

## Information in Reality. Logic and Metaphysics

Joseph E. Brenner

Chemin du Collège, P.O. Box 235  
CH-1865 Les Diablerets, Switzerland  
Phone /FAX: +4124 492 21 18

E-mail: [joe.brenner@bluewin.ch](mailto:joe.brenner@bluewin.ch)

### Abstract:

The recent history of information theory and science shows a trend in emphasis from quantitative measures to qualitative characterizations. In parallel, aspects of information are being developed, for example by Pedro Marijuan, Wolfgang Hofkirchner and others that are extending the notion of qualitative, non-computational information in the biological and cognitive domain and include meaning and function.

However, there is as yet no consensus on whether a single accepted definition or theory of the concept of information is possible, leading to many attempts to view it as a complex, a notion with varied meanings or a group of different entities. In my opinion, the difficulties in developing a unified theory of information (UTI) that would include its qualitative and quantitative aspects and their relation to meaning are a consequence of implicit or explicit reliance on the principles of standard, truth-functional bivalent or multivalent logics. In reality, information processes, like those of time, change and human consciousness, are contradictory: they are regular *and* irregular; consistent *and* inconsistent; continuous *and* discontinuous. Since the indicated logics cannot accept real contradictions, they have been incapable of describing the multiple but interrelated characteristics of information.

The framework for the discussion of information in this paper will be the new extension of logic to real complex processes that I have made, Logic in Reality (LIR)<sup>1</sup>, which is grounded in the dualities and self-dualities of quantum physics and cosmology. LIR provides, among other things, new interpretations of the most fundamental metaphysical questions present in discussions of information at physical, biological and cognitive levels of reality including, especially, those of time, continuity vs. discontinuity, and change, both physical and epistemological. I show that LIR can constitute a novel and general approach to the non-binary properties of information, including meaning and value. These properties subsume the notion of semantic information as well-formed, meaningful and truthful data as proposed most recently by Luciano Floridi. LIR supports the concept of 'biotic' information of Stuart Kauffman, Robert Logan and their colleagues and that of meaningful information developed by Christophe Menant.

Logic in Reality does not pretend to the level of rigor of an experimental or mathematical theory. It is proposed as a methodology to assist in achieving a minimum scientific legitimacy for a qualitative theory of information. My hope is that by seeing information, meaning and knowledge as dynamic processes, evolving according to logical rules in my extended sense of logic, some of the on-going issues on the nature and function of information may be clarified.

**Keywords:** logic, reality, contradiction, dynamic opposition, process, levels, qualitative, meaning

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<sup>1</sup> Brenner, J. E. 2008. *Logic in Reality*. Dordrecht: Springer.

## 1. Introduction

### 1.1 Rationale and Objective

Despite the widely varying content of theories of information, their emphasis has been on the quantitative aspects of information and their mathematical, abstract and essentially passive character, despite the fact that information may involve human agents as senders and receivers [1]. Many theories of information have developed in parallel with conceptions of the universe 'as' or 'like' a computer", as well as with the new information and communications technologies (ICTs). The properties and functions of computation have thus had a major influence on how information and information transfer have been perceived.

The objective of this paper, on the contrary, is to focus on the qualitative and causal properties of information, primarily in relation to complex biological and cognitive phenomena. The framework for my discussion will be the new extension of logic to real complex processes that I have made, Logic in Reality (LIR)[2]. In my view, information is a phenomenon which, like human consciousness and change, instantiates real contradictions. LIR, in contrast to standard logics, is capable of describing such contradictions in physical, biological and cognitive phenomena, permitting stable inferences about them.

### 1.2 Outline

The next Section 2 provides a brief summary of some current approaches to the definition of information and of a unified theory of information. I proceed in Section 3 with an overview of LIR as a complete but non-standard logic, including its categorial ontology. In Section 4, I will propose an LIR approach to information, without pretending that it is a complete or unified theory. In Sections 5-8, a number of different theories of information are analyzed from the LIR perspective. In Section 8, I attempt to arrive at a better definition of the relation between information and meaning. My hope is that by seeing the more complex forms of information, meaning and knowledge as dynamic processes - "Information in Reality" -

evolving according to logical rules in my extended sense of logic, some of the on-going issues on the nature and function of information may be clarified, providing an additional metaphysical but non-computational dimension to information.

## 2. Recent Developments and Directions

Some examples of recent developments, related to LIR, are as follows: Pedro Marijuan [3], Wolfgang Hofkirchner and others in the Foundation of Information Science (FIS) initiative are extending the notion of qualitative, non-computational information in the biological [4] and cognitive domain and include meaning [5] and function. Marijuan [6] suggests that rather than the outcome of a single, particularized conceptual discussion, "information becomes the intellectual adventure of developing a 'vertical' or 'transdisciplinary' science connecting the different threads and scales of informational processes, which demands both a *unifying* and *multi-perspective* approach".

