject as the "informational subject".

These two categories recall Sartre's division of being into the categories of in-itself (*en-soi*) and for-itself (*pour-soi*). We cannot pursue further here the complex origins and roles of these categories, except to stress that they offer a way of talking about the essence of existence and information, and the approach to objective information from the object to the subjective information that is continuous and compatible with its processing.

- Regenerated information

  Regenerated information is the informational level at which the subjective creativity of the informational activities of the informational subject operating on for-itself information. Its basic forms are concept-image information, and symbolic information, whose existence is also subjective and indirect. For-itself information that is grasped by subject and regenerated information created by subject in him- or herself as an individual are what are usually referred to as "mind" or spirit.
- Social information

  Social information is a dependent form of information constituted by the triple of in-itself, for-itself and regenerated information, in which the second two, involving information grasping, processing and creation by humans, are the most important. Social information undergoes its own process of "evolutionary" development.

2.2.3 The Informational Field

Wu's concept of an informational field further defines the essence of information. The field is multidimensional, including the various functions, roles, structures and relationships

involved in the production, transmission and reception of information. From the standpoint of LIR, all of these entities, especially structures, must be looked at as causally effective processes. Lupasco used the term structuration, "*structuration*" in French, to emphasize the dynamic *process* aspects of complex structures, biological, cognitive or social. The answer he gave to his own question "*What is a structure?*" [Lup67] was that structures are also dynamisms, not to be objectified and reified. In the LIR perspective, structuration is a real operation on the relations between two individuals. Any individual structure is never rigorously actual, that is, absolute in any sense, given the nature and logic of energy. It is a dynamic "structuring" that is always functionally associated with an antagonistic and contradictory potential structuring. Another way of saying this is that a structuring seen externally is a kind of form; looked at internally, it consists of the processes themselves.

In the remainder of this paper, we will continue on the basis that the principles of LIR in fact support the descriptive resegmentation of the field of existence (the extant domain) by Wu to which LIR adds a new logical dimension.

2.3. The Brenner Logic in Reality (LIR). Information-as-Process

Logic in Reality (LIR) is a new, non-propositional kind of logic that extends the domain of logic to real processes. LIR is grounded in a particle/field view of the universe, and its axioms and rules provide a framework for analyzing and making inferences about complex entities and interactive processes in the real world at biological, cognitive and social levels of reality or complexity.

The term Logic in Reality (LIR) is intended to imply both 1) that the principle of change according to which reality operates is a *logic* embedded in it, *the* logic in reality; and 2) that what logic really *is* or should be involves this same real physical-metaphysical but also logical principle. The major components of this logic are the following:

- The foundation in the physical and metaphysical dualities of nature
- Its axioms and calculus intended to reflect real change
- The categorial structure of its related ontology
- A two-level framework of relational analysis

Details of LIR are provided in [Bre08]. Stated rapidly, its most important concepts are that 1) every real complex process is accompanied, logically and functionally, by its opposite or contradiction (Principle of Dynamic Opposition; PDO), but only in the sense that when one element is (predominantly) present or actualized, the other is (predominantly) absent or potentialized, alternately and reciprocally, without either ever going to zero; and 2) the emergence of a new entity at a higher level of reality or complexity can take place at the point of equilibrium or maximum interaction between the two.

LIR should be seen as a logic applying to processes, in a process-ontological view of reality, to trends and tendencies, rather than to 'objects' or the steps in a state-transition picture of change. Processes are described formally as transfinite chains of chains of chains, etc. of alternating actualizations and potentializations of implications, considered with the other logical operators, conjunction and disjunction as real processes themselves. The directions of change are either 1) toward stable macrophysical objects and simple situations, the result of processes of processes, etc. going in the direction of a "non-contradictory" identity or diversity: or 2) toward a state of maximum contradiction (T-state for included third term) from which new entities can

emerge. LIR is, therefore, a logic of emergence, a new non-propositional, non-truth-functional logic of change.

2.3.1 Information in LIR

Logic in Reality does not pretend to offer or to constitute an independent theory of information that would supersede any or all existing approaches. LIR provides a new interpretation of the concept of qualitative information or information-as-process [Bre10] as contrasted with quantitative information. Given its contradictorial approach to all complex real phenomena, LIR can be seen as a method, a logical methodology that would encourage the retention and use of partially conflicting notions and theories of information, among others.

Among the key open problems in the philosophy of information, Floridi [Flo04] includes several concerning the relation between information and the actual world. Thus, information can be viewed from three perspectives: information *as* reality (e.g. as patterns of physical signals, which are neither true nor false), also known as *environmental* information; information *about* reality (semantic information, alethically qualifiable); and information *for* reality (instructions, like genetic information, algorithms, orders, or recipes).

Many extensionalist approaches to the definition of information *as* reality or *about* reality provide different starting points for answering the question of what information *is*, but the broad theory of information proposed by Wu requires an understanding of the properties and role of information at all levels of reality, in all material-energetic structures. Whatever contributes to this understanding must accordingly be valuable for philosophy in general.

A new characterization of information as a process and with philosophical significance has also been made by Luhn [Luh11]:

Information is the process:

- which describes as initial values a particular physical system, its actual state, its potentially possible state space and accordingly its region of stability, as well as the lawfully regular and thereby macrophysically measurable description of the system,
- which describes as further initial values the description of an energetic-material influence on the system,
- and describes as the resultant values the physical system, its actualized state, its actualized potential phase space, and accordingly its region of stability, as well as the lawfully regular and thereby macrophysically measurable actualized description of the system,
- as well as further possible output values (output signal).

