Systems and Information: A Transdisciplinary Study

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This paper summarizes some current views of transdisciplinarity, in particular the theory and methodology of transdisciplinarity in the approach of Basarab Nicolescu. His conception of the Logic of Transdisciplinarity suggests that explicit reference should be made to it in transdisciplinary studies. I first develop this idea in a critique of current systems science and thinking. Nicolescu has stated that transdisciplinarity is not a paradigm. However, transdisciplinary methodology may nevertheless be an essential part of an emerging informational paradigm. In this paper, I claim that in fact information cannot be properly understood without using what is effectively a transdisciplinary methodology. I describe the philosophy of information of Wu Kun and his concept of informational thinking and contrast it with standard systems thinking. In Wu's approach, the philosophy and ethics of information are eminently transdisciplinary. I suggest that transdisciplinary practice and informational thinking are essential ways of furthering the common good.

Keywords*:* attitude, common good, contradiction, information, logic, systems, transdisciplinarity.

1 Introduction

1.1 Transdisciplinarities Today

Since the publication in 2002 by Basarab Nicolescu of his *Manifesto of Transdisciplinarity* [1] and in 2008 of his important compendium *Transdisciplinarity–Theory and Practice* [2], applications of transdisciplinarity in both areas have greatly increased. Organizational networks devoted to transdisciplinary research and publication such as *td-net* in Switzerland, *TheATLAS* and *INIT* provide centralized sources of information and opportunities for exchange of ideas. The major task of transdisciplinarity is generally understood as a new way of potentially correlating scientific capabilities with human individual and social needs. Nevertheless, the scope and value of transdisciplinarity remains problematic for many people.

The difficulty of capturing the complex concept of transdisciplinarity in a single definition - a similar situation obtains with respect to information - is well-recognized. Nicolescu has recently restated [3] his conviction that our formulation of transdisciplinarity is both unified (in the sense of unification of different transdisciplinary approaches) and diverse: unity in diversity and diversity through unity is inherent to transdisciplinarity and its logic. It is thus best to start from the position that there are three major forms of transdisciplinarity: *theoretical transdisciplinarity, phenomenological transdisciplinarity, and experimental transdisciplinarity.*

The word theory implies a general definition of transdisciplinarity and a well-de-fined methodology. Phenomenology is used here to imply the building of models that connect the theoretical principles with observed experimental data in order to pre-

dict further results. The word experimental implies performing experiments following a well-defined procedure, justified when it results in an acceptable level of reproducibility to the scientific community. From this perspective, the work of Michael Gibbons, Helga Nowotny and Atila Ertas can be classified primarily as phenomenological transdisciplinarity, and Nicolescus, together with that of Jean Piaget and Edgar Morin, as theoretical transdisciplinarity. Experimental transdisciplinarity refers to the large amount of experimental data already collected not only in the framework of knowledge production but also in fields such as education, psychoanalysis, medicine, art, literature, history of religions, etc. As Nicolescu states the reduction of transdisciplinarity to only one of its aspects is dangerous because it could transform transdisciplinarity into a set of more or less fashionable doctrines. It should be clear that simultaneous consideration of theoretical, phenomenological, and experimental transdisciplinarity could permit a unified, non-dogmatic treatment of transdisciplinary philosophy, theory and practice, coexisting with a plurality of transdisciplinary models. The three forms of transdisciplinarity, following the Logic of Transdisciplinarity (see below), are by no means totally separated or independent but can and should inform one another.

In the most general way, one may say that the practice of transdisciplinarity consists in application of the theory and methodology of transdisciplinarity to 1) the understanding of the relations between specific disciplines; 2) the solving of specific practical problems and 3) the understanding of the relation of transdisciplinarity to structured human thought, philosophy, logic and epistemology. In this paper, I will focus on the third area, as it may provide a basis for further progress in the usefulness of the transdisciplinary approach.

In the acceptation of Atila Ertas [4], the transdisciplinary model for, specifically, education and research transcends the artificial boundaries imposed by traditional academic organizational structures and directly addresses the problems arising in the satisfaction of human needs, especially in the process of implementation of the major recent advances in science and technology. These in turn are related to the solution of large and complex problems by teams consisting of many people from diverse backgrounds. The essence of transdisciplinary education, research, and development processes lies in the common ground built on the foundation of design fundamentals and process development and management. This "common ground" is a good example of something that "lies beyond" individual disciplines as in the theoretical transdisciplinarity of Nicolescu.

The supporting transdisciplinary philosophy and culture that Ertas calls for has been pointed towards by Nicolescu: a philosophy of the underlying unity of knowledge and a culture of openness and tolerance of opposing views combined with rigor in analysis. These views are restatements of basic ethical principles in other terms, but placing them in the framework of the logic and methodology of transdisciplinarity helps to insure that they are discussed with the adequate rigor. I propose this paper, accordingly, as a contribution to the domain of theoretical transdisciplinarity in the sense of Nicolescu.

1.2 Rationale and Objective of Paper

The basic thesis of this paper is that *if in fact* theoretical and phenomenological transdisciplinarity are to be accepted simultaneously and rigorously, their essential components must also be accepted and used and not only more or less explicitly stated. If, as is often the case, transdisciplinarity is claimed to derive from and/or exemplify theories of systems and information, such claims most be considered vacuous unless the theories concerned embody the necessary features of a relevant transdisciplinary logic and methodology.

In this paper, I will use the term of transdisciplinarity as referring to a complex corpus of knowledge and a set of attitudes constituting an operator that has or can have a *functional* role in human society. I note, however, that Nicolescu has stated clearly that transdisciplinarity is not a paradigm. This does not mean, however, that a transdisciplinary attitude or "mind-set" or transdisciplinary thinking may not be an essential part of or support to a new paradigm that has appeared, namely that of information. I suggest that the information paradigm may be essential for the development of the common good in what has been called the emerging information society.