Similarly, the recent history of information theory and science shows increased interest in qualitative characterizations. Mark Burgin's General Information Theory [7] refers to, among others, a qualitative theory of information as one of its sub-theories. The evolution of current concepts of information has been well summarized by Robert K. Logan in his forthcoming book *What Is Information?* [8] Earlier, Rafael Capurro [9] asked a similar question in developing a hermeneutical alternative to the standard paradigms of information science.

On the other hand, the qualitative properties of information suffer from being viewed as imprecise, inconsistent, subjective, value-laden and context-dependent, rendering rigorous discussion and progress difficult. Semantic and algorithmic approaches to the quantitative aspects of information are mathematically tractable, while the qualitative cannot be subsumed under the standard logical criteria of bivalent or multi-valent truth-functionality. I feel that Logic in Reality can

improve this situation by addressing issues of qualitative information and giving them proper ontological value, and I will proceed to describe it in the next Section.

### 3. Logic in Reality (LIR)

#### 3.1 Axioms, Calculus, Semantics

Logic in Reality (LIR) is a new kind of logic that extends its domain to real processes, relating them to an underlying particle/field view of the universe. Its axioms and rules provide a framework for analyzing and explaining real world entities and processes 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:

- Foundation in the physical and metaphysical dualities of nature
- Axioms and calculus intended to reflect real change
- Categorial structure of its related ontology
- Two-level framework of relational analysis

Details of LIR are provided in [2]. 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), 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 [10], 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.

Standard logic underlies, rather, the construction of simplified models which fail to capture the essential dynamics of biological and cognitive processes, such as reasoning [11]. LIR does not replace classical binary or multi-valued logics but reduces to them for simple systems and situations. These include chaotic systems which are not mathematically incomprehensible but also computational or algorithmic, as their elements are *not* in a functionally interactive relationship. The interactive relationships within or between levels of reality to which LIR applies are characteristic of entities with some form of internal representation, biological or cognitive.

The levels of reality referred to in LIR are *ontological*, defined by the different, but isomorphic physical laws that apply. The LIR view of reality as constituted by levels can be compared to Floridi’s *Levels of Organization* (LoOs) [12] which also support an *ontological* approach, and contrasted with the same author’s epistemological Levels of Abstraction (LoAs).

#### 3.2 The Categorial Ontology of LIR. Inconsistency

Many theoretical arguments depend on some form of absolute separability of dichotomous terms *via* the importation, explicit or implicit, of abstract principles of propositional binary logic exemplified in standard notions of time, space and causality. In the categorial ontology of LIR, the sole

material category is Energy, and the most important formal categories are Process and Dynamic Opposition, and the sub-categories of Separability and Non-Separability. The critical categorial feature of the LIR process ontology is the *Non-Separability* of opposing phenomena, e.g., two theories or elements of phenomena, e.g., syntax and semantics, types and tokens.

From the LIR metaphysical standpoint, for real systems or phenomena or processes in which real dualities are instantiated, their terms are *not* separated or separable! Real complex phenomena display a contradictory relation to or interaction between themselves and their opposites or contradictions. Note that the requirements in classical 1) category theory of exclusivity and exhaustivity and 2) set theory of absolute separation of sets and their elements do not apply: they are bivalent logic in another form.

LIR thus approaches in a new way the inevitable problems resulting from the classical philosophical dichotomies as well as such concepts as space and time, or simultaneity and succession as categories with *separable categorial features*. Non-Separability underlies all other metaphysical and phenomenal dualities, such as cause and effect, determinism and indeterminism, subject and object, continuity and discontinuity, and so on. I thus claim that Non-Separability at the macroscopic level, like that being explored at the quantum level, provides a principle of organization or structure in macroscopic phenomena that has been neglected in science and philosophy.

The philosophy of LIR can be characterized as a non-naïve dualistic realism that postulates a real, interactive, oppositional relation between all the classic dualities when they are instantiated in reality. It is part of the new *ontological* turn in philosophy. The LIR view, critical for any discussion of free will and the origin of moral responsibility, is that the world is ontologically deterministic and epistemologically indeterministic, in the contradictory relation suggested above.

In contrast to standard logics, LIR has no difficulty in dealing with inconsistency, interpreting it as a natural consequence of the underlying principle of dynamic opposition in

physical reality. Many if not most of the problems in the (endless) debate about the nature of change, as pointed out by Mortensen [13], seem to require a fundamental inconsistency in the world, which LIR naturalizes. Logic in Reality, then, is an information system that is not “brittle, like a classical logic system” in the presence of an inconsistency. Inconsistency in the former is not only not as destructive as in the latter, but is accepted as an essential part of its ontology.