As Luhn points out, this definition captures both algorithmically describable, deterministic processes as well as non-algorithmic ones which can lead to new laws, ideas and experience. Information in this sense is a synonym for what is open in the world.

Another definition of information congenial to LIR was made by Kolmogorov to the effect that information is any operator which changes the distribution of probabilities in a given set of events. This is quite different from his well-known contribution to algorithmic information theory, but fits the process conceptions of LIR. In LIR, logical elements of real processes resemble (non-Kolmogorovian) probabilities, and the logical operators are also processes, such that a predominantly actualized positive implication, for example, is always accompanied by a predominantly potentialized negative implication. It is possible to analyze both information and

meaning (higher level information [Bre10]) as having the potential or being a mechanism to change the informational context.

LIR thus can provide bridging concepts or 'glue' between concepts of semantic information at the lowest data level and their broader applications. LIR places this concept, and thus the "superconcept" [Hof09] of information, in a naturalized physical, metaphysical and logical context. Information is both a means to model the world and part of the world that is modeled, and LIR describes the dialectic relation between them.

3. THE METAPHILOSOPHY OF INFORMATION

The difficulties and errors made in the analysis of the phenomenon of information and in defining its nature reflect insufficiency in modes of thinking about science and philosophy that can be traced back the continued use of a small number of dogmatic concepts. From the Deacon and Wu perspectives, as well as that of LIR, there are two kinds of problems, physical and metaphysical that have afflicted theories of information to date: key dualities, in particular that of subject and object, have been defined solely by mutual exclusion and absolute opposition, without connection, transition and inversion between them. Attempts are made to define information in terms of static differentially measured bits and then say that real interactive processes derive from them.

In our view, information is the energetic pattern of evolution of real processes, as complex and as simple as the ways in which energy expresses itself in reality with its dynamics and its logic. In Wu's informational field, energy is fundamental; its structure, better structuring has the characteristics of displaying and representing entities that are capable of being seen in partial independence from the background, but not separate from that background. The field is multidimensional, including all the various functions, roles, structures and relationships involved in the production, transmission and reception of information. From the standpoint of LIR, all of these entities, especially structures, must be looked at as causally effective processes.

We consider the metaphilosophy of information and the science of information as being different perspectives, but that there is no disjunction between them, and both refer to information as a phenomenon produced in an energetic process, albeit one that shows analytically distinguishable ontological features. They are grounded in physics and extend to complex human social behavior. If naturalizing a philosophical complex, for example of phenomenology, means bringing it into science, the metaphilosophy of information is naturalized *ab origine.* We thus see as hopelessly naïve a recent proposal of a definition of a naturalized metaphilosophy that "discovers" that philosophy is an activity carried out by human beings and that social forces shape its development. However, the relation to science is totally absent. A naturalized metaphilosophy may indeed be needed that can provide tools to gain a better understanding of what philosophy is and if progress is possible in it. Many other changes in the basis of knowledge are required in addition, and the role of a new dialogue around the subject of information could thus be very important.

To gain historical perspective on this approach, let us now look at the theory of systems as an early attempt to provide a deeper, more dynamic understanding of the complexity of the world.

4. SYSTEMS AND SYSTEMS THINKING

The thesis to be defended here is that by referring to the informational properties and components of systems, as well as their logical dynamics, one insures a minimum ontological content as a basis for further understanding. We start our discussion by looking at the origin of systems theory and science.

4.1 General Systems Theory

Ludwig von Bertalanffy deserves the historical credit for taking various global theories of the physical, biological and social sciences and proposing one that went radically beyond them. In his *General Systems Theory* [vBe69], based on his fundamental research in biology and embryology, he proposed that the only meaningful way to study organization was to study it as a system. GST was to be a new discipline whose subject matter was the formulation and derivation of principles that were valid for systems in general.

Von Bertalanffy defined systems simply as "complexes or sets of elements standing in interactions or interrelations," but GST was supposed to be capable of giving exact definitions of and even quantifying complex concepts. As stated by von Bertalanffy himself, however, he provided no axiomatic basis for his theory of systems. This is one reason, among others, why the GST has been criticized. Von Bertalanffy stated that his "science of wholeness" should be a formal logico-mathematical discipline based essentially on the equations of differential calculus. But what logic did he have in mind? Where is the system of logico-mathematical laws he would like to apply to real phenomena? He did say that the 'all-or-none' concepts of traditional logic fall short of continuity concepts basic for mathematical analysis, but he saw their origin in the structure of our central nervous system as a digital computer. This is the origin of our bivalent yes-or-no logic, thinking in terms of opposites and why "our mental representation of the universe always mirrors only certain aspects or perspectives of reality". He saw this way of thinking, which could not handle problems of biological wholeness or form as a "tremendous embarrassment" to occidental physics.

Dynamic Systems Theory and differential equations have been suggested as the most appropriate tool for modeling human behavior and human knowledge. Von Bertalanffy's initial presentation of GST focused on differential calculus, but he clearly recognized that there were "well-defined problems" in non-physical fields which could not be handled by this approach [vBe72].