1.3 Outline of Paper

In the next Section 2, I first present a summary of the methodology and logic of transdisciplinarity according to Nicolescu. This logic is the original

logic of the included third, the major contribution of the Franco-Romanian thinker Stéphane Lupasco (Bucharest, 1900 – Paris, 1988) [5], to which Nicolescu added the features of complexity and levels of reality. My recent restatement and elaboration of that logic [6] is discussed. As an introduction to the discussion of systems and transdisciplinarity, Sections 3 and 4 summarize briefly some additional theoretical work of Lupasco, Section 3 his dialectical methodology and Section 4 his foundational work on the origins of systems in physics, as well as some of the problems in using current concepts of systems, systems science and systems thinking. The alternative, proposed in Section 5, is to use current much deeper views of information theory and science, which turn out to have a close relation to the Logic of Transdisciplinarity. In Section 6, I develop further the concept of Informational Thinking and the role of the philosophy of information. The final Section 7 addresses in more detail questions of ethics and the common good, and in which I show that all three key perspectives – ethical, informational and transdisciplinary - come into play.

2 Transdisciplinarity in the View of Nicolescu

2.1 The Nature of Transdisciplinarity

At the beginning of his *Manifesto* [1], Basarab Nicolescu describes transdisciplinarity as a new philosophical movement. Transdisciplinarity is not to be considered a new discipline, but rather possesses a number of characteristics, and can accomplish a number of things, of which the following are a brief and highly personal selection of mine:

- Transdisciplinarity is a **process** that offers a new vision of nature and reality.
- Transdisciplinarity provides a **platform** for expressing and reinforcing the hopes and aspirations of mankind.
- Through its **logic** of human experience and human intelligence, transdisciplinarity provides a new *approach* to age-old problems and paradoxes of human thought, science and philosophy.
- Transdisciplinarity is a **method** for thinking about the relations and implications between human actions and events and about how to include emotional, artistic and philosophical elements in discussion of solutions to practical problems.

2.2 The Pillars or Methodology of Transdisciplinarity

As proposed by Nicolescu, transdisciplinarity can be described as being supported by three major conceptual "pillars": complexity, levels of reality and the logic of the included middle or third. The general methodology of transdisciplinarity is based on these three pillars, as they have emerged from the study of modern science, especially, of quantum physics, but also of molecular biology and cosmology.

To begin with, an important distinction needs to be made regarding the pillars: they are, and should be considered, as different kinds of things, albeit closely related ones:

- Complexity is a *property* which is exemplified or attached in some way to its instances, the things or systems that are complex, and to a certain extent codified in the *discipline* of complexity science, the study of complex structures;
- Levels of reality is a *categorical concept*;
- The logic of the included middle or third is a *discipline* as such.

More recently [3], Nicolescu has reformulated the methodology of transdisciplinarity in axiomatic terms, as follows:

1. **The Ontological Axiom**: *There are, in Nature and society and in our knowledge of Nature and society, different levels of reality of the Object and, correspondingly, different levels of reality of the Subject.*
2. **The Logical Axiom**: *The passage from one level of reality to another is ensured by the logic of the included middle or third.* (Such a passage implies to me a dynamics, that is, a real energy flow that takes place at both the lower physical and higher cognitive levels.)
3. **The Complexity Axiom**: *The structure of the totality of levels of reality or perception is a complex structure: every level is what it is because all the levels exist at the same time.*

The first two get their experimental evidence from quantum physics, but they go well beyond the exact sciences. The last one has its source not only in quantum physics but also in a variety of other exact and human sciences. All three are in agreement with traditional thinking present on the earth since the beginning of historical time. It is for this reason, among others, that I believe that Nicolescu considers it is inappropriate to talk about transdisciplinarity as "paradigm", a term developed by Thomas Kuhn in the 1970s to apply to distinctions between current social and natural science.

For the purposes of this discussion, I suggest that above Axioms of levels of reality have two major aspects:

- In our *knowledge* of Nature and society, according to the ontological Axiom, what Nicolescu defines as the transdisciplinary Object and its levels of Reality, the transdisciplinary Subject and its levels of perception, and the Hidden Third define the ternary transdisciplinary *model* of reality.
- Nature and society themselves, however, following the logical Axiom, also define subjects and objects linked causally by the Lupasco Principle of Dynamic Opposition that also defines a ternary *structure* of reality.

Based on these ternary models and structures of reality, one can deduce other ternaries of levels that are extremely useful in the analysis of concrete situations by contextualization. Nicolescu provides the following list, which I have separated in two for purposes of discussion. The placing of a) in both groups is intentional:

- Logical
  a) Levels of objectivity – Levels of subjectivity – Levels of complexity
  b) Levels of organization – Levels of structuring – Levels of integration
  c) Levels of confusion – Levels of language – Levels of interpretation
  d) Physical levels – Biological levels – Psychical levels
- Ontological
  a) Levels of objectivity – Levels of subjectivity – Levels of complexity
  b) Levels of knowledge – Levels of understanding – Levels of being
  c) Levels of materiality – Levels of spirituality – Levels of non-duality

In the remainder of this paper, I will be focusing on the analysis of the phenomena of systems and information with reference to the *Logical Axiom* of the methodology of transdisciplinarity. For this purpose, we will need to look more closely at the Logic of Transdisciplinarity (LOT) itself. I wish to make it clear that all further references to LOT in this paper refer to the Nicolescu acceptation of transdisciplinarity. (It is difficult to conceive of a specific non-standard logic of phenomenological transdisciplinarity in the Gibbons-Nowotny construction. The dynamic elements of this theory are essentially classical, and standard logic is, accordingly, applicable to them.)

2.3 The Logic of Transdisciplinarity and Logic in Reality

In Nicolescu's most recent summary of the Logic of Transdisciplinarity [3], the emphasis is on the major revision of the 3rd Axiom of Aristotle by Lupasco to allow a third term T (the "T-state") which is at the same time A and non-A. This existence of this third term is completely clarified once the notion of "levels of Reality", not existing in the works of Lupasco, was introduced by Nicolescu. In Nicolescu's view, "If one remains at a single level of Reality, all manifestation appears as a struggle between two contradictory elements. The third dynamic, that of the T-state, is exercised at another level of Reality, where that which appears to be disunited is in fact united, and that which appears contradictory is perceived as non-contradictory. It is the projection of the T-state onto the same single level of Reality which produces the appearance of mutually exclusive, antagonistic pairs (A and non-A). A single level of Reality can only create antagonistic oppositions."