### 3.3 LIR and Other Logics

LIR resembles paraconsistent logics (PCL), in which the law of non-contradiction fails. Paraconsistent logics (PCL) are *defined* such that contradiction does not entail triviality [14]. According to the LIR axiom of Conditional Contradiction, however, if A and non-A are present at the same time, it is only in the sense that when A is (predominantly) actual, non-A is (predominantly) potential.

LIR is perhaps closest to quantum logics since its elements are similar to non-standard probabilities which do not follow the laws of commutation or distribution.

The formalism of Diederik Aerts' [15] converts quantum mechanics into a system that can be applied to complex macroscopic phenomena, including the emergence of biological form and human cognition. Situations or entities that are intermediate between pure classical and pure quantum are not only possible, but their combined quantum and classical aspects can be described by different types of generalized mathematical structures. In this relatively new form of quantum logic, standard connectives take on new, non-classical meaning, suggesting that, as in LIR, there is a close relationship between logic and physics that may offer new insights into the structure and dynamics of information.

### 3.4 Information Logic

A first step toward developing a logic applicable to information has been made by Floridi [16]; his Information Logic (IL), or Logic of Being Informed, recognizes something static and abstract about standard formulations of epistemic and doxastic logics

and opens the door to a more dynamic view of information processes. Floridi makes a basic case for a non-doxastic informational approach to the acquisition of knowledge that does not depend on the (tripartite) notion of knowledge as justified true belief. I consider that LIR fulfills Floridi's implied requirement [12] that logic be regarded as a natural phenomenon dealing with other natural phenomena, recovering its original philosophical function. LIR provides a logical foundation for discussion of ethical questions based on *kinds* of information that complements IL. Both are reconsiderations of logic that, as Marijuan suggests [3], may be necessary for the advancement of information technology in an ethical direction [17]. Logic in Reality ascribes a logical, non-metaphorical content to descriptions of an antagonistic interaction between the individual and the world, as an on-going process. It is a process in which both players change as the reactions of one or the other, alternately, predominate. Rather than a Logic of Being Informed, LIR is a Logic of *Informing*.

### 3.5 Cognitive Aspects of LIR

A source of difficulty in understanding the dynamics of complex cognitive interactions has been the apparent absolute dichotomy between two individual human minds. While it is easy to see a cell or a person in a dynamic exchange of information with its environment or context, with change possible in both directions, it is difficult to understand how our cognitive context can be both internal and external without externality being determined by our consciousness. This would demand a full-blown anti-realist position.

The LIR epistemological approach to consciousness analyzes the details of the acquisition of perceptions, and postulates that afferent stimuli are 'split' into conscious potentialities and unconscious actualities. Higher levels of cognition develop from subsequent interactions with both internal and externally related (efferent) processes. Thus while your mind is physically external to mine, some of its perceptible potentialities can be internalized by me, perhaps by mirror neurons in the concept of Ramachandran. The LIR position is thus that two or more human

individuals are also systems in the category not only of Subject-Object, but that of Non-separability. An individual is no more isolated logically, psychologically and morally than he or she is economically. This principle applies to the interaction between the sender and receiver of information, in the usual model, placing them on the same basis.

## 4. The LIR Approach to Information

### 4.1 The Components of Information

Based on the contradictorial principles of LIR outlined above, what information is in reality and what constitutes a proper theory of information, of which information is its substrate, cannot be totally separated. Further, the real properties of informational entities or processes, binary and non-binary, are not independent of and cannot be discussed without reference to the *a priori* non-binary energetic processes that are their source, in some real situation, at all levels of reality.

The LIR approach thus incorporates and provides for a relation between two complementary components of information: 1) information as well-formed, meaningful and truthful data [12]; and 2) information as real energetic processes, whereby information-as-processes can function as higher-level operators on information-as-data at a lower level or reality or abstraction.

Gordana Dodig-Crnkovic has provided a useful overview [18] of theories of information divided into the following main categories or approaches: syntactic, cybernetic, algorithmic, semantic and situated. The situation semantics of Barwise and Perry is perhaps closest in spirit to LIR, since it seeks to go beyond the dichotomy between natural and linguistic phenomena. In her further discussion of syntactic vs. semantic information, however, Dodig-Crnkovic maintains the dichotomy between syntax and semantics as corresponding to one between form and content, contrary to the basic ontological concepts of LIR.

### 4.2 The Floridi Perspectives

In Floridi's Philosophy and Logic of Information, 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, etc.).