From a Lupascian perspective, DST only displaces the philosophical and metaphysical problem. The usual notion of infinitesimal calculus is that it captures the simultaneously continuous and discrete nature of changing phenomena - change at an instant in formal terms. But this begs the question of whether reality is composed of "instants" in the sense used in the theory [Bel98]. If it is not, *pace* Hermann Weyl, then differential calculus, like classical logic, does *not* fully capture the essential properties of real processes and systems. Lupasco provides a theory of consciousness and "systems epistemology" in which knowledge, as von Bertalanffy saw, is or is in the interaction between the knower and the known, and that this interaction follows the Principle of Dynamic Opposition.

4.2 The Evolution of Cybernetics

The further evolution of cybernetics, due to the generalizations by von Foerster toward second-order cybernetics, the cybernetics of observing systems and the elaboration of the notion of *autopoiësis* (self-production) by Maturana and Varela have all led to substantial new insights into the "structure" of existence. The "Neuchâtel Model", proposed by Schwarz [Sch97], places

all these concepts, plus those of autogenesis (the self-production of rules of its production by an entity), in terms of planes (or levels), structures, information and totality. Schwarz' model is useful in that objects and laws are not separable and operate within the constraints of a static, binary Aristotelian logic, but form complex wholes which are existing (non-physical) entities.

Concomitant work by Prigogine and his school is well known. As Brenner has noted and Schwarz also points out, Prigogine contributed to the understanding of living and other complex systems as emergent *dissipative structures*, far from equilibrium, to which classical determinism did not apply. However, the availability of energy cannot by itself provide an explication of morphogenesis. The next series of developments in the theory of self-organizing systems, dynamical systems theory, non-linear dynamics or chaos theory will not be discussed here. In our terminology, these approaches can be seen as attempting to break the bonds of a classical logic of identity by giving adequate foundational philosophic value to the diversity inherent in living systems. Unfortunately, due to the absence of an appropriate development, in these authors, of the dynamic relationship in the *feedback loop*, neither GST nor the concepts of Prigogine seemed to have fulfilled their early promise. Although von Bertalanffy's rejected all forms of absolutism in philosophy and science, he lacked a vision of logic that was broad enough to support this. His concept of a system included antagonistic relations among the parts themselves, but not between the parts and the whole.

4.3 Systems Science and Complex Systems

Systems science developed after GST from the interaction of standard information theory and cybernetics. One definition of systems science is the following[1]: "A new discipline that combines theoretical, practical and methodological approaches relative to research topics that are recognized as being too complex to be accessed in a reductionist fashion, and that pose problems of 1) boundaries, internal and external relations, structure and laws or emergent properties characterizing the system as such and 2) modes of observation, representation and model building or simulation of a complex totality." The reader will recognize in this definition issues that have been addressed in a logical fashion that hopefully is non-reductionist.

Systems science overlaps with complexity science, in that the latter is based on a definition of the complex systems that are the objects of systems science study, albeit from a less computational standpoint. A complex system is loosely defined as constructed by a large number of simple, mutually interacting parts, capable of exchanging stimuli with its environment and of adapting its internal structure as a consequence of such interaction. The non-linear interactions involved can give rise to coherent, emergent complex behavior with a rich structure. Key concepts in complexity science are, for example, the coexistence of diversity and stability, for which LIR provides an interpretation. Complexity science also looks at the dynamics of systems in transition regions of self-organized criticality. Schematic systems are used to investigate self-organization, but without the grounding in dynamic opposition and potentiality that we have proposed as necessary to explain the functioning of such organization, as well as the ambiguity in the term 'self'-.

As Brenner stated at a Congress in 2005[2], the major objective of systems science today is to provide a consensual, transdisciplinary approach to the increasingly complex problems faced by workers in all areas of society, with the laudable intention of 'placing man at the center of its

[1] French Association of the Science of Cybernetic, Cognitive and Technical Systems (*AFSCET*), 1994.

[2] 6th European Systems Science Congress, Paris, September 19 – 22, 2005.

preoccupations'. Models and strategies are designed to develop effective operational tools as well as conceptual and philosophical ones.

Systems science includes aspects of such a diversity of sciences and disciplines that makes it difficult to capture in a few words. One example is the science of ago-antagonist systems (SAAS), developed by Bernard-Weil, which bears as superficial resemblance to LIR. SAAS purports to identify and take into account, in concrete systems, pairs of elements that are both conflicting and cooperative, either at the same time or alternatively. It is necessary to specify more completely what is meant by 'at the same time' or 'alternatively' and to look for the origins of both conflict and cooperation in the potentialities of the systems' elements.

This theory, like many others in systems science, has practical applications as a step in understanding the role of pairs of antagonists in living cells, the human body, business enterprises, etc.

4.4 Systems, Complexity and Emergence

By taking a minor step away from the debates about systems, emergence and complexity, it becomes fairly obvious that they are not independent concepts but that their definitions are closely entangled, not to say circular. In using them for the discussion of information, another major problem is that much of systems science and complexity theory is cast in epistemological terms, referring to more or less abstract observers and models.

As one example of such an approach to systems and emergence, we cite the work of Minati, Penna and Pessa [Min98]. These authors do show that the usual picture of systems is too limited to deal with logically open systems, in which the internal state of a system, as well as its environment, need to be taken into account. The major strategy of Minati is to establish a principled role for the observer that defines epistemological levels of logical openness.