In addition, however, Lupasco clearly described a modification of the 2^{nd} Axiom, that of non-contradiction, by seeing the elements of a real system in opposition as partially actual and partly potential, in what he called contradictorial conjugation. The elements are what would be called today conjugate variables in a system of non-standard probabilities (the limits are > 0 and < 1). Thus the antagonistic oppositions remain, without self-destruction, exactly

because they are, as Nicolescu says, connected to a higher level of reality. A and non-A are indeed present at the same time but only to the extent that when A is actualized (but always less than 100%), non-A is potentialized (but always less than 100%), alternately and reciprocally, unless and until conditions favor the emergence of a new entity from the T-state. I have proposed this modified interpretation as a Logic of and in Reality (now, LIR) first in a paper presented at the 2nd International Congress of Transdisciplinarity in Vitoria, Brazil in 2005 and in the Nicolescu Compendium [7]. The differences, very briefly, in the two approaches is that Nicolescu looks "upward" toward the ontological included middle and the Transdisciplinary Subject and Object and further toward the hidden included middle, while LIR remains as a logical tool for the explication of the evolution of complex real processes and systems, such as those involved in information.

The view expressed of transdisciplinarity and its relation to a logic is supported by Roderick Lawrence in his paper "Transgression of Disciplinary Frontiers" [8]. In particular, he cites the statement by Thierry Ramadier that "the specificity of transdisciplinarity consists in simultaneously integrating *two contradictory movements* (emphasis mine) of disciplinary logic, that is, the fragmentation of knowledge and the relation between the "fragments", in order to do research into the connections possible between the (forms of) knowledge produced". These are the kinds of movements to which the Lupasco logic and LIR apply.

2.4 Logic in Reality and Information

The best expression of the situation is thus perhaps to say, in the spirit of the original dialectics of Lupasco, that Logic in Reality (LIR) and the Logic of Transdisciplinarity (LOT) are the same *and* different. LOT reproduces the original change proposed by Lupasco in the third of the three fundamental axioms of Aristotle; LIR does also but restates Lupascos Principle of Dynamic Opposition (POD) as three additional axioms. This enables the non-linguistic terms of the Lupasco system to be seen not only as a logic of the included middle (or third), but also as a logic of conditional contradiction and a logic of emergence of new entities. I have included functional references to Logic in Reality, and thus indirectly to Lupasco and the Logic of Transdisciplinarity in a series of recent papers [8], [9] dealing with its application in the field of information theory and philosophy. I will return to aspects of LIR as they become useful in the more detailed discussion of systems and information that follows.

3 The Dialectical Methodology of Lupasco

Lupasco made two major applications of his logic and its principles which are perhaps less well-known but which in my opinion are relevant to the practice of transdisciplinarity. The first of these is outlined in a late book *The Psychic Universe* [11].

The dialectical methodology proposed by Lupasco involves looking, in any process, 1) for the logical elements that are in real interaction or opposition, actively "overlapping" and then 2) to what extent each is actualized and/or potentialized by the other, following the Principle of Dynamic Opposition. It is the physical movement involved in these interactions that are the basis for the existence of systems as discussed below. Lupasco uses the neologism dialectology as the theory of such processes. In this approach, the probability for synergy as well as opposition of the energies involved also exists, resulting in the emergence of new entities at the "T-state" as described by the Axiom of the included third.

I will not follow Lupasco further here in his application of these ideas, unfortunately little detailed, in the areas of psychology, normal and pathological, and religion. To the extent that transdisciplinary methodology involves integration of critical aspects of these disciplines, the use of the Lupasco concepts could also constitute a significant way of organizing them.

4 Systemology. the Origin of Systems in Basic Physical Principles

I have previously discussed Lupasco's "systemology" in [6], but I believe that it is relevant to the applications of transdisciplinarity that are subject of this paper and summarize them briefly here. The originator of General Systems Theory (GST), Ludwig von Bertalanffy [12], 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, and failed to see beyond differential calculus, the basis for current so-called Dynamic Systems Theory, as a basis for systems theory.

In one of his last articles, "The History and Status of General Systems Theory" [13], von Bertalanffy wrote that ultimately all the boundaries of real objects are dynamic rather than spatial. "Hence an object (and in particular a system) is definable only by its cohesion in a broad sense, that is, the interactions of its component elements".

Totally independently of von Bertalanffy, despite the fact that they were contemporaries, in his "Notions of General Systemology" [14], Lupasco set forth the principles underlying all of his work in terms of systems. These principles constitute an alternate expression of his non-propositional, non-truth-functional logic that enables an interpretation of the dynamics of "cohesion and interaction".

4.1 Axiomatic Statements

4.1.1 The Relation of Antagonism

Lupasco's first axiomatic statement is that systems are not possible if there is no force of repulsion or exclusion between elements which prevents their "agglomeration" into an undifferentiated mass, and not possible if nothing attracts or associates two or more elements; they all fly apart, so to speak. (I consider here that repulsion; exclusion and dissociation are equivalent terms.)

Accordingly, for a system to form and exist, its constituents must be able, at the same time, both to attract and repel one another, associate and dissociate, integrate and disintegrate. The constitution and evolution of every system, be it nuclear, atomic, molecular or at the level of the macroscopic objects of our senses is always a function of this relation of linked antagonistic or opposing forces, constituting a relation of antagonism. Systems which tend towards an equality of tension, such as hadrons, will be more stable and resistant to disintegration than those in which one dynamism is heavily favored over the other.

4.1.2 The Relation of Contradiction

The second axiomatic statement has a similar form: a system is not possible if all the constituents or elements involved are strictly identical, strictly also meaning with relation to their location and configuration in space-time. They would be "confounded" in the same continuity or homogeneity. No system is possible, either, if all elements are totally heterogeneous, without some degree of homogeneity that would prevent this diversity not only from not being a system, but not even a class or set.

Every system thus implies at the same time homogeneity and heterogeneity, identity and diversity. The relation of contradiction is maximal as identity and diversity approach equality, as in the notation by Lupasco for "systemogenesis" [6].