Extensionalist approaches to the definition of information as reality or *about* reality provide different starting points for answering the question of what information is. I have selected from his list [12] those that are most relevant to Logic in Reality.

3. The probabilistic approach > probability space and the inverse relation between information in  $p$  and probability of  $p$ ;

4. The modal approach > modal space and in/consistency:

5. The systemic approach > state-space and consistency: information tracks possible transitions in the state-space of a system;

6. The inferential approach > inferences space: information depends on valid inference relative to a person's theory or epistemic state;

7. The semantic approach > data space: semantic information is well-formed, meaningful and truthful data. This formulation indicates that we are dealing with propositions, and the applicable logic is a bivalent, propositional logic.

#### 4.3 Information in LIR

My thesis is that a firm distinction cannot be maintained between these different approaches insofar as information as reality is concerned. Thus, if information describes real process systems and these in turn are described as probability distributions, they share aspects of 3, 4 and 5. To the extent real information processes are inconsistent, 4 is required, and if the description is a logical one (in the extended sense of logic of Logic in Reality, LIR), inference and therefore 6 is also involved.

This leaves definition 7 but let us assume with Floridi that we are, in this case, at the lowest level of reality. LIR provides the basis for saying that there is no absolute disjunction between this level of reality and

those to which the more complex concepts of information apply. Logic in Reality provides two *new elements* in relation to these points:

- a physical and logical grounding for a real, dialectical interaction between informational Levels of Abstraction, such that information at any level shares *some* of the properties to *some* extent of the structure of the information at the levels above and below it;
- a focus on information that is complex and value-laden which, unlike simpler data, is not and does not have to be decoupled from its support.

Floridi finds the concept that semantic information is true if it *points* to the actual state of the world somewhat equivocal. I mention it to contrast it with what could be called the basic concept of information in the LIR logic of processes, namely that logical (in the LIR sense) information *is* the actual state of the world. Thus information in LIR includes, but is not limited by, the following characteristics:

- a) information as what is processed by a computer;
- b) information as a scalar quantity of uncertainty removed, the standard entropy/negentropy picture;
- c) semantic information as truthful, well-formed, meaningful data (Floridi);

The definition of information that is, however, most congenial to LIR, was made by Kolmogorov [19] 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.

Among the well-known definitions of information, I note the dictum of Bateson that information is "a difference (and/or distinction) that makes a difference is generally accepted. However, I think this difference cannot be an ordinary "delta", but rather an active referring or better differing term like the *différance* of

Derrida. *Différance* in this informational context looks also like an operator. In LIR, where logical elements of real processes resemble (non-Kolmogorovian) probabilities, the logical operators are also processes, such that a predominantly actualized positive implication, for example, is always accompanied by a predominantly potentialized negative implication.

LIR can thus provide bridging concepts or 'glue' between semantic information at the lowest informational level and higher ones. It is not a new concept that higher levels of information subsume aspects of semantic information. What LIR does is to place the "superconcept" of information in a naturalized physical, metaphysical and logical context. Information is thus both a means to model the world and part of the world that is modeled, and LIR describes the relation between them.

## 5. Toward a Unified Theory of Information

Among proposals for unifying concepts of information, I note that of Hofkirchner [20]. His approach to a Unified Theory of Information (UTI) is to eliminate the absolute and in my view artificial separation between critical concepts of information in favor of a dialectical relationship similar to the ancient intuition of 'unity-in-diversity'. Specifically, his "UTI seeks a concrete-universal concept of information rather than an abstract one".

Hofkirchner considers information as a "superconcept", which includes a group of overlapping concepts such as message, signal and so on. Broadly, they apply to communication, cognition and cooperation between human and non-human organisms. A UTI has the objective of classification from a philosophical, disciplinary and "clusters" standpoint. By clusters, Hofkirchner refers to information as 1) structural; 2) a complex processing involving the sender; and 3) a complex processing involving the receiver. Hofkirchner asks how matter and idea, mind, information, *etc.* can be grasped as complements and with them information as a thing (a structure, a flow) or as a human construction. Hofkirchner gives a dialectical

answer to the implied division between subject and object, suggesting that mind, and with it information, is of a different 'materiality' than 'non-emergent' states of matter.

From the LIR standpoint, mind and information can be seen as "complements" if one sees them as processes. Structure, flow and "human processing activity" all follow the same real, physical dialectics. If matter and information are differentiated in a "common genus", for LIR, *that genus is simply energy, and both follow its logical patterns of evolution*, avoiding the problems of the term "different materiality". Logic in Reality is, also, a logic of emergence or "emergent materialism".

Hofkirchner wishes to avoid reliance on a "formal-logical figure of necessary and sufficient conditions" and use a way of thinking that integrates as well as differentiates the particular and universal", with which LIR agrees. Hofkirchner seeks support for it in Edgar Morin's concepts of complexity involving "unity-in-diversity, diversity-in-unity and diversity-through-unity."