However, for many complex phenomena whose description and overall dynamics have not been captured by current theories, such as information, change, intentionality, *etc.*, an account in which the observer has an epistemological role needs to be supplemented by an ontological non-conceptual account in which the rules governing the real interactions between entities, including the observer, are also applied. In LIR, the observer is in an *ontologically prior* dynamic relation with the observed of which he is a part. One such relation is that between the scientist and his experimental configuration.

Thus the sequence proposed by Minati *et al.* - REAL SYSTEM → REDUCTION BY OBSERVER → MODEL 1,2,3 … → EPISTEMIC CHANGE IN OBSERVER - is an epistemological construction in "epistemic" space; nothing has "happened" to the system. Minati discusses his General Theory of Emergence (GTE) in the context of the concept of generalization itself [Min09]. His theory does not deal *directly* with physical, cognitive processes of any kind, and emergence is seen generally as the emergence of new formal properties and operators whose validity can be extended from one domain to another. GTE focuses on collective phenomena that establish can be viewed as systems and is better described as a meta-theory that deals with

- the establishment of systems through a form of cognitive emergence but where the dynamics do not relate to their reality as processes with respect to timebut to multi-modeling, epistemological hierarchies;
- correspondences between models and representations of phenomena considered emergent;

- identification and classification of possible non-equivalent kinds of emergence, such as biological and physical.

The nature of the differences between Minati's GTE and the concepts presented in this paper are thus clear: a system for Minati is the *model* of a phenomenon, not the phenomenon itself and its evolution. The effective modeling of such systems is not based on separate models, but rather on integrated models able to represent interactions between levels and processes of emergence, in which Minati's conception of the dynamic usage of models (DYSAM) plays a key role. This process of acquisition of emergent properties and its codification in a GTE may offer a wide new variety of approaches applicable to life, mind and development in general but they are only epistemological.

In contrast, the views of Wu and LIR of real-world processes as emergent are not epistemological but ontological, similar to that of Hofkirchner. As Hofkirchner stresses in his discussion of information and computation, "only if computation is meant as a self-organizing process involving emergence in a *non*-epistemological sense can it do justice to the generation of information [Hof10]."

4.5 The Notion of Systems Thinking

Systems thinking is been defined primarily as an approach to problem solving, by viewing problems as features of an overall system which are best understood in the context of relationships with each other and with other systems, rather than in isolation. In principle, systems thinking techniques may be used to study any kind of system - natural, scientific, engineered, human or conceptual. The difference and advantages of systems thinking *vs.* traditional forms standard analysis is clear.

In practice, two things are missing that are necessary, in our opinion, to give systems thinking the necessary depth: one is an adequately grounded definition of a system in the first place, in which contradictorial interactions are present constitutively and second a proper conception of how qualitative properties of systems may be expressed.

In her 2005 paper, Debora Hammond [Ham05] summarizes developments of systems thinking since the establishment of its categories of application – technology, science and philosophy – by von Bertalanffy. We can all agree today with his conception of General Systems Theory that emphasizes a more holistic and humanistic approach to knowledge and practice, while deploring the fact that such an approach has not materialized.

We consider this article a very accurate reflection of the "state-of-art" of systems thinking. Starting with von Bertalanffy, the author points to many significant contributions to a systems view, which she defines: "The systems view reinforces a constructivist orientation to knowledge as a dialectical, pluralistic and participatory process that emphasizes the importance of mutual understanding, meaning and values." All of the well-known difficulties in achieving such goals are indicated, the fragmentation of knowledge, the use of systems thinking for social control and that indeed "we have yet to discover the appropriate approach to systems"[3].

The approach of one of the most influential systems thinkers, Peter Senge [Sen90], amounts to not much more than an exhortation to look at the "whole", an organization as a holistic, dynamic process and to balance short-term and longer-term cost-benefit parameters. This is fine as far as it goes, but no one can say today that it goes far enough.

[3] Brenner considers the Lupasco grounding of systems in the inherent physical antagonisms of matter-energy, formulated in 1962 [Lup62] as one such approach.

Hammond's statement of objective nevertheless merits repetition here: "Perhaps the primary challenge for systems thinkers in the 21st Century is to find ways of integrating the insights emerging out of the various branches of systems thinking over the past fifty or sixty years." We propose that it is Informational Thinking that suggests new ways of accomplishing this integration, despite the difficult *de*-fragmentation of knowledge that must take place.

4.5.1 System Dynamics

System dynamics is an approach to understanding the behavior of complex systems over time. It deals with internal feedback loops and time delays that affect the behavior of the entire system. While the approach is in principle applicable to ecosystems and political systems, in fact it can only be used for the most mechanical, quantitative features of such systems, capable of being modeled in causal loop diagrams. Accordingly, system dynamics adds nothing fundamental, as a form of systems "thinking" to the understanding of information or other complex phenomena as such.

With hindsight, the notion of applying systems theory to the solution of practical problems, for example, those of organizations, is neither more nor less than common sense. The unfortunate state of the world, however, is a demonstration that such solutions have been limited in scope. As a systems scientist, in his major book on the relation of systems, semiotics and information, Brier [Bri08], clearly understands the limitations of a systems theory such as that of Niklas Luhmann, in which the subject is lost in functionalism that is not adequately grounded in an external reality and a proper philosophical framework.

5. COMPLEXITY

It is often suggested that notions of complexity provide substantial additional insight into the nature of information. On closer inspection, it turns out to be easy to show that current relatively rigorous notions of complexity are all tied back to computer science, specifically, algorithmic information theory, as in the Kolmogorov complexity of an informational object. We believe, however, that none of the existing approaches based on systems or standard computational notions of complexity are adequate to define the unique ontological status of information.