4.1.3 The Principle of Antagonism applied to Energy

The third axiomatic statement is that every real system requires the energy involved in its dynamic relations in order to exist. All its constituents and elements, according to the equivalence of mass, energy and information, must consist of energy. Lupasco developed his "logical algebra of energy" with the addition of another key concept. Every energy (or phenomenon) passing from a potential state to an actual state finds itself necessarily, at a certain moment in an intermediate T-state (see above), where it conflicts with the antagonistic energy passing from a state of actualization A to one of potentialization P. This is an alternative statement of the Axiom of the Included Third.

Each of the three elements (A, P, T) is an antagonistic energetic duality or alternatively an antagonistic conjunction. Each is a system, and all more complex systems are generated by concatenation of such antagonistic dynamisms. Logical systems of energy thus apply to all phenomena or aspects of experience, from microscopic to macroscopic, since antagonism and contradictory values are irreducibly constitutive of all real events. These logical systems are the basis for the generation of systems of systems, formally, by the extension of the concept of actualization, potentialization and T-state to that of implication, considered, with the other logical operators, conjunction and disjunction, as real processes themselves.

In these principles, I see a basis for von Berta-

lanffy's concept of continuous multivariable interactions as well as their modern formulation by Hofkirchner and others of meta-system transitions [15]. Already in 1962, Lupasco related the concepts of feedback and a non-Shannon type of information. Lupasco noted that any cybernetic system has the capacity for *feedback* or "counter-action", initiated by some perturbation. The key point, according to Lupasco, is that the interactions are not only associative and epistemic but physical. In order for real processes to evolve, there must be a driving force that is primitive, and this in fact is a consequence of the existence of duality or polarity at the most fundamental physical level. "Self" - organization can only occur in systems that are already sufficiently complex to have the potential for the organizing process to occur.

In my opinion, these principles exemplify the Logic of Transdisciplinarity and point toward the need to consider its implications in the understanding of the evolution of real complex systems. In particular, in my view, it is the above systems view that insures the foundations in reality of the recursive aspects of complex processes described as loops or circuits (cf. Hofstadter [16] and Morin [17].)[1]

Von Bertalanffy stated that the development of GST could lead to the unification of science, a science of the future that could play a role similar to Aristotelian logic in the science of antiquity. At a Symposium on Lupasco in 2010 [18], I showed that his extension of logic to encompass reality effected a metalogical rejunction, restoring logic to its original role, in antiquity, of a science of nature. A major conclusion of this study is thus that the logical approach of Lupasco might provide a unique framework for accomplishing the task that von Bertalanffy set for his General Systems Theory. Logic, in the extended Lupasco sense, could be an integral part of what is now called Systems Thinking (see below Section 4.4).

[1]David Pouvreau has studied the importance given by von Bertalanffy to mathematics in the GST. In my view, although standard mathematics is necessary, it is not sufficient to capture all of the non-Boolean, non-Markovian aspects of systems. This is where the Lupasco approach may be useful. However, to make a satisfactory comparison, a mathematization remains to be made, in more familiar terms, of Lupascos calculus of chains of chains of implications as describing the evolution of real processes.

4.2 Systems Science and Complex Systems in Morin

Edgar Morin has given his own, highly personal and humanistic readings of systems theory since its codification by von Bertalanffy. He has developed his own logical framework, dialogic, and showed how it can apply to complex phenomena, leading to his fundamental principle of complexity – the ecology of action – in a new epistemology of complexity (see also Section 4.5 below). The relation between complexity and dialogic is that the latter is one of the principles of the former: the dialogic principle allows us to maintain duality at the heart of unity. It associates two terms that are at the same time complementary and antagonistic.

Another expression linking systems and complexity is that "extremely complex systems (are those) where the part is in the whole and the whole is in the part". One is beyond holism and reductionism in a recursive relational circuit in which parts and wholes "explain" one another, neither term being reducible to the other (Morin's "holographic" principle of complexity). Three terms, for example species, individual and society, also can refer to one another in a circuit that itself is the true system: its three terms are at the same time concurrent and antagonistic.

Morin collaborated with Lupasco and Nicolescu, in the foundation of the International Center for Transdisciplinary Research in 1984, and it was primarily Nicolescu, after Lupascos death in 1988, who made the major effort to develop the critical notions of theoretical transdisciplinarity.

Unfortunately, neither Nicolescu nor Morin has reviewed the notions of Lupasco summarized above of a general dynamics of the origin of systems. Systems science developed after General Systems Theory from the interaction of standard information theory and cybernetics. One definition of *systems* science is therefore the following[2]: "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

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

a complex totality."

Systems science thus overlaps 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 I have proposed as necessary to explain the functioning of such organization, as well as the ambiguity in the term 'self'.

As stated at a Congress in 2005[3], 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 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 a superficial resemblance to Lupasco's principles. 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. 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. As I have shown, however [6], 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.

[3]6th European Systems Science Congress, Paris, September 19 – 22, 2005.

4.3 Systems and Emergence

By taking a minor step back from the debates about systems, emergence and complexity, it becomes fairly obvious that they are not independent concepts but that their usual definitions are closely entangled, not to say circular. 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, I cite the work of Minati, Penna and Pessa [19]. 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. In the view of LIR, real-world processes are emergent not, or not only in an epistemological but also in an ontological sense.

4.4 Transdisciplinarity and Systems Thinking

Systems Thinking, like phenomenological transdisciplinarity, has been defined primarily as an approach to problem solving: it views 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 of standard analysis are clear.

In practice, two things are missing that are necessary, in my 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. I suggest that this has in fact been provided by the Lupasco systemology. The second is a proper conception of how the *qualitative* properties of systems may be expressed.

In her 2005 paper, Debora Hammond [20] 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 GST that emphasizes a more holistic and humanistic approach to knowledge and practice, while deploring the fact that such an approach has not materialized.

I 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". I of course consider the Lupasco grounding of systems in the inherent physical antagonisms of matter-energy, formulated in 1962 [13] as one such approach.

On the other hand, the approach of one of the most influential systems thinkers, Peter Senge [21], amounts to not much more than an exhortation to look at the "whole", at 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.

Hammond's statement of objective 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." She proposes that it will be some form of new thinking emerging from the *new informational paradigm* that will suggest new ways of accomplishing this integration, despite the difficult de-fragmentation of knowledge that must take place. I consider this an excellent expression of one of the tasks facing transdisciplinarity.