In my view, however, these principles have substantial humanistic value but cannot be used as such in a theory of anything. Morin's 'dialogic' simply restates these principles, giving as the basis for their instantiation in reality a reference to the well-known concept of *autopoiesis*, which itself is less than adequately grounded. LIR, on the other hand, is grounded in the fundamental physical dualities of the universe, and provides a principled basis for the contradictory relations in real emergent physical processes. These no longer constitute the standard formal-logical figures that Hofkirchner correctly critiques, but a dynamic logic of information-with-meaning that could support a UTI.

## 6. Qualitative Information Theory

As discussed by Burgin [7], qualitative information is not a *general* area (yet?) of information theory, like the others mentioned here. However, his new General Theory of Information (GTI) treats information from a pragmatic, dynamic perspective, involving

changes of structure or behavior of the receiver (and, as below, of the sender as well). While Kolmogorov [21], following Shannon, discussed several approaches to defining the notion of the amount of information, the work of Marian Mazur and Burgin's own view of a GTI refers to, among others, a qualitative theory of information as one of its sub-theories. Mazur discovered and defined the models of information and code strings of communications, and developed an information theory designated as qualitative by Burgin on this basis. However, Mazur's formulas give estimations only of the composition of character sequence and leave out the specific sequential order of characters in sequences. We are here still quite close to a simple scalar characterization of information.

Burgin's definition of Qualitative Information Theory is "information (that) is a transformation of one communication of an information association into another communication of the same association", using some realistic information measure. This concept in my view is necessary but not sufficient to capture the all the qualitative properties of information, its positive or negative "valence" that can be dependent or independent of the sender's intentions, but can have a differential impact on the receiver. LIR allows the dialectical association of the quantitative (measurement) and qualitative properties of information *qua* process.

Most congenial to LIR are dynamic theories of information, included in this GTI, where information is an action, that is, a process or operator, causing some form of transformation. Marijuan proposes the concept of "Information Proceeding" to capture the process by which information always changes the subject and there is "no such thing as a separate observer in the information realm". Logan [8] also points out the lack of attention paid to the qualitative as opposed to the quantitative aspects of information, that is, the need to incorporate a functional notion of meaning, recalling pioneering work by Donald MacKay.

### 6.1 The Valence of Information

My thesis is that the values conveyed by information should be viewed as positive or negative in terms of their effect on both sender and receiver, and that accordingly the essential quality of information is its intentional *valence*, positive or negative. This corresponds to a property or characteristic of qualitative information in process terms as a reality in a physical space (as opposed to a data space, cf. Floridi [22]), in a morally valued interaction between producer and receiver. LIR is neither topic-neutral nor context independent, and can support a view of information involving apparently contradictory perspectives and assigns equal ontological value to negative as well as positive information.

In his discussion of the typological neutrality of information, Floridi defines secondary data "as the converse of primary data, constituted by their absence (one could call them anti-data). ... This is a peculiarity of information: its absence may also be informative." The absence of a response to a computer query is also given as a *bona fide* instance of negative information-as-data. Floridi discusses ([12] and elsewhere) why, in any truth-functional propositional theory of information, false information and misinformation should not be considered as information at all. But in LIR, we are not dealing with truth-functionality, and negative qualitative information is not falsehood. LIR uses the term negative information to mean intended messages in a necessarily social context that have negative or unnecessarily and unfounded pessimistic content with, probably, negative consequences for the receiver. This point is made by Capurro [9] who also calls attention to the philosophical necessity, for a theory of information in reality that refers to the existentiality of our "being-in-the-world-with others", to include a discussion of misinformation and its interwovenness (non-separability) from information. In his view, it is the absence of separation that insures that information science is a hermeneutic science and accordingly a foundation of an ethics of information.

There is a further and more 'positive' side to 'negative' information. Marijuan [23] conceptualized absences, needs, voids, etc. as instances of symmetry breaking in the



trajectory of a life cycle. He noted that most approaches to information pay attention only to the 'positive' or constructive side ('presences') of a phenomenon: its composition, construction rules, emergence, effective, that is actual activity, etc. However, the 'negative' or degrading aspects ('absences', disappearance of activity) are equally important within most biological-informational processes. The theme of absence, need, void, etc., which is needed to provide a complete picture of the 'infosphere' goes back to the views of McLuhan who had pointed to "negativity", and the subtle economy involved in predominantly signaling by "absences".