While the lack of formalism in the complex systems approach serves to differentiate it from strictly computational ones, the lack of foundations diminishes the value of its humanistic and ethical characteristics. The only complex systems studied in detail seem to be those simple enough to be computationally tractable. If the essence of complexity is *non*-computability, then the right of such systems to be called complex is open to question.

A far more appropriate methodology is to relate complexity to simplicity, dialectically, as situations in which simplicity can emerge from complexity and *vice versa.* This is, of course, where concepts from Logic in Reality are useful in insuring some coherence in the discussion of the dynamics of the changes involved. No reason is given as to why such things as complex processes can and do emerge in nature, but it might be essential for the understanding of how they operate what the basis for the emergence might be.

5.1 Morin

From the standpoint of Wu Kun's Philosophy of Information, the Morin notion of complexity suffers from being, like the views of systems outlined above, one-dimensional and

not sufficiently complex. In our view, the lack of grounding of all of the systems approaches or "ways of thinking" has blocked its further as a way of gaining further insights into nature. Thus the "systems thinking" in this case assumes *ab origine* a mathematical structure of reality which it may not have, or have only in the case of simple processes that take place "spontaneously", that is are highly linear.

Morin's system of logic, dialogic, which is often referred to in systems theory bears some relation to that of Lupasco, with whom he was loosely associated. Morin [Mor08] defines a "dialogical principle that allows us to maintain duality at the heart of unity. It associates two terms that are at the same time complementary and antagonistic." However, neither this principle nor the basis for its operation is grounded in physics. The Lupasco Principle of Dynamic Opposition describes not the abstract elements or concepts of complexity, philosophical, political, *etc.*, but the instantiation of the complex elements in reality.

Our working hypothesis is, therefore, that Systems Thinking, even enhanced by the concept of complexity, neither further defines information or how it can be both a constituent and a display and a representation of reality. We will therefore look more closely at the concept of Informational Thinking as an alternate paradigm, its dynamics and the LIR logic of its functioning.

6. INFORMATIONAL THINKING

In his Metaphilosophy of Information, Wu Kun positions information as a critical component of all disciplines, beyond the scientific content specific to them. As a first step in our comparison of Informational Thinking and Systems Thinking, we will establish that in addition to changes that the informational approach implies in science, philosophy and logic outlined above, a new, still deeper critique using the doctrine developed by Wu that employs Informational Thinking is essential for progress throughout them.

As noted in the Abstract, this paper is a result of the cooperative effort between the authors that began following the Beijing FIS Conference in 2010. We found that the conjunction of Wu's Basic Theory of the Philosophy of Information and Brenner's Logic of and in Reality could lead to the following formulations of the relation between complexity, structure, emergence and information:

1. Informational structures and systems are not static objects, but processes with causal efficiency constituted by patterns of energetic, interactive relations following the Principle of Dynamic Opposition.
2. The most important characteristic of complexity is as an expression of the set of micro-variable relational interactions leading to new, macro-variable (emergent) relational structures that constitute information.
3. Information is the displayed form and has the level of existence of what is encoded in the patterns that constitute these relational structures and their emergent holistic properties.
4. Everything in the world is connected to everything, not only by positive relations, but by negative relations or relations of absence in Deacon's terms.

Further consequences of the application of LIR to Wu's conception of the nature and role of information will be seen in the remaining Sections of this paper.

6.1 The Reconstruction of Phenomenology

Wu again expressed his views of the critical role of information in 2011 [Wu11]. Basically, in the light of information theory, the weaknesses of modern philosophy, from Kant through Husserl become apparent. It is the existence of information, even more than, but in concordance with, the logic of and in reality (LIR), that breaks the traditional absolute separation of subject and object. Although Husserl found a way of beginning to describe the reality of consciousness, his one-dimensional phenomenological reduction maintains, in another form, the disastrous (for human society) polarization of standard bivalent logics. As a hermeneutic process, Husserl's bracketing is thus fundamentally flawed.

In place of standard phenomenology, Wu proposes an informational ontology in which we as humans have (self-evidently) access to "things-in-themselves". He emphasizes that his philosophy of information and logic in reality are not phenomenology because phenomenology is the subjective intent of interpreting the structure of the world. We live, however, also as indicated in the dialectics of Lupasco, by adhering to route on which "the natural noumenon's own movement explains the world". Articles in the major 1999 compendium, edited by the important figures of Petitot and Varela [Pet99], *Naturalizing Phenomenology* fail to reach the minimum complexity required.

We have come to the conclusion that while functional and operational definitions of information have their role to play in practical applications, they also fail to capture both the intrinsic dynamics of complex processes and the nature of information itself which is instantiated in them. It is thus, fortunately or unfortunately for some, that, for example, for the understanding of knowledge and knowledge propagation, drastic modifications of points in standard epistemology, also foreseen in LIR, have to be made. Information in the new epistemology that is to be developed provides the indication of indirect existence even as it exemplifies indirect existence, and its consequences for the emergence of new entities and meaning, in the contradictorial relationship that is formalized in LIR.

Using an informational paradigm illuminates work such as that of Lakoff and Johnson [Lak99] on "The Embodied Mind", in which the physical and physiological structures of the mind and body interact in an informational complex which Wu calls the informosome. To talk about information at any but the lowest computational level requires attention to the entire objective dynamics and subjective idiosyncratic patterns, consistencies and inconsistencies, styles of the human actors involved in its generation and reception, and its historical dimensions, and so on.