Azad Madni has stated that what distinguishes transdisciplinary system science-oriented thinking from traditional approaches is that transdisciplinary thinking emphasizes lateral or associative thinking [22], often relying on metaphors and analogies to enhance problem understanding. In particular, transdisciplinary approaches employ integrative (or synthetic) problem solving as opposed to analytic problem solving typically employed by reductionist approaches. He compares and contrasts analytic and synthetic problem solving that underlie traditional (reductionist) and transdisciplinary (holistic) approaches. In the view developed here, these considerations are necessary but not sufficient. If the language used is of an opposition only with separation, it can lead only to persistence of a philosophy of separation. The reciprocity of reductionism and holism was noted early by Hofstadter [16], but it failed to yield useful further results in the absence of a framework for comprehending their interactive dynamics.

4.4.1 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 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, Sören Brier [23], clearly shows 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.

4.5 Complexity

It is often suggested that notions of complexity provide substantial additional insight into the nature of systems and real processes. 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. I 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.

From the LIR standpoint, the Morin notion of complexity suffers from being, like the views of systems outlined above, 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 as noted he had been associated. To repeat, Morin [17] 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.

My tentative conclusion is, therefore, that Systems Thinking, even enhanced by this concept of complexity, neither further defines information or how it can be both a constituent of reality and a display or representation of reality. We will therefore look more closely at the concept of information as a domain to which the application of a transdisciplinary approach may be fruitful, and which may in turn inform concepts of transdisciplinarity.

4.5.1 Simplexity

Although this overview cannot mention all current work that tends to confirm the relevance of Lupasco's vision to transdisciplinarity, I should mention briefly that of Alain Berthoz [24]. Berthoz was driven to the concept of what he calls simplex systems by observation of the way in which neural processes operate cooperatively, integrating spatial and temporal elements. The body finds simplex solutions to problems that more rapid and efficient by "detours" through (configuration) spaces of higher complexity. Berthoz insists on the modularity of the simplex responses at the level of body and mind, as a way of simplifying the necessary neurocomputations.

Berthoz feels it necessary to "oppose" the concepts of simplexity and complexity, but this should not detract from the significance and utility of either. The preferred methodology would be to relate complexity to simplexity, dialectically, as situations in which simplexity can emerge from complexity and *vice versa*. This is, of course, where concepts from the Logic of Transdisciplinarity are useful in the discussion of the dynamics of the changes involved. Nicolescu has shown [1] that there are degrees of transdisciplinarity. Thus, to the extent that simplexity instantiates a higher level of reality than complexity, one may say that it is "more' transdisciplinary.

Berthoz concludes with a *credo* that I feel can be useful for anyone convinced of the importance of transdisciplinary thinking (my translation): "Simplexity is a way of living with one's world. It is elegance rather than sobriety, intelligence rather than cold logic, subtlety rather than rigor, diplomacy rather than authority ... It is adaptive rather than normative or prescriptive, probabilistic rather than deterministic". These ideas are of course related to prior work by Sartre, Merleau-Ponty and Morin, as well as Nicolescu, but using, that is taking the best parts of complementary views is itself a form of simplexity.

5 An Informational Paradigm

5.1 Transdisciplinarity and Information

By any definition, the domain of information, consisting of information theory, science and technology is clearly transdisciplinary. The disciplines involved include (at least) philosophy, epistemology, mathematics, logic, psychology, electronics, computer science, electronics and the social, political and economic sciences. This being so, the difficulty of trying to capture information within a single definition or category is understandable.

In the view which I have expressed, [25], information is best viewed as a conjunction of the energetic processes involved in the transmission and reception of meaning and that meaning, such that information cannot be separated from the underlying physical processes of its generation. If this hierarchical picture is partially correct, however, information is constitutive of the disciplines but not reducible to them, since it is present in all human activities, creative, emotional and so on. We may thus say that information is something that lies within, between and beyond all disciplines, a phrase that exactly parallels the Nicolescu definition of transdisciplinarity.

The first corollary of this position, following my thesis as expressed in the Introduction (1.2), is that the logic of information and the methodology of understanding its operation might be something like those of transdisciplinarity; in particular, the logic of the included third or Logic in Reality (LIR) should be applicable. Applicable here means permitting stable inferences about the evolution of the concepts, processes and events under consideration, provided they are sufficiently complex for their elements to be in some dynamic, interactive relation.

5.2 What is Missing from Theories of Information?

There is general agreement that information is a complex but perhaps unifying concept that nevertheless comes in a wide variety of forms. One version of the problem is that information clearly has an energetic substrate that can in part be quantified (bits), but it has proven difficult to explain its being somehow associated with a qualitative, higher level of meaning dependent on its interpretation by a receiver, human or other. The current set of assumptions about its nature, still based largely on computational extensions of Claude Shannon's original ideas, is sufficient to explicate its minimal physical characteristics but insufficient to define its representational character or its functional, qualitative and normative value.

Terrence Deacon has proposed a new approach to information as a process instantiating a complex dynamics that starts with thermodynamics and continues throughout higher ontological levels of form (morphodynamics) and intentionality (teleodynamics). In his *Incomplete Nature* [26], Deacon extends a thermodynamic concept of energy derived from statistical mechanics to yield a description of complex processes in which *absence* plays a critical role in the emergence of living systems, mind and information. Deacon shows how an *interactive* operation of both Shannon entropy and Boltzmann entropy must be taken into account in information. (The title of this Sub-Section is that of another important paper by Deacon [27].)

Deacon shows that the hallmark of information processes is its absent content, a resultant function of their necessary physicality, and LIR shows that presence (actuality) and absence (potentiality) in such processes must be related dynamically. While the importance of a concept of absence for information was indicated by Marijuan and others some ten years ago, it is Deacon's detailed current development that now calls for our attention.

Due to its own rigorous ascent from the properties of matter-energy as first described by Lupasco, Logic in Reality provides a reconciliation of the logic of physical science and the logic of living and mental teleology and can link energy, form and information, using potentialities to achieve teleological properties from unambiguously non-teleological starting points. 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 that information is primitive to matter-energy ("it from bit") have been profoundly misleading.