## 7. Semiotic Information Theory

At first sight, the semiotic approach to information might appear to capture its multiple facets, ordering them into the functional categories proposed by C. S. Peirce. Advocates of this approach, such as Sören Brier, have the laudable objective of capturing "what is missing" in standard algorithmic accounts. Peirce's system can be described as a combination of semiotic monism, conjoined with an ontological category theory. Peirce based his theory on categories of Firstness (possibility), Secondness (existence) and Thirdness (reality), without the requirement for radically different ontological domains. The 'First' is a 'Sign' or 'Representamen' which is in a genuine triadic relation to a 'Second', called its 'Object' so as to be capable of determining a 'Third', its 'Interpretant' to assume the same triadic relation to its Object in which it stands itself to the same Object'. The term 'Sign' was used by Peirce to designate the irreducible relation between the three terms, irreducible in the sense that it is not decomposable into any simpler relation, such as some form of part-whole relation.

The common interpretation is that the relation is dynamic because it leads to 'chains of triads'. I consider this theory insufficiently dynamic because there is no energy that can be assigned to the triadic relation that would give it a basis in reality (physics).

Despite his deep and anticipatory intuitions, Peirce made no ontological commitment regarding his concepts. He wrote specifically that his 'phaneroscopy' (phenomenology) had nothing at all to do with the question of how far the 'phanerons' it studied correspond to any realities. I see the problem with Peirce's categories as being like that with the Hegelian triad of thesis, antithesis and synthesis: there is no deductive basis for the movement from one term to the other or a description of any physical interaction between them. If the argument is made that nothing of the sort is required, my response is that is exactly the problem – the terms are not physically grounded and hence have limited explanatory value other than as a heuristic device for keeping track of the entities involved in biological processes [24]; its use should not make one neglect the real properties of the system. It is clear that if semiosis is a process of meaning making, of construing a material entity or phenomenon as a Sign, then semiotic interpretation differs from simple physical interaction. It is, nevertheless, a physical as well as an epistemological process, a process of knowing involving emergence of a more complex process that constitutes meaning. It should not and does not have to be cut off from its physical base since cognitive processes also follow the LIR Principle of Dynamic Opposition.

The Peircean semiotic concept of information has been summarized by Quieroz, Emmeche and El-Hani [24] (QEE) as a "triadic dependent" process where a form is communicated from an Object to an Interpretant through the mediation of a Sign. My critique of this approach is that as stated by Peirce himself, it is derived from a *formal* science of signs that provides an *analytical* framework. Thus the QEE approach to information as process is constrained by the abstract characteristics of the Peircean categories, that is, their abstraction from dynamic aspects of real physical phenomena.

In contrast to QEE, I derive the triadic characteristics from the LIR view of the contradictory evolution of all real processes, providing the physical basis for the QEE differentiation of potential and effective (actual) semiosis and consequent definition of

potential and effective *information* as well. In LIR, information is a complex of processual interactions with both binary (dyadic) and ternary (triadic) properties, all of which can be predominantly actualized (effective) or potentialized (not effective) at any time. This would seem preferable to the nebulous concept of a Sign as a Medium for communication of Form.

An additional problem arises from the essentially static linguistic definition of Form in terms of “conditional propositions” stating that certain things would happen under certain circumstances. Strikingly, as quoted by QEE, Peirce said that “*Form can also be defined as potentiality ('real potential': EP 2.388)* (emphasis mine). In LIR, structure and form are also physical processes, including the physical processes of their conceptualizations. Form is characterized not as ‘potential’ only, but as a process whose elements are both actual and potential at the same time. The distinction between Object and Interpretant does not have to be maintained: all complex process entities (last but not least two people), are, alternately, more or less one or the other, with both capable of the interpretation, that LIR accepts, of conferring meaning on information.

LIR thus provides a new approach that confirms the QEE critique of the argument by Jablonka that “for a source to be an information input rather than merely a source of energy or material, its *form*, or variations in its form, rather than any other attribute should affect the interpreter’s response in a consistent, regular way”. The problem is not that we have lost the (formal) Peircean agent mediating a relation between Object and Interpretant, but that a distinction has been created according to which form is idealized as something non-energetic, but still with causal properties. To say that form is also energy is not to make a physicalist reduction, but to avoid conceptualizing it out of existence.

## 8. Biological Information Theory and Meaning

### 8.1 Meaning in LIR

Meaning in metaphysics and logic generally refers to the meaning of propositions or sentences, and is closely related, not to say dependent on, the notion of linguistic truth. There exists a strong commonsense intuition, however, that events, processes and living beings, especially humans, have meaning. People have always sought the ‘meaning’ of life and existence. Meaning thus has several definitions, which run from “something that is signified, especially by language” to “something that is felt to be the inner significance of something”. I see in this polysemy the same conceptual range as in my logic, that is, from a method for managing linguistic phenomena [25] to a description and explanation of the structure of the world.