This is a difficult task for science, but it is a more correct position from which to start than by eliminating the complex informational properties of existence from consideration. To quote Wu: "Informational activities have their origin not in the pure "life world" of an idealized subject, but in the objective world of their own interactive existence and evolution." One must maintain in the forefront of one's mind the synergism between the physical form and the informational form and the rules of their evolution to fully understand their unified relationship.

Logic in Reality provides a formalism for discussing the "intertwining" of internal and external, present and potential (or absent) awareness and interactions, the "subjective active and the objective passive", ultimately of man and nature in their unity-in-duality noted by Hofkirchner. To repeat, it is the construing of these ideas in informational terms, in the interactions between the forms of information outlined in Section 2.2, their requirements and

mutual constraints, which Deacon has now analyzed in depth, which provide the new and necessary multi-dimensional framework for the "leap forward" in understanding the world.

Application of the philosophy of information thus brings out the ontological domain of indirect existence as part of total existence, something that is objective, complex has meaning and value and thereby constitutes the elusive thing-in-itself that does not require further empirical proof in the reductionist classical sense.

6.2 Wu's Metaphilosophy of Information. Informational Thinking

As Brenner discussed for the first time in at the Conference in Varna in 2011, it is perhaps a first indication of an approaching maturity of the field of information that, based on the contribution of Wu Kun, one can begin to talk about a metaphilosophy of (a theory of) information. One of the consequences, however, is that the comprehensive nature of such a metaphilosophy establishes the role of those involved as a socio-political role, involving them in the social and ethical aspects of the informational components of existence.

The Metaphilosophy of Information, then, requires attention to the informational aspects of complex processes as a methodological necessity, in a process that Wu calls Informational Thinking. Informational Thinking *(IT)*, as conceived of by Wu, refers to a way of grasping and describing the essential characteristics and attributes of things by reference to the structure and dynamics of the information involved in their evolution, from their historical origins to future possibilities and probabilities. This strategy involves something like a Husserlian bracketing of the details of any complex process to consider the ways in which information functions in its dynamics, as well as the dialectical relations between its logical elements as proposed by LIR. However, the difference between Wu Kun's theory and that of Husserl is obvious: the purpose of Wu's original Philosophy of Information is to clarify the nature of the dual existence and dual evolution of material and information in the objective world, starting from the logic of the existence and dynamics of the natural human self. The doctrine of Wu, unlike that of Husserl, does not have to be "naturalized", that is, brought into the domain of natural science[4]. It is already there. Wu then discloses directly the mechanisms of the processes involved in an individual's understanding at the level of the integrated object and subject, with internal and external interactions providing the necessary multi-level objective and subjective mediation.

In this sense, all of the cognitive issues addressed by Wu, especially informational values, valence and social evolution, have implied the use of Informational Thinking for their analysis. *IT* requires the abandonment of thinking in traditional, absolute material terms while retaining its original foundations. *IT* is basically a methodological concept that, *via* the definitions of carriers and codes of information, enables *inferences* to be made about the historical and potential or probable future states of an information system. *IT* dialectically unifies energy factors and informational factors, determinism and indeterminism, internal and external feedback processes, independence (autonomy) and interdependence. LIR provides the additional *logical* structure for the dialectic interpretation of such a unified approach, based as Brenner repeats on the impossibility of any total logical or physical separation between these dualities. In fact, Informational Thinking is the Metaphilosophy of Information in other terms.

To the extent that Informational Thinking requires the consideration of all the philosophical and scientific facets of information, we believe that we are close to a new scientific

[4]As noted, the naturalization of Husserlian phenomenology was the subject of the major 1999 study [Pet99]. Wu's approach eliminates the arduous task of finding natural equivalents for Husserl's transcendental intuitions.

(and logical) paradigm where Informational Thinking, as opposed to thinking in terms of entities, results in new interpretations of, among other things, traditional disciplines and their theories. Above all, we see the (meta-) philosophy and (meta-) logic of information outlined here as a contribution to revealing the essence of information as a natural process. In other words, by seeing the relations between the changes in values that take place in human informational activities and the forms of society, a more profound understanding of information is possible that could be a contribution to overall progress and sustainable development of human civilization. Information Science, Metaphilosophy, Metalogic and Thinking may thus facilitate what Wu calls for, namely, a change in the commitment to and the interpretation of the dynamic oppositions in all complex natural processes in informational terms.

Through the study of information as one of the most basic features of existence, and the formalization of informational activities, the Metaphilosophy of Information of Wu can and should change the way basic philosophical – metaphysical, epistemological and ontological – issues are discussed. The Philosophy of Information supported by the new extension of logic to the same processes that it discusses, could be a "comprehensive revolution in philosophy", as LIR has been called "an important event in the current revolution in non-classical logics"[He08].

6.3 Informational Thinking *vs.* Systems Thinking

Wu Kun made an analysis of the relation between information and systems theory in 2006 [Wu06] in which he called attention to the limitations of the latter, as well as of the research programs of information science and complexity theory. We have called attention to some of these weaknesses above, to which should be added the insufficient degree to which separations of these theories from one another were established and maintained.