The relation of modes of information to meaning, Deacons approach to dynamics and Logic in Reality (LIR) accomplish several objectives: first of all, they ground and extend a concept of the relativity of information, in that information is not only not an invariant quantity, but a process or set of processes of processes. In this concept of information, biological or cognitive meaning is defined by interaction with the context (or environment) that interprets the

information.

From the perspective of this paper, information or better information-as-process becomes an integral part of a broader transdisciplinary view of both knowledge and the finality of knowledge. Let us now look more closely at how information can be related to the discussion of systems above.

5.2.1 Information and Communication Technologies (ICTs) and Society: A Transdiscipline

Before leaving the domain of information *per se*, readers of this *Journal* may be interested in the recent work in both information and the ICTs by Wolfgang Hofkirchner and his associates in Salzburg and (now) Vienna. Their concept that the study of the emerging theory of the information society is transdisciplinary, and in particular the new field of research in the Information and Communication Technologies (ICTs) and Society is a transdiscipline, was proposed in 2007 [28]. In my opinion, this paper is completely consistent with the functional definition of a transdiscipline in the basic charter of ATLAS [4].

By the term transdiscipline Hofkirchner et al. mean something distinct in two respects: its scientific status and its potential societal function.

a) Scientific Status

As regards the scientific status of the field, the concept of a transdiscipline does not mean a mere combination of existing disciplines but a transgression of the traditional borders of the participating disciplines and thereby their transformation into something new with its own identity insofar as it disposes of its own terminology overarching the terminologies of the single disciplines it departs from. A transdiscipline therefore is expected to bridge several gaps: the gap between the two cultures of (natural) science and social and human sciences as well as the gap between specialists and generalists and the gap between applied research and basic research. It is the result of a process that departs from mono- or multidisciplinarity and transcends interdisciplinarity.

b) Potential Societal Function

If it is the aim of an as-yet-to-be-developed science of and for the Information Society to help govern society when confronted with the well-known global challenges, it is the aims of transdisciplinary ICTs-and-Society research to contribute to shaping ICTs so as to help bring about a Global Sustainable Information Society (GSIS). A GSIS can be defined in a normative way and the ICTs can be assessed according to how they facilitate society to live up to these values. This is in sharp contrast to either undertaking research solely for reasons of curiosity or being instrumental to whatever is demanded by parts of society. In contrast to the ideology of value-free science, here the normative criteria are laid down to which ICTs as well as society should be subject. A state of future society is envisioned in which these criteria are met.

Hofkirchner argues that to the newly established field of ICTs-and-Society research must thus inhere transdisciplinary features, if it is to 1) be critical of current socio-economic developments; 2) aim for the establishment of a GSIS (global sustainable Information Society); 3) tackle the complex problems of society and technology; and 4) use social-scientific and technological, empirical and theoretical methods in a proper way.

As I have discussed elsewhere [29], the Logic of Transdisciplinary, as expressed in Logic in Reality, supports this transdisciplinary view in general. LIR supports further integrative ITC assessment and design approaches that incorporate a normative view of technology and society. There is no place in LIR for value-free science; the practitioner is *always* involved logically with the material substrate of his science, whose dynamics and properties he partly shares. As clearly stated by Hofkirchner *et al.*, a normative approach requires "doing justice" to what is normative and factual, actual and potential.

The term "transdiscipline" should thus be adopted in discussions of transdisciplinarity where it brings out better the issues under discussion. The conclusion of an on-line debate on this question [30] in regard to ICTs-and-Society was generally favorable. Whether the use of the term conflicts with a definition of transdisciplinarity which is also supposed to be beyond *all* disciplines is for me a secondary question, perhaps best answered pragmatically by reference to transdisciplinary openness itself.

6 The Philosophy of Information. Informational Thinking

6.1 The Reconstruction of Phenomenology

Support for this picture of information, in which what is ultimately the logic of Lupasco plays a central role comes from recently published work in the area of the philosophy of information by Wu Kun [31] At the heart of Wu's theory is a necessarily alternative worldview that emphasizes its relational and process aspects completely in the spirit of Lupasco's (*toute est relation*; everything is relation). We move from a quantitative, "technological" conception of information to what may fairly be called a transdisciplinary one.

In his Metaphilosophy of Information, Wu Kun positions information as a critical component of all disciplines, beyond the formal content specific to them. A summary of his views in English can be found in [32]. 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 Transdisciplinarity, 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. From a Lupascian standpoint, Husserl's bracketing is thus fundamentally flawed as a hermeneutic process.

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 Jean Petitot and Francisco Varela [33], *Naturalizing Phenomenology* fail to reach the minimum complexity required. The implications of this view for phenomenological transdisciplinarity are most interesting, but outside the scope of this paper.

While standard functional and operational definitions of information have their role to play in practical applications, they fail to capture both the intrinsic dynamics of complex processes and the nature of information itself which is instantiated in them. Thus, in the understanding of knowledge and knowledge propagation, drastic modifications of points in standard epistemology have to be made, with consequences for the dynamics of 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 [34] on "The Embodied Mind", in which the physical and physiological structures of the mind and body interact in an informational complex. Many workers in transdisciplinarity refer to some such concept as a way of better describing mind-body interactions in a nonreductive manner. 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, its historical dimensions, and so on. Wu has called this informational complex, constituted by the complete set of all of the informational processes and interactions of an individual, past, present and potential the "informosome".

Taking into consideration the complex informational properties of existence is a difficult task for science, but it is the more correct position from which to start. 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 synergy between the physical form and the informational form and the rules of their evolution to fully understand their unified relationship.

LIR 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 [35]. Application of the philosophy of information thus brings out an ontological domain, which Wu has called that of indirect existence as part of total existence, something that is objective and complex, having meaning and value and thereby constituting the elusive thing-in-itself

that does not require further empirical proof in the reductionist classical sense.

6.2 Wu's Metaphilosophy of Information and Transdisciplinarity

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 new, functional 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 in them in the social and ethical aspects of the informational components of existence. The lack of separability between the informational and transdisciplinary approaches and their complementarity deserves much further work. For now, I will just say that to me the spirit of both forms of thought is similar, without being or having to be identical.