In the LIR dynamic view of meaning, it is what is *felt* that is significant, in other words, meaning-as-experience, and my experience of the world. (I do not advocate a conception of meaning based on indexicals since in a typically binary fashion, they obfuscate the dynamic, contradictory (or reciprocal) aspects of the relation between the world and me. Non-metaphorically, if the world has meaning for me, I should have meaning for the world.)

Everything logical in the LIR sense is experimental or existential, *has* a meaning and *is* meaning because it not only emerges from the underlying dualities of energy, but is directed toward the relationship with the other – ‘meaning for’. Meaning is thus inherent to all dynamic processes, and there is a transfinite multiplicity of meanings. Meaning cannot be finite or infinite, because then it would be absolute and meaningless. One can define logic, existence and becoming as an incessant activity of partial signification, as a movement of meanings that never stops.

Floridi discusses [12] how information as data “acquire” meaning, where meaning is primarily semantic and above all non-anthropocentric and teleological. In the LIR interactionist picture, however, meaning, like consciousness, is a *necessary* consequence of the existence of the physical world and its characteristics. As Peruzzi puts it [26], it is the furniture of the base macro-world (light, chemical bonds, gravity, temperature) that

molds conditions on the earth's surface and living beings, among other things for the emergence of language. Language cannot be separated from its basis in perception, and the "Scylla of relativism and the Charybdis of idealism" can be avoided by maintaining the flux of meaning from perception and action to cognition. The consequence, that conforms to the LIR category of Non-Separability, is that there cannot be any cut between perception and cognition without depriving sentences of meaning. The choice of logic is not arbitrary. Both the structure of objects and the patterns of perceptual interaction with objects establish features of both logic and language.

## 8.2 Biotic Information

In their key 2008 paper [4], Kauffman, Logan and their colleagues propose a new reading of information inherent in biological processes that unites matter, energy and information that is fully compatible with and supported by Logic in Reality. They show that neither the Shannon definition of information as a scalar quantity of bits, devoid of meaning, nor Kolmogorovian information which refers to standard probability distributions of non-interactive systems, is applicable in biology. Information should be designated as 'instructional' or 'biotic' in the sense that it carries meaning and consists of constraints or their physical equivalents - boundary conditions that also partially cause events. Most importantly, the coming into existence of the constraint is itself part of the propagating organization of the entity. "Constraints are information and information is constraints." This recursive aspect is characteristic of non-Markov chains, the non-Kolmogorovian probability behavior of two mutually dependent entities to which LIR applies.

LIR proposes a "missing ingredient" of dynamic opposition or antagonism that reinforces this picture of information for the evolution of living systems, without violating any principle of physical closure. It provides a cybernetic explanation of how constraints-as-information in their physical manifestations can be causally effective when identified with the residual potentialities of all material structures more complex than an isolated

quantum particle. By locating the causal powers of constraints in the physical potentials available "from the bottom up", one has at least part of an explanation of why structures, up to and including social structures, have the properties they have. The assumption of "auto"-catalysis and totally "spontaneous" processes is unnecessary, as discussed. (In this connection, one can introduce the term 'constraining' in addition to constraint, the participle giving a more accurate description of a process.)

Christophe Menant [5] looks at information in the relation between an arbitrary real signal and an entity or system capable of interpreting that signal. In this "bottom-up" explanation of information and meaning, a meaning is meaningful information generated by some purpose or action in connection with a constraint on that system. "The generated meaning is precisely the connection (I would add the emergent connection) between the received information and the constraint." That the meaning associated with an outside entity depends on the entity and also on the internal state of the system I see as a *logical* process that follows the rules of LIR of non-separability and alternating actualization and potentialization.

I disagree, however, with the concept of a meaningful *representation* as a "network" of meaningful information that is distinct from that information (meanings). I do not see the *necessity* of the attribution of a name "meaningful representation" that refers to more than the network of meanings themselves, and I question its *value* since it might be (mis)understood as an entity in its own right rather than a set of processual states. In fact, LIR confirms the views of Brooks, cited by Menant that "It turns out to be better to use the world as its own model". I propose the LIR Principle of Dynamic Opposition (PDO), first described by Stéphane Lupasco in 1960 [27], as a candidate for the "something fundamental and currently unimagined in our models of biology" that Brooks thinks we might be missing, without the need for any vitalist postulate.