Earlier in his work, Wu saw the importance of systems theory, as it emerged from the work of von Bertalanffy, as well as its relation to information. The objective of his project has been and is neither more nor less than making a start on explaining and transcending the separated research programs of information science, systems science and complexity. We conclude that it is Informational Thinking that will be the most useful, since it includes and goes beyond Systems Thinking as the descriptions of Systems Dynamics which cannot sufficiently capture and reveal the complexity of real processual changes.

In this paper, Wu makes a further comparative study of Informational Thinking (*IT*) *vs.* Systems Thinking (*ST*) as outlined below in part. Logic in Reality, as an initial approach to effecting a rejunction of logic with the dynamics of the real world has been called a revolution in logic. From our point of view, the implied changes proposed by Wu, if reasonable, could bring about a "revolution" throughout philosophy and science! The relation to Logic in Reality and Deacon's theory of absence is also noted here where particularly appropriate:

- Ontology
  ST: Basically descriptive, a way of looking at the properties of things in an integrated fashion.
  IT: Basically constructive, establishing new divisions of the extant domain as a dual-existent dimension of direct and indirect existence, bringing about the integrative and fundamental transformation of philosophy and other disciplines.

- Epistemology
  ST: Provides a methodology for grasping cognitive activities.

IT: Embodies mechanisms for complex innovative thought, illustrating the integrative emergent complex process and mechanism of multi-level objective and subjective mediation of the generation of cognition.

- Theory of Evolution
  ST: Useful contributions to biological evolution and in fact the evolution of the material world in general in terms of levels (cf. Nicolescu).
  IT: Broader, principled basis for the dual evolution of matter-energy and information. The description in terms of levels of dynamics by Deacon is compatible with this informational approach.

- Space-time
  ST: Uses essentially standard notions of background space-time in an Einsteinian universe.
  IT: Establishes a new internally unified view of space-time as the transformation and condensation of information in interaction, which is in fact a mutual transformation of space-time, compatible with the Lupasco contradictorial picture. (The correct model of the universe to be used may be closer to a De Sitter universe, cf. Carroll, *From Eternity to Here* [Car10].)

- Value
  ST: No internally defined conception of value (no "best" system).
  IT: A natural duality theory of the value of information and matter as nature and emerging from nature. Similar to but more humanistically formulated than in Floridi's *Philosophy of Information* [Flo10].

- Social Development Theory
  ST: Captures much of the complex structure of society.
  IT: Has an interpretive function that integrates informational developments with the essence of human society and its evolution, and from the dimension of information activities, establishing the essence of human society and its criteria of evolution.

- Economic Development Theory
  ST: Has, as above, the capability of describing informational activities as economic facts.
  IT: Can constructively relate all aspects of information production and human productivity to an underlying process of creating an informational world.

- Scientific Research. The Transformation of Science and Philosophy
  ST: As indicated, Systems Thinking is a valid way of focusing on and solving problems related to defined complex cognitive entities at biological, cognitive and social levels of reality.
  IT: Informational Thinking is a global system (sic) of understanding the world in as a set of informational terms that extends from fundamental physics and

metaphysical concepts (*e.g.*, determinism and indeterminism) through to complex behavior patterns of individuals and groups. Unlike *ST*, *IT* provides a new informational paradigm for the overall fundamental transformation of both traditional and modern scientific ones. The informational paradigm generated leads to a new modern scientific system oriented by it, which Wu presented and foretold in 1995, when he described the tendency as an "informational rescientification (or naturalization) of science itself"'.

- Systems Thinking and Informational Thinking
  ST and IT: As implied above, *IT* not only includes *ST* as it is currently conceived but goes beyond it, much as transdisciplinarity goes beyond multi- and interdisciplinarity.

In the spirit of LIR and this paper, no invidious message of *exclusion* is intended here; as perspectives on knowledge, *ST* and *IT* too are related dialectically, and one can look, for example, at the interactive patterns of organizational structure and relational networks with a greater or lesser emphasis, depending on the objective, using the informational philosophical underpinning that Wu's new illustrations of existence can provide. Nevertheless, it is Informational Thinking, its logic (LIR) that is primitive and provides the framework for an improved understanding of systems. To this we may add the necessary comprehensive complexity of *IT*. We might thus even formulate a "Law of Requisite Complexity", something like Ashby's Law of Requisite Variety, that says that there is a minimum number of perspectives that must be included in any explication of biological, cognitive or social processes. Information is then the "glue" that enables the operation of all the perspectives to be perceived and processed.

In view of the rich space of possibilities for advances in philosophy and science offered by the concepts we have defined of Information Knowing and Informational Thinking, we hope that it may be possible to move the focus of debate away from the details of the formal, mathematical conceptions of information toward a more holistically natural, human, social, approach. Wu's term of the "informational rescientification of science" is not intended to exclude any less rigorous criteria for the physical and logical validity of our system increasing the required degree of scientific and ethical responsibility by its practitioners. But, we should realize, only that standard conceptions are *a priori* inadequate for this purpose.

In his new and remarkably honest book *Who's in Charge?* [Gaz11], the neuroscientist Michael Gazzaniga, in discussing the relation between the appearance of free will and the science of the brain, states that "a unique language, *which has yet to be developed* (emphasis ours), is needed to capture the thing that happens when mental processes constrain the brain and *vice versa*", a vocabulary for describing the interactions at the interface of our layered, hierarchical existence. We conclude by hoping that the informational thinking and attitude described in this paper may stimulate the development of such a language, both in neuroscience and elsewhere.