Let us assume, for clarity in the discussion, that there are higher levels of human thought, in the Heideggerian "clearing". Then theoretical transdisciplinarity, in the view of Nicolescu which I endorse, and which includes his concepts of the transdisciplinary Subject and Object opens out into these higher ontological levels of human thought and existence. I will continue the discussion in this paper, however, at the lower logical level of the evolution of complex real processes, essentially concentrating on their immanent aspects.

The Metaphilosophy of Information 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. However, 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 in what I claim is a transdisciplinary configuration. Wu discloses directly the mechanisms of the processes involved in an individuals 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 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 (and logical) paradigm in which 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

[4] As noted, the naturalization of Husserlian phenomenology was the subject of the major 1999 study [33]. Wus approach eliminates the arduous task of finding natural equivalents for Husserls transcendental intuitions.

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", which I consider to be transdisciplinary in character.

6.3 Informational Thinking vs. Systems Thinking

Due to the inclusion in Informational Thinking of some of the principles, especially the logic, of transdisciplinarity that are comparable – (they do not have to be "identical") to those of transdisciplinarity – one can "go beyond" the limitations of a systems approach that lacks a comparable grounding. Further inferences, for example, about how best to bridge the gap between natural and social science can be made in informational terms, since inherent to it, *ab origine*, is a theory of ethical value present in informational entities at the lowest to highest levels. As a case study for inclusion in this paper, let us look at the advantages which the informational paradigm brings to a number of domains of research as compared with Systems Thinking as outlined above.

Wu Kun made an analysis of the relation between information and systems theory in 2006 [36] in which he called attention to the limitations of the latter, as well as of the related research programs of information science and complexity theory. His comparative study of Information Thinking (*IT*) vs. Systems Thinking (ST) is outlined below in part. The reader may wish, as an exercise, to judge from this comparison if *IT* has some of the "flavor" of transdisciplinarity.

- Ontology

  ST: Basically descriptive, a way of looking at the properties of things in an integrated fashion, based on established philosophical foundations.

  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.

- 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. It is similar to but more generally formulated than Floridi's Philosophy of Information [36], as higher cognitive levels are addressed

- 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 criteria of its evolution.

- Economic Development Theory

  ST: Has 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 approach to 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 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".

As implied above, Informational Thinking not only includes Systems Thinking 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, including a logic of the included third, that is primitive and provides the framework for an improved understanding of systems.

In view of the rich space of possibilities for advances in philosophy and science offered by the concepts I have defined of Information Thinking, I 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 and 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 current science but increases the required degree of scientific and ethical responsibility of its practitioners. One should realize, only, that standard conceptions of logic, systems and information are *a priori* inadequate for this purpose.

6.4 The Informational Stance

Informational Thinking in fact 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 [38] is an attitude that requires attention to the informational aspects of complex processes as a methodological necessity that goes beyond the empirical epistemological formulation of van Fraassen [39].

Transdisciplinarity supports a humanistic worldview that is primary, similar to Wu's idea that "we should have a metaphysical picture of the world to discipline scientific methodology, and science and education policy". I note, as originally formulated by Wu, the non-separability of metaphysics, epistemology, value theory and social issues. The Informational Stance is 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 my overall logical approach, it is not necessary to make absolute separations between an 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 requires 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, that is, the "informosome".

6.5 The Consequences for Man and Society

The superiority of thinking centered on information in contrast to thinking centered on systems, Informational Thinking, (in which I 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[5]. The fundamental shift of philosophy toward a valuation of what one might call *immanent/transcendent realism* was also analyzed by Wu Kun in [31]. 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 new principles. When not well meant, the finality is limited to more effective operation of existing economic structures. 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 would be nave to suggest that the arrival of a new informational society with more democracy and individual freedom would mean that anti-social

[5]This is, philosophically, an alternate to a Husserlian phenomenology based on transcendental subjectivity.

behavior would disappear overnight, even if reference to Informational Thinking and transdisciplinarity became widespread. What I 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.

7 Transdisciplinarity, Ethics and the Common Good

The relationship between transdisciplinarity and the common good was very clearly laid out in a recent *ATLAS* paper by Christian Pohl [40]. He first describes alternative combinations of four characteristic features of transdisciplinarity, namely (a) to relate to socially relevant issues, (b) to transcend and integrate disciplinary paradigms, (c) to do participatory research, and (d) to search for a unity of knowledge. Rapidly, the Nicolescu conception focuses on d) as well as on how to approach all of these areas.

Pohl has established a concept of the function of a new transdisciplinarity network in Switzerland, the *td-net*, namely, to add additional features to the recent concentration on participatory research as the finality of transdisciplinarity. His concept "endeavors to frame, analyze, and process a socially relevant issue in such a way that the research project (1) grasps the complexity of the issue, (2) takes the diverse perspectives on the issue into account, (3) links abstract and case-specific knowledge, and (4) develops knowledge and practices that promote what is perceived to be the common good." He then goes on to say that "the promotion of the common good – or, more generally speaking, the evaluative component of transdisciplinary research – is rarely stated explicitly in definitions of transdisciplinarity even though an evaluative component is inevitable in order to know what an improvement of the current situation might look like." Later he says: '... one of the challenges for transdisciplinary researchers is to clarify underlying value systems by jointly developing the concrete meaning of, for example, sustainable development for the research project's specific context".

I agree with Pohl's overall thesis as stated in these sentences, but I disagree with his choice of emphasis. In my opinion, the purport of the terms common good, peace, ethics and sustainability go beyond research and researchers in these fields toward the more general substantive meaning of the subjects of research, the necessity for their implementation and the barriers to that implementation. Accordingly, a next step, in my opinion, is to include, in transdisciplinarity practice, a greater explicit commitment toward the actual nature of the objectives of the research.

I therefore discuss below some further issues in the area of ethics and the common good to which the transdisciplinary attitude may make a contribution. In my opinion, participating in "transdisciplinarity as a philosophical movement" (see above, Section 2.1) is not politically neutral, since any orientation toward a common good implies, more or less directly, some rather fundamental changes in social, political and economic values and priorities. I believe, however, in the area of information, a functional role for the transdisciplinary attitude and transdisciplinary thinking is beginning to take shape.

7.1 What has happened to the common good?

There is general agreement that the objective of new science and technology is to promote advances in human civilization, civilized behavior and well-being. Thus what is new and requires the attention of philosophers and logicians is not technology – science and engineering *per se*. What is new is the ever-increasing space, material and mental, that is abusively occupied by the artifacts of technologies. Unless logic and philosophy address this issue, they will have failed to address the reality of our world. François Flahault is a French philosopher without illusions about the current direction of society. In his recent book [41], whose title is that of this Sub-Section, he shows that social reciprocity and coexistence are the essential requirements for a satisfactory individual life, defining the real, non-economic "common good". However, the necessary codification of the rights of individuals, in the Universal Declaration of Human Rights in the aftermath of World War II, is now interpreted in an overwhelming context of market-driven globalization of the new information and communications technologies (ICTs), leading to a drastic and inhuman devaluation of the common good.

The new social media enabled by the new ICTs are only partly and superficially effective in creating new ties, since the overwhelming emphasis is on the

new capacities available to (some) individuals, seen as their rights, with very little about their duties, the other half of the dialectic of the common good. (The positive role of these media in pathological socio-political situations is not in question here.) Flahault shows that the concept of the common good is anterior to that of individual rights, but pious statements about the need to "work together" and "love one another" are inoperative. In order for the balance of power at the political level to further the common good, a new more scientific basis for the ties between individuals must be found than the market relations, the economic-social contract of individual consumption that relieves buyer and seller of all moral obligation.

Logic in Reality provides this: Two or more human individuals and their relations constitute interactive systems in the LIR categorial sense of non-separable subjects and objects, sharing in part one anothers characteristics. An individual is no more isolated logically, psychologically or morally than he or she is economically. Logic in Reality thus supports the relation between what was called pre-scientifically "natural law" and the conception of human society as necessary to human psychological existence, the real common good.

Neglect of the informational, and accordingly of the logical (in the above sense of the logic of the included third) and transdisciplinary aspects of thought may insure the purity of some academic research, but it also insures its irrelevance. In contrast, no scientific and technological work is without some redeeming actual or potential value to the community and hence has ethical entitlement to its share of limited resources. The role of information and its technology in this respect has been clearly outlined by Rafael Capurro [42]

8 Conclusion

In this paper, the theory of transdisciplinarity as defined by Nicolescu, consisting of its three ontological 'pillars' and the three axioms of its methodology, has been outlined. Three relevant and closely related logics, the original logic of the included third of Lupasco, the Nicolescu Logic of Transdisciplinarity and my Logic in Reality are compared. In particular, the principles of the Logic of Transdisciplinarity are shown to be essential to the understanding of problems in the areas of systems and information.

Transdisciplinarity is not a paradigm in the sense that a paradigm is a limiting concept. However, it can be related to recent developments, for example by Wu in the philosophy of information that have been shown to go far beyond the standard conceptions of philosophy. They establish the philosophy of information as a framework for the understanding of both philosophy and science in what may be termed a new informational paradigm. In particular, the concept of Informational Thinking has been shown to be more potentially valuable to the extent it incorporates a view of systems that fits Lupascos dynamic logical conception of the origin of systems in the antagonistic dualities of physics and metaphysics. Informational Thinking, like transdisciplinarity in the acceptation of Nicolescu, defines a stance or attitude in which rigor, opening and tolerance are both scientific and moral necessities, augmented by the feeling for information as a constituent of existence from the lowest to highest levels and having value as a consequence. This informational paradigm is a transdisciplinary one in that it seeks, like transdisciplinarity in general, what lies in, between and beyond the different conceptions of information.

I share the conviction, expressed by Pohl and others, that the transdisciplinary approach, embodying the Logic of Transdisciplinarity, does not only have enhanced potential for problem-solving, but also direct implications for insuring that the "problem-solving" is done for the common good. The Logic of Transdisciplinarity, unlike standard logics, is not topic-neutral or morally neutral but founds an ethics. It is my hope that a transdisciplinary ethics, which has not yet received a minimum necessary codification, may develop from this work. In summary, the inclusion of transdisciplinary and informational perspectives in scientific or philosophical work is not simply an intellectual exercise but a social and moral imperative.

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Since our first meeting in 1999, Professor Basarab Nicolescu has been a constant source of energy and inspiration in support of my effort to make accessible, in English, the fundamental logical philosophy of Stéphane Lupasco and his own contributions to it. I had agreed with Nicolescu that this logic was the Logic of Transdisciplinarity, as discussed in 2005 at the 2nd International Conference of Transdisci-

plinarity in Brazil. In the next phase of my work, transdisciplinarity became to a certain extent secondary to establishing the legitimacy of Lupasco's Principle of Dynamic Opposition and the Logic of the Included Third (Logic in Reality; LIR) in current philosophical-metaphysical terms. However, as my interest then turned to the application of LIR in the most currently significant fields of systems science and information, the necessary functional role of transdisciplinarity and the transdisciplinary attitude, in the complex acceptation of Nicolescu, became again clearly "actualized". In this, I am also very grateful to Professors Wolfgang Hofkirchner and Wu Kun who have encouraged the application of the Lupasco system to their theories and philosophy of systems and information in which appear their own visions of transdisciplinarity. This paper is a first attempt to show the convergence of these two lines of thought.

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Dr. Joseph E. Brenner was born in Paris in 1934. In 1958, he earned a Ph.D. in Organic Chemistry from the University of Wisconsin, After a career in the chemical industry (Du Pont de Nemours International) in R&D and corporate development, he began collaboration with the International Center for Transdisciplinary Research (CIRET) in Paris, working with its President-Founder, Basarab Nicolescu. His major objective has been to make the logical system of the Franco-Romanian thinker Stéphane Lupasco (Bucharest, 1900 – Paris, 1988), a co-founder of CIRET, accessible to English-language readers. Key publications are his 2008 book, Logic in Reality, Springer, Dordrecht, and recent papers on applications of this logic to information and the philosophy of information. He was involved in the 2010 inception of the International Society for Information Studies, Vienna, Austria, of which he is the Vice-President for Inter- and Transdisciplinarity. Also in 2010 he was named an Associate Director of the International Center for the Philosophy of Information in XiAn, China. Dr. Brenner is a member of the American Association for the Advancement of Science; the New York Academy of Sciences; and the Swiss Society for Logic and the Philosophy of Science.