## 8.3 Biological Information Theory. The Mirage of Self-Organization

Any theory of biological development or becoming must capture the duality of biological systems, that is, the composition of living systems by non-living substrates. The LIR dynamic process ontology is grounded in the contradictorial dualities of physics and the coexistence of actuality and potentiality in all real systems. Its principles have the advantage of providing an explanation for ontic, non-epistemological emergence of more complex entities, including living systems, from less complex substrates based on the residual, physical potentialities of all atomic particles above the level of quanta, that is, protons, neutrons, and the hydrogen atom, without recourse to arbitrary notions of self-organization. It is the residual potentialities of these particles for entering into further chemical reactions that are the carriers of the *information* necessary for that emergence. For atoms, the information is their oxidation-reduction potential; for amino acids, it is their residual charge, measured by the isoelectric point, which constitutes the information. From this point of view, the assemblage of amino acids into macromolecules requires an inorganic catalyst, but such a catalyst also has a surface energy whose origin is the potentialities of the atoms composing it. At the level of the gene, biological information is more than genetic information in the sense that the full information content of the gene also involves the residual potentialities in its ternary and quaternary structure.

In our world, therefore, the initial pre-biotic conditions are not completely random. Describing information content in terms of potentialities is not a reduction in the invidious sense but the attribution of an element of structure and cause that has been ignored in science and philosophy.

From the LIR perspective, there is no need to postulate totally autonomous agents [28] or real-world systems [29] capable of “spontaneous self-organization”. This strategy only begs the question of the origin of the capacities for that “self”-organization. The well-known chain of argument, from Prigogine through Varela to Kauffmann is not totally incorrect, but it is incomplete and partially misleading. It is clear that “matter-energy variations” have an effect on biological processes, but it is not necessary to redefine

them as Peircean Signs: they are, already, information-with-meaning.

## 9. Conclusion and Outlook

In this paper, I have discussed information in terms of a new kind of logic of real processes, Logic in Reality (LIR). LIR is an extension of logic to real phenomena, grounded in quantum mechanics and applicable to complex real processes, and is a method of analyzing the underlying dynamics of information and information transfer. Unlike standard bivalent or multivalent propositional and predicate logics, even in their modal or deontic versions, LIR provides a basis for describing the behavior and evolution of real systems in logical terms, and information itself in the same terms. Similar logical principles, in this view, govern the nature of knowledge and the relation of information and meaning. LIR is sufficient as a part of a description of information, but also necessary since without it the physical driving forces for the behavior of information as a meaning-laden process cannot be properly associated with conceptual epistemological descriptions of information in terms of Levels of Abstraction that are observer-dependent.

Logic in Reality thus provides a new contradictorial description of information as it *is* in reality. Information *is* reality in a way that includes higher dimensional cognitive processes relevant to the construction of a theory of the emerging Information Society and its non-informational components. The development of a proper theory of information is thus an eminently transdisciplinary task, and Hofkirchner, Marijuan, Floridi and other information scientists have called attention to the transdisciplinary aspects of the ICTs both as such an in relation to society.

The LIR theory of information is not intended to supersede any or all existing approaches. It is proposed, rather as a logical methodology that would encourage the retention and use of partially conflicting notions of information as produced and used. Like standard bivalent and multivalent logic, digital conceptions of information will persist that will support the further development of

computer science and engineering. From the LIR perspective, such developments are not only probable, but essential to the overall development of the understanding of “information in reality”. My hope is that the approach of Logic in Reality, suggested in this paper, may favor a proper balance between information-as-data, and information-as-process, as well as the more complex normative worldview that is embodied in the latter as a form of qualitative information theory.

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## About the Author

### *Joseph E. Brenner*

Joseph E. Brenner was born in Paris in 1934, the son of the American sculptor Michael Brenner (Lithuania, 1885 – New York, 1969). After primary and secondary education in New York, he received B.A. and M.S. degrees from the University of Chicago. In 1958, he earned a Ph.D. in Organic Chemistry from the University of Wisconsin, which was followed by postdoctoral studies at the Swiss Federal Institute of Technology, Zurich and the Massachusetts Institute of Technology. In 1960, he joined the E. I. Du Pont de Nemours Company at its Wilmington, Delaware laboratory as a polymer chemist. From 1965 to his retirement in 1994, he was involved in corporate development and technology transfer with Du Pont de Nemours International in Geneva, Switzerland, working primarily in the Middle East, Africa and Eastern Europe. In 1998, he began collaboration with Basarab Nicolescu, Professor (em.) of Theoretical Physics at the University of Paris VI and President of the International Center for Transdisciplinary Research (CIRET) in Paris. The focus of this on-going collaboration has been to make the logical system of the Franco-Romanian thinker Stéphane Lupasco (Bucharest, 1900 – Paris, 1988) accessible to English-language readers. Brenner's extension and up-dating of this work has been the subject of publications and presentations at conferences and seminars in Europe, Brazil and the U.S.A. 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. He recently joined the Editorial Board of *triple-C*.