6.5 The Informational Stance

As suggested elsewhere, the approach of Informational Thinking proposed in this paper further describes an attitude or stance, the *Informational Stance*, a philosophical position and attitude that is most appropriate for, and above all not separated nor isolated from, the emerging science and philosophy of information itself. The Informational Stance [Sag09] is an attitude that

requires attention to the informational aspects of complex processes as a methodological necessity that goes beyond its empirical epistemological formulation by van Fraassen.

The Informational Stance that we describe eliminates the necessity for even the points of empiricism that Ladyman would like to retain in his scientism, namely, "disdain for demands for explanation" and "the hostility to non-naturalistic metaphysics". Our theory supports his idea that "we should have a metaphysical picture of the world to discipline scientific methodology, and science and education policy", and we note, as originally formulated by Wu, the non-separability of metaphysics, epistemology, value theory and social issues. We view the Informational Stance as an interactive process, in which the human individual or group is engaged morally and politically, as well as being an epistemic observer in the standard philosophical sense. In fact, consistent with our overall logical approach, it is not necessary to make absolute separations between informational stance, thinking, philosophy and the ethical dimension. It is rather an integrating position with alternating focus. The right integrative property enables complexity, because the origin of the basic emergent character of complexity is an integration, for which is needed only the prior multiplicity of difference and identity. Of course, emergence occurs not only at the integrative level, but also at the partial level, when the informational dimension is introduced, producing the holographic property of the general informational nature of entities (the informosome).

7. CONCLUSION AND OUTLOOK

We have presented the consequences of the application of the major body of work on the foundations of information science and philosophy that are possible based on the work of Wu Kun. We have related this work both to prior standard theories of information and to new promising work on the dynamics of complex real processes by Terrence Deacon. As we have suggested elsewhere, the theories described in this paper may constitute part of a new transdisciplinary paradigm, in which information has a central role, together with but more general than approaches from the systems and complexity standpoints. Application of Wu's Metaphilosophy of Information, supported by Logic in Reality and Deacon's complexification of dynamics could contribute to resolving critical outstanding issues in the field of information.

In our view, it is this perspective, proposed by Wu as early as 1987, that "fills the vacuum" of speculation in previous dialectical philosophy, (including, in a necessary self-criticism that of Lupasco's and the LIR description of processes as constituted by chains of chains of alternating actual and potential implications).

As we have shown, thinking of processes in terms of systems provides a first insight into the evolving energetic relationships of their elements. The logic of energy of Lupasco, as extended in Logic in Reality, describes this dialectic evolution. Informational Thinking, however, involves grasping and describing the essence, features and properties of such processes, their interactive patterns of organization, relational structure and patterns of evolution in informational terms. It depends on a view of information as a kind of basic existence which, in a dialectic that only Logic in Reality permits, both differing from and being compatible and containable within a conception of pure "quality" and energy. These complete the basic world picture by taking into account and decoding their historical relations, current states and future tendencies in which all these material-energetic structures and relations are viewed as carriers or codes of information. The "resymbolization" of objects corresponds to the varied knowledge and knowing systems created by cognitive subjects, whose views of these aspects, theory, principles,

explanations and forms of activity together constitute the basic state and method of Informational Thinking.

7.2 The Consequences for Man and Society

The superiority of thinking centered on information in contrast to thinking centered on systems, Informational Thinking, (by which we include the informational attitude or stance), over Systems Thinking, can be brought out by reference to the development of a coherent ontological conception of one's place in the world. This is, philosophically an alternate to a Husserlian phenomenology based on transcendental subjectivity. The fundamental shift of philosophy toward a valuation of what one might call *immanent/transcendent realism* was analyzed by Wu Kun in 2011 [Wu11]. As he writes, "the revolutionary significance and value of information has gone beyond all previous theories of traditional philosophy". The term Information Society, where information has been understood primarily in a limited pragmatic sense, may be becoming devoid of meaning as a consequence. Rather, one should perhaps speak of an Information Era as a more historically comprehensive concept.

The justification for Systems Thinking, when well meant, is its orientation toward more effective and just management of a society based on existing principles. When not well meant, the finality is limited to more effective operation of existing, *i.e.*, neo-capitalist economic structures, as can be readily seen in discussions of Systems Dynamics. The Philosophy of Information, like Logic in Reality, on the other hand, can contribute to the morally necessary objective of philosophically grounding of a more just society, in which invidious Manichean distinctions, supported by standard logics even in their modern forms, have no place. It is has taken this long, in our opinion, to see that Kant's rejection of the "thing-in-itself" amounts to a rejection of the other.

It would be naïve to suggest that the inevitable arrival of a new informational society with more democracy and individual freedom would mean that anti-social behavior would disappear overnight, even if Informational Thinking became widespread. This is not a position either of Brenner's Logic in Reality or of Wu's Basic Theory of the Philosophy of Information. What we stress here is only the desirability of independence in the new informational society, which means informational independence of human individuals from *institutions* but relative free will involving *interdependence* of human beings. From a theoretical perspective, free access to information implies the collapse of the centralization of power at the level of social control and organization, and the developing of individual character at the level of individual action. Together, they could help bring about a diversified developing tendency of social, organizational and individual opinion patterns, ways of action and strengthened moral criteria. Facing this tendency, how to mediate the interrelationship between levels of society and people properly, and to adjust and regulate the moral criteria of society and individuals, is inevitably becoming a imperative task.